

51ST ANNUAL CONFERENCE OF THE EUROPEAN SOCIETY FOR ENGINEERING EDUCATION (SEFI 2023)

September 10th to 14th 2023



2023 Draft Book of Abstracts

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Date: Sunday, 10/Sept/2023

8:45am - 9:30am Front Atrium / Reception	Registration for Doctoral Symposium and Welcome Refreshments Location: Front Atrium / Reception
9:30am - 12:00pm EQ-212a-d (All)	Doctoral Symposium Session 1-1 Location: EQ-212a-d (All)
12:00pm - 1:00pm Front Atrium / Reception	Doctoral Symposium Lunch Location: Front Atrium / Reception
1:00pm - 3:10pm EQ-212a-d (All)	Doctoral Symposium Session 2-1 Location: EQ-212a-d (All)
3:10pm - 3:30pm Front Atrium / Reception	Doctoral Symposium Refreshments Break Location: Front Atrium / Reception
3:30pm - 4:30pm EQ-212a-d (All)	Doctoral Symposium Session 3-1 Location: EQ-212a-d (All)

Date: Monday, 11/Sept/2023

8:00am - 9:00am Front Atrium / Reception	Welcome Registration & Info Desk Location: Front Atrium / Reception
9:00am - 9:30am EQ-010 Performance Hall & EQ-002 Lecture Hall	Opening Session Location: EQ-010 Performance Hall & EQ-002 Lecture Hall
9:30am - 10:30am EQ-010 Performance Hall & EQ-002 Lecture Hall	Plenary Panel Session - Recent trends in Engineering Education Research - How to support change and inclusive futures in engineering education? Location: EQ-010 Performance Hall & EQ-002 Lecture Hall
10:30am - 11:00am Front Atrium & Back Atrium	Refreshment Break 11-1 Location: Front Atrium & Back Atrium
11:00am - 12:00pm EQ-002 Lecture Hall	EDI 1 - Background and Belonging 1 Location: EQ-002 Lecture Hall Session Chair: Ines Direito
11:00am - 12:00pm EQ-116 Flat Room	Fostering Engineering Education Research 1 Location: EQ-116 Flat Room Session Chair: Catherine Deegan
11:00am - 12:00pm EQ-211 Flat Room	Teamwork and Team Projects 1 Location: EQ-211 Flat Room Session Chair: Tinne De Laet
11:00am - 12:00pm EQ-203 Flat Room	Virtual and Remote Education Post Covid 1 Location: EQ-203 Flat Room Session Chair: Louise Lynch
11:00am - 12:00pm EQ-204 Flat Room	Climate Change and Sustainability 1 Location: EQ-204 Flat Room Session Chair: Klara Kövesi
11:00am - 12:00pm EQ-112 Flat Room	Engineering Ethics Education 1 Location: EQ-112 Flat Room Session Chair: Roland Tormey
11:00am - 12:00pm EQ-208 Flat Room	Mentoring and Tutoring Location: EQ-208 Flat Room Session Chair: Sophia Economides
11:00am - 12:00pm EQ-117 Tiered Room	Skills Development for Sustainability Location: EQ-117 Tiered Room Session Chair: John Mitchell
11:00am - 12:00pm EQ-118 Tiered Room	Built Environment Location: EQ-118 Tiered Room Session Chair: Yolande Berbers
12:15pm - 1:15pm EQ-208 Flat Room	Parallel Workshops 1-01 Location: EQ-208 Flat Room
12:15pm - 1:15pm EQ-113 Flat Room	Parallel Workshops 1-02 Location: EQ-113 Flat Room

12:15pm - 1:15pm EQ-207 Technology Room	Parallel Workshops 1-03 Location: EQ-207 Technology Room
12:15pm - 1:15pm EQ-212a-d (All)	Parallel Workshops 1-04 Location: EQ-212a-d (All)
12:15pm - 1:15pm EQ-112 Flat Room	SIG Workshop 1-01 Location: EQ-112 Flat Room
12:15pm - 1:15pm EQ-116 Flat Room	SIG Workshop 1-02 Location: EQ-116 Flat Room
12:15pm - 1:15pm EQ-203 Flat Room	SIG Workshop 1-03 Location: EQ-203 Flat Room
12:15pm - 1:15pm EQ-315 Flat Room GD	SIG Workshop 1-04 Location: EQ-315 Flat Room GD
12:15pm - 1:15pm EQ-002 Lecture Hall	SIG Workshop 1-06 Location: EQ-002 Lecture Hall
1:15pm - 2:30pm Front Atrium / Reception	Lunch All Delegates Location: Front Atrium / Reception
1:15pm - 2:30pm Back Atrium	Lunch for Conference New Comers Location: Back Atrium
2:30pm - 3:30pm EQ-002 Lecture Hall	Sustainable Development - Curriculum and Programme Approaches Location: EQ-002 Lecture Hall Session Chair: John Mitchell
2:30pm - 3:30pm EQ-116 Flat Room	Engagement with Industry and Innovation 1 Location: EQ-116 Flat Room Session Chair: Sonia M. Gomez Puente
2:30pm - 3:30pm EQ-211 Flat Room	EDI 2 - Women in STEM Location: EQ-211 Flat Room Session Chair: Catherine Deegan
2:30pm - 3:30pm EQ-203 Flat Room	Climate Change and Sustainability 2 Location: EQ-203 Flat Room Session Chair: Ceri Almrott
2:30pm - 3:30pm EQ-204 Flat Room	Fostering Engineering Education Research 2 Location: EQ-204 Flat Room Session Chair: Gareth Thomson
2:30pm - 3:30pm EQ-112 Flat Room	Innovation in T&L 1 - Laboratory Location: EQ-112 Flat Room Session Chair: Mark Michael McGrath
2:30pm - 3:30pm EQ-208 Flat Room	Student Recruitment and Retention Location: EQ-208 Flat Room Session Chair: Balázs Vince Nagy
2:30pm - 3:30pm EQ-117 Tiered Room	Sustainability in Engineering Education 1 Location: EQ-117 Tiered Room Session Chair: Klara Kövesi
2:30pm - 3:30pm EQ-118 Tiered Room	Education with Artificial Intelligence 1 Location: EQ-118 Tiered Room Session Chair: Sefi Session Chair
3:30pm - 4:00pm Front Atrium & Back Atrium	Refreshment Break 11-2 Location: Front Atrium & Back Atrium
4:00pm - 5:00pm EQ-112 Flat Room	SIG Meeting Physics Location: EQ-112 Flat Room
4:00pm - 5:00pm EQ-116 Flat Room	SIG Meeting Ethics Location: EQ-116 Flat Room
4:00pm - 5:00pm EQ-203 Flat Room	SIG Meeting Attractiveness Location: EQ-203 Flat Room
4:00pm - 5:00pm EQ-204 Flat Room	SIG Meeting Curriculum Development Location: EQ-204 Flat Room

4:00pm - 5:00pm EQ-208 Flat Room	SIG Meeting Continuing Education and LLL Location: EQ-208 Flat Room
4:00pm - 5:00pm EQ-211 Flat Room	SIG Meeting Capacity Building Location: EQ-211 Flat Room
5:00pm - 6:00pm EQ-112 Flat Room	SIG Meeting Mathematics Location: EQ-112 Flat Room
5:00pm - 6:00pm EQ-116 Flat Room	SIG Meeting Diversity and Inclusion Location: EQ-116 Flat Room
5:00pm - 6:00pm EQ-203 Flat Room	SIG Meeting Sustainability Location: EQ-203 Flat Room
5:00pm - 6:00pm EQ-204 Flat Room	SIG Meeting Engineering Education Research Location: EQ-204 Flat Room
5:00pm - 6:00pm EQ-208 Flat Room	SIG Meeting Engineering Skills Location: EQ-208 Flat Room
5:00pm - 6:00pm EQ-211 Flat Room	SIG Meeting Open and Online Education Location: EQ-211 Flat Room
6:00pm - 7:30pm Front Atrium & Back Atrium	Welcome Reception and Fellowship Awards Location: Front Atrium & Back Atrium

Date: Tuesday, 12/Sept/2023

7:45am - 9:00am Front Atrium / Reception	Welcome Registration & Info Desk Location: Front Atrium / Reception
8:00am - 9:00am EQ-116 Flat Room	Parallel Workshops 2-01 Location: EQ-116 Flat Room
8:00am - 9:00am EQ-112 Flat Room	Parallel Workshops 2-02 Location: EQ-112 Flat Room
8:00am - 9:00am EQ-203 Flat Room	Parallel Workshops 2-03 Location: EQ-203 Flat Room
8:00am - 9:00am EQ-315 Flat Room GD	Parallel Workshops 2-04 Location: EQ-315 Flat Room GD
8:00am - 9:00am EQ-208 Flat Room	Parallel Workshops 2-05 Location: EQ-208 Flat Room
8:00am - 9:00am EQ-207 Technology Room	Parallel Workshops 2-06 Location: EQ-207 Technology Room
8:00am - 9:00am EQ-113 Flat Room	Parallel Workshops 2-07 Location: EQ-113 Flat Room
8:00am - 9:00am EQ-204 Flat Room	Parallel Workshops 2-08 Location: EQ-204 Flat Room
8:00am - 9:00am EQ-212a-d (All)	Parallel Workshops 2-09 Location: EQ-212a-d (All)
8:00am - 9:00am EQ-211 Flat Room	SIG Workshop 2-01 Location: EQ-211 Flat Room
9:00am - 10:00am EQ-002 Lecture Hall	EDI 3 - Gender in Engineering Education Location: EQ-002 Lecture Hall Session Chair: Ines Direito
9:00am - 10:00am EQ-116 Flat Room	Teamwork and Team Projects 2 Location: EQ-116 Flat Room Session Chair: Roland Tormey
9:00am - 10:00am EQ-211 Flat Room	Fostering Engineering Education Research 3 Location: EQ-211 Flat Room Session Chair: Gavin Duffy

9:00am - 10:00am	Virtual and Remote Education Post Covid 2
EQ-203 Flat Room	Location: EQ-203 Flat Room Session Chair: Hannu-Matti Järvinen
9:00am - 10:00am	Sustainability - Student Perceptions
EQ-204 Flat Room	Location: EQ-204 Flat Room Session Chair: Jye Benjamin O'Sullivan
9:00am - 10:00am	Engagement - Society and Communities
EQ-112 Flat Room	Location: EQ-112 Flat Room Session Chair: Diana Adela Martin
9:00am - 10:00am	Climate Change and Sustainability 3
EQ-208 Flat Room	Location: EQ-208 Flat Room Session Chair: Raffaella Manzini
9:00am - 10:00am	Engagement with Industry and Innovation 2
EQ-117 Tiered Room	Location: EQ-117 Tiered Room Session Chair: Patrick Flynn
9:00am - 10:00am	Innovation in T&L 2 - Interdisciplinarity
EQ-118 Tiered Room	Location: EQ-118 Tiered Room Session Chair: Siara Isaac
10:00am - 10:30am	Refreshment Break 12-1
Front Atrium & Back Atrium	Location: Front Atrium & Back Atrium
10:30am - 11:30am	Parallel Workshops 2-10
EQ-112 Flat Room	Location: EQ-112 Flat Room
10:30am - 11:30am	Parallel Workshops 2-11
EQ-116 Flat Room	Location: EQ-116 Flat Room
10:30am - 11:30am	Parallel Workshops 2-12
EQ-203 Flat Room	Location: EQ-203 Flat Room
10:30am - 11:30am	Parallel Workshops 2-13
EQ-207 Technology Room	Location: EQ-207 Technology Room
10:30am - 11:30am	Parallel Workshops 2-14
EQ-208 Flat Room	Location: EQ-208 Flat Room
10:30am - 11:30am	Parallel Workshops 2-15
EQ-211 Flat Room	Location: EQ-211 Flat Room
10:30am - 11:30am	Parallel Workshops 2-16
EQ-212a-d (All)	Location: EQ-212a-d (All)
10:30am - 11:30am	Parallel Workshops 2-17
EQ-315 Flat Room GD	Location: EQ-315 Flat Room GD
10:30am - 11:30am	Parallel Workshops 2-18
EQ-113 Flat Room	Location: EQ-113 Flat Room
11:30am - 1:00pm	Plenary Panel Session - Which Engineering is Needed for AI?
EQ-010 Performance Hall & EQ-002 Lecture Hall	Location: EQ-010 Performance Hall & EQ-002 Lecture Hall
1:00pm - 2:30pm	Lunch All Delegates
Front Atrium / Reception	Location: Front Atrium / Reception
1:00pm - 2:30pm	Lunch for Deans of Engineering
EQ-113 Flat Room	Location: EQ-113 Flat Room
2:30pm - 3:30pm	Learning Supports for Students
EQ-002 Lecture Hall	Location: EQ-002 Lecture Hall Session Chair: Deolinda Maria L. Dias Rasteiro
2:30pm - 3:30pm	Engineering Ethics Education 2
EQ-116 Flat Room	Location: EQ-116 Flat Room Session Chair: Fiona Truscott
2:30pm - 3:30pm	EDI 4 - Inclusivity and Design
EQ-211 Flat Room	Location: EQ-211 Flat Room Session Chair: Helena Kovacs
2:30pm - 3:30pm	

EQ-203 Flat Room	Virtual and Remote Education Post Covid 4 Location: EQ-203 Flat Room Session Chair: Eugene Coyle
2:30pm - 3:30pm	Climate Change and Sustainability 4 Location: EQ-204 Flat Room Session Chair: Domhnall Ó Sioradáin
EQ-204 Flat Room	
2:30pm - 3:30pm	Engineering Graduate Attributes 1 - Transversal Skills Location: EQ-112 Flat Room Session Chair: Kevin Gaughan
EQ-112 Flat Room	
2:30pm - 3:30pm	Mathematics and Sciences 1 Location: EQ-208 Flat Room Session Chair: Ann Marie F McKeon
EQ-208 Flat Room	
2:30pm - 3:30pm	Innovation in T&L 3 - Sustainability Location: EQ-117 Tiered Room Session Chair: Uchenna Sampson Igwe
EQ-117 Tiered Room	
2:30pm - 3:30pm	Transformative Experiences in Teaching Location: EQ-118 Tiered Room Session Chair: Mike Murphy
EQ-118 Tiered Room	
3:30pm - 4:00pm	Refreshment Break 12-2 & Group Picture Location: Front Atrium & Back Atrium
Front Atrium & Back Atrium	
4:00pm - 5:30pm	SEFI General Assembly Location: EQ-002 Lecture Hall
EQ-002 Lecture Hall	

Date: Wednesday, 13/Sept/2023

7:45am - 9:00am	Welcome Registration & Info Desk Location: Front Atrium / Reception
Front Atrium / Reception	
8:00am - 9:00am	Engineering Graduate Attributes 2 - Competency, Policy and International Outlook Location: EQ-002 Lecture Hall Session Chair: Eugene Coyle
EQ-002 Lecture Hall	
8:00am - 9:00am	Problem and Challenge Based Learning 1 Location: EQ-116 Flat Room Session Chair: Raffaella Manzini
EQ-116 Flat Room	
8:00am - 9:00am	Innovation in T&L 4 - Assessment Methods Location: EQ-211 Flat Room Session Chair: Greet Langie
EQ-211 Flat Room	
8:00am - 9:00am	Work Based and Experiential Learning Location: EQ-203 Flat Room Session Chair: Donal McHale
EQ-203 Flat Room	
8:00am - 9:00am	Interdisciplinarity in Engineering Location: EQ-204 Flat Room Session Chair: Jye Benjamin O'Sullivan
EQ-204 Flat Room	
8:00am - 9:00am	Teacher Training and Development Location: EQ-112 Flat Room Session Chair: Cian Farrell
EQ-112 Flat Room	
8:00am - 9:00am	MATLAB Workshop Enhance and Scale Engineering Education with MATLAB
8:00am - 9:00am	Workshop Unassigned 3-02
8:00am - 9:00am	Workshop Unassigned 3-03
9:00am - 10:00am	Plenary Keynote by Professor Anette Kolmos - Interdisciplinary Projects – Moving From Transfer To Transformation In Learning Location: EQ-010 Performance Hall & EQ-002 Lecture Hall
EQ-010 Performance Hall & EQ-002 Lecture Hall	
10:00am - 10:30am	Poster Pitch Location: EQ-010 Performance Hall & EQ-002 Lecture Hall
EQ-010 Performance Hall & EQ-002 Lecture Hall	
10:30am - 11:00am	

Front Atrium & Back Atrium	Refreshment Break 13-1 Location: Front Atrium & Back Atrium
11:00am - 12:00pm EQ-002 Lecture Hall	Sustainability in Engineering Education 2 Location: EQ-002 Lecture Hall Session Chair: Waqas Saleem
11:00am - 12:00pm EQ-116 Flat Room	EDI 5 - Background and Belonging 2 Location: EQ-116 Flat Room Session Chair: Sophia Economides
11:00am - 12:00pm EQ-211 Flat Room	Innovation in T&L 5 - Student Engagement and Feedback Location: EQ-211 Flat Room Session Chair: Paul Francis Leamy
11:00am - 12:00pm EQ-203 Flat Room	Competencies for Lifelong Learning Location: EQ-203 Flat Room Session Chair: Sonia M. Gomez Puente
11:00am - 12:00pm EQ-204 Flat Room	Education with Artificial Intelligence 2 Location: EQ-204 Flat Room Session Chair: Diana Adela Martin
11:00am - 12:00pm EQ-112 Flat Room	Engineering Skills 1 Location: EQ-112 Flat Room Session Chair: Uchenna Sampson Igwe
11:00am - 12:00pm EQ-208 Flat Room	Problem and Challenge Based Learning 2 Location: EQ-208 Flat Room Session Chair: Emanuela Tilley
11:00am - 12:00pm EQ-117 Tiered Room	Technology for Support of Teaching and Learning Location: EQ-117 Tiered Room Session Chair: Colm O'Kane
11:00am - 12:00pm EQ-118 Tiered Room	Engineering Students - Self Development 1 Location: EQ-118 Tiered Room Session Chair: Kevin Gaughan
12:00pm - 2:00pm EQ-212a-d (All)	Poster Session Location: EQ-212a-d (All)
12:15pm - 1:15pm EQ-002 Lecture Hall	Student Perspective Location: EQ-002 Lecture Hall
1:15pm - 2:30pm EQ-110 and EQ-111	Lunch Corporate Partners Location: EQ-110 and EQ-111
1:15pm - 2:30pm Front Atrium & Back Atrium	Lunch All Delegates Location: Front Atrium & Back Atrium
2:30pm - 3:30pm EQ-116 Flat Room	Parallel Workshops 3-01 Location: EQ-116 Flat Room
2:30pm - 3:30pm EQ-211 Flat Room	Parallel Workshops 3-02 Location: EQ-211 Flat Room
2:30pm - 3:30pm EQ-203 Flat Room	Parallel Workshops 3-03 Location: EQ-203 Flat Room
2:30pm - 3:30pm EQ-113 Flat Room	Parallel Workshops 3-04 Location: EQ-113 Flat Room
2:30pm - 3:30pm EQ-315 Flat Room GD	Parallel Workshops 3-05 Location: EQ-315 Flat Room GD
2:30pm - 3:30pm EQ-112 Flat Room	Parallel Workshops 3-06 Location: EQ-112 Flat Room
2:30pm - 3:30pm EQ-208 Flat Room	Parallel Workshops 3-07 Location: EQ-208 Flat Room
2:30pm - 3:30pm EQ-204 Flat Room	Parallel Workshops 3-08 Location: EQ-204 Flat Room
2:30pm - 3:30pm EQ-207 Technology Room	Parallel Workshops 3-09 Location: EQ-207 Technology Room

3:30pm - 4:00pm	Refreshment Break 13-2 Location: Front Atrium & Back Atrium
4:00pm - 5:00pm	Sustainability - Pedagogy and Programme Design Location: EQ-002 Lecture Hall Session Chair: Fiona Truscott
4:00pm - 5:00pm	EDI 6 - Identity and Cognition Location: EQ-116 Flat Room Session Chair: Natascha van Hattum-Janssen
4:00pm - 5:00pm	Climate Change and Sustainability 5 Location: EQ-211 Flat Room Session Chair: Waqas Saleem
4:00pm - 5:00pm	Mathematics and Sciences 2 Location: EQ-203 Flat Room Session Chair: Deolinda Maria L. Dias Rasteiro
4:00pm - 5:00pm	Innovation in T&L 6 - Student Centered Learning Location: EQ-204 Flat Room Session Chair: Joseph Little
4:00pm - 5:00pm	Continuing and Lifelong Learning Location: EQ-112 Flat Room Session Chair: Keith Martin Sunderland
4:00pm - 5:00pm	Engagement with Industry and Innovation 3 Location: EQ-208 Flat Room Session Chair: Janusz Szpytko
4:00pm - 5:00pm	Engineering Skills 4 Location: EQ-117 Tiered Room Session Chair: Helena Kovacs
4:00pm - 5:00pm	Teaching Technical and Digital Skills Location: EQ-118 Tiered Room Session Chair: Henning Meyer
7:00pm - 11:30pm	Gala Dinner, Leonardo da Vinci and Maffioli Awards Location: Royal Dublin Society

Date: Thursday, 14/Sept/2023

8:30am - 9:00am	Welcome Registration & Info Desk Location: Front Atrium / Reception
9:00am - 10:00am	Virtual and Remote Education Post Covid 3 Location: EQ-002 Lecture Hall Session Chair: Joseph Little
9:00am - 10:00am	Health and Well Being Location: EQ-116 Flat Room Session Chair: Sharon Feeney
9:00am - 10:00am	Innovative in T&L 7 - Teaching Skills Location: EQ-211 Flat Room Session Chair: Michael Carr
9:00am - 10:00am	Climate Change and Sustainability 6 Location: EQ-203 Flat Room Session Chair: Emanuela Tilley
9:00am - 10:00am	Teaching Professional Skills Location: EQ-204 Flat Room Session Chair: David Kennedy
9:00am - 10:00am	Engineering Skills 2 - Self Reflection Location: EQ-112 Flat Room Session Chair: Tinne De Laet
9:00am - 10:00am	EDI 7 - Recruitment and Student Experiences Location: EQ-208 Flat Room Session Chair: Michelle Therese Looby
9:00am - 10:00am	Engineering Skills 3 - Sustainability Location: EQ-117 Tiered Room Session Chair: Keith Martin Sunderland
9:00am - 10:00am	Engineering Students - Self Development 2 Location: EQ-118 Tiered Room Session Chair: Greet Langie

<p>10:00am - 11:00am EQ-010 Performance Hall & EQ-002 Lecture Hall</p>	<p>Plenary Keynote by Professor Ed Byrne - Contemporary Landscape, Drivers and Developments in Engineering Education for Sustainability Location: EQ-010 Performance Hall & EQ-002 Lecture Hall</p>
<p>11:00am - 11:30am</p>	<p>Best Papers Committee Meetings</p>
<p>11:00am - 11:30am Front Atrium & Back Atrium</p>	<p>Refreshment Break 14-1 Location: Front Atrium & Back Atrium</p>
<p>11:30am - 12:30pm</p>	<p>Best Papers Awards and Closing Ceremony</p>
<p>12:30pm - 2:00pm Front Atrium & Back Atrium</p>	<p>Lunch All Delegates Location: Front Atrium & Back Atrium</p>

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Presentations

Plenary 1: Plenary Panel Session - Recent trends in Engineering Education Research - How to support change and inclusive futures in engineering education?

Time: Monday, 11/Sept/2023: 9:30am - 10:30am · Location: EQ-010 Performance Hall & EQ-002 Lecture Hall

Recent trends in Engineering Education Research - How to Support Change and Inclusive Futures in Engineering Education?

Johri, Aditya

George Mason University

Convened and Moderated by **Professor Aditya Johri** with Panel Members; **Professor Kristina Edström, Dr Diana Martin, Professor John Mitchell and Professor Bill Williams**

Recent trends in Engineering Education Research - How to Support Change and Inclusive Futures in Engineering Education?

The panel aims to bring to the attention of the SEFI community recent trends in engineering education research (EER) and discuss their role in supporting change. Prompted by the launch of the International Handbook of Engineering Education Research, panelists will discuss ways to document the teaching and implementation of engineering education via research and how research can contribute to strengthening engineering education and promoting sustainable change. The panelists will discuss issues such as:

- What constitutes a contribution to the field of engineering education research? What counts as knowledge? Who gets to create and disseminate new ideas and knowledge?
- How does the community translate new knowledge based on EER to actual practice of improving education?
- What is the status of EER in engineering programs in Europe? How can EER gain legitimacy and improve its visibility or status in engineering programs?
- What can we say about where the field needs to go next? What is missing?

Aditya Johri is Professor of Information Sciences & Technology and Director of Technocritical Research in AI, Learning & Society Lab (trailsLAB) at the College of Engineering and Computing at George Mason University, USA. He studies how technology shapes learning across formal and informal settings and the ethical implications of using technology. He publishes broadly in the fields of engineering and computing education, educational technology, and computer-supported collaborative work and learning and is the editor of International Handbook of Engineering Education Research (IHEER) (Routledge/ 2023). His research has been recognized with several best paper awards and his co-edited volume, the Cambridge Handbook of Engineering Education Research (CHEER), received the 2015 Best Book Publication Award from Division I of AERA. He served as a Fulbright-Nokia Distinguished Chair in ICT at Aalto University, Finland (2021) and is a past recipient of the NSF Early Career Award (2009). He received the University Teaching Excellence Award (2002) and Mentoring Excellence Award (2022) for undergraduate research at George Mason University. He was awarded a Ph.D. in Learning Sciences & Technology Design (2007) from Stanford University, Palo Alto, CA. More information is available at: <http://mason.gmu.edu/~johri>

Kristina Edstrom is Associate Professor in *Engineering Education Development* at KTH Royal Institute of Technology, and Editor-in-Chief of the *European Journal of Engineering Education*. She is active in educational development and research at KTH, in Sweden and internationally. Her research takes a critical perspective on the *why, what and how* of engineering education development.

Diana Adela Martin has a PhD in Engineering Education (TU Dublin) and is currently an educational researcher at TU Eindhoven. Her research examines how ethics, sustainability, and societal responsibility are taught and implemented in the engineering curricula, with a focus on real-life educational settings. In Romania, Diana founded an educational NGO (2008-2015) which fostered cooperation between academia and the private sector, and in 2015 was selected by the European Forum Alpbach as one of Europe's innovators in tackling inequality in education. Diana is the co-chair of the Ethics Special Interest Group of SEFI – The European Society for Engineering Education (2022-25) and the Europe board representative in REEN – The Research Network in Engineering Education (2022-26). Diana serves also as an Associate Editor for the *European Journal of Engineering Education, Science and Engineering Ethics* and the *International Handbook of Engineering Education Research*.

John E. Mitchell is Professor of Communications Systems Engineering in the UCL Department of Electronic and Electrical Engineering and Co-director of the UCL Centre for Engineering Education. Between 2012 and 2016 he was on secondment to the UCL Engineering Sciences Faculty office, where he led the introduction of the Integrated Engineering Programme, a major revision of the curriculum across the engineering faculty. In 2018 he was part of the team that was awarded the HEA Collaborative Award for Teaching Excellence (CATE). He has published widely on curriculum development, active learning and issues of diversity within engineering education. From 2015 to 2022 he was Vice-Dean Education of the UCL Faculty of Engineering Sciences. Professor Mitchell is a Chartered Engineer, Fellow of the Institution of Engineering and Technology (IET), Senior Member of the Institute of Electrical and Electronics Engineers (IEEE), Principal Fellow of the Higher Education Academy, President of the UK's Engineering Professors' Council, Vice-President Publications of the IEEE Education Society and was until recently a Member of the Board of Directors of the European Society for Engineering Education and Editor-in-Chief of the IEEE Transactions on Education.

Bill Williams is a researcher at CEGIST, the Centre for Management Studies of Instituto Superior Técnico, University of Lisbon, is *Professor Jubilado* of Setúbal Polytechnic Institute, Portugal, and Adjunct Senior Research Fellow at TUDublin, Ireland. He originally trained as a chemist at UCC, National University of Ireland and went on to work in education in Ireland, UK, Eritrea, Kenya, Mozambique, and Portugal. He serves as an associate editor of the *European Journal of Engineering Education* (EJEE) published by the European Society for Engineering Education (SEFI) and senior associate editor for the *Journal of Engineering Education* (JEE) published by the American Society for Engineering Education (ASEE). He was lead editor of "Engineering Practice in a Global Context, Understanding the Technical and the Social" an edited volume published by Routledge in 2014. He is a founder member of the Portuguese Society for Engineering Education (SPEE) and is active in SEFI special interest groups on Engineering Education Research and on Diversity and Inclusion.

ORCID: <https://orcid.org/0000-0003-1604-748X>

Paper Session 1-01: EDI 1 - Background and Belonging 1

Time: Monday, 11/Sept/2023: 11:00am - 12:00pm · Location: EQ-002 Lecture Hall
Session Chair: Ines Direito

Exploring racialized ideologies about Latino/a/x Engineering Students in the United States Southwest Region

Mejia, Joel Alejandro

The University of Texas at San Antonio, United States of America

Although efforts in the United States (U.S.) to improve the participation and representation of minoritized populations in engineering have increased, there is a stagnant representation of Latinos/as/xs in engineering spaces. Given that a historical context of engineering education for Latinos/as/xs in the U.S. is limited in the engineering education research literature, this paper provides a description of the historical educational landscape of Latinos/as/xs in the U.S. Southwest region and connects that sociohistorical context to the current realities of Latinos/as/xs in the region through their *testimonios*. The U.S. Southwest is home to the largest Latino population in the U.S., who also happen to be predominantly, and historically, Mexican and Mexican American. Thus, this research paper focuses primarily on this region since it is also the location where most of the Latino/a/x engineering students reside and attend school. This paper draws from the theoretical framework of racialization to explore the ways in which racialized ideologies about Latinos/as/xs emerged from an orchestrated process of Americanization, linguistic violence, and deficit thinking that continues, to this day, to impact Latino/a/x engineering students. Implications of this study suggest that recognizing the role of racialized ideologies in shaping engineering education spaces may serve to help engineering educators identify the ways in which historical and sociopolitical forces are (re)enacted, perpetuated, but also challenged.

Making meaning together: An autoethnography study on our role in ethics education

Bairaktarova, Diana¹; Lhotska, Lenka⁴; Moktefi, Amirouche³; Pevkur, Aive³; Vică, Constantin²

¹Virginia Tech, United States of America; ²University of Bucharest, Romania; ³Tallinn University of Technology, Estonia; ⁴Czech Technical University in Prague, Czechia

Representation of diverse people's perspectives, cultures, and ideas enriches societies. Equally important for communities to flourish is to have diverse perspectives on what good ethics education is. For 50 years the European Society of Engineering Education (SEFI) has been uniting and supporting engineering educators and researchers from around the globe and particularly from Europe. However, involvement from institutions in Eastern Europe is still very low. To diversify and strengthen the community by bringing perspectives from these countries, we engaged in an autoethnography study to share insights on participation barriers broadly and ethics education, more specifically. We choose autoethnography as this methodology allows researchers not only to share their own experiences but to connect in making meaning of a phenomena and to form a community of practice. The researchers and authors of this paper are representing STEM institutions in three Eastern European countries. Applying an interactionist approach, we engaged in a community of practice group to discuss the current state of the art of ethics education in our own institutions and to talk about the experiences with ethics education, academic integrity, and ethics culture. We collectively selected an appropriate framework and applied that framework to interpret the findings. Transcripts were analysed by all five researchers. The paper and the presentation will be presented together as a narrative story. The goal of this work is to form a community of practice and to create an agenda to engage the newly formed community of practice with the broader SEFI ethics education community.

Disruptions to the "Modeled Minority" in Engineering: Why Do Some Asian American Students Leave Engineering?

Ausman, Michelle Choi; Zhu, Qin

Virginia Tech, United States of America

Asian American students are the largest non-White racial group in US undergraduate engineering, though they are still considered members of a unique minority population - the "model minority." However, scholars in Asian American studies continue to disrupt the norms placed on Asian American students. And with the stereotypes of Asians as geeks and doctors, Asian American students are typically boxed into STEM-oriented majors. The model minority myth and the overrepresentation concern challenging Asian American engineering students has limited their access to diversity, equity, and inclusion (DEI) programs. One overlooked aspect of DEI in engineering is why some Asian American students leave engineering. While there have been limited studies in both engineering education and the social sciences regarding Asian American student experiences in engineering, even less attention has been brought to why some Asian American students leave engineering.

This pilot study aims to explore the paths some Asian American students took in deciding to leave either the field of engineering or engineering as a major. Semi-structured interviews are utilized to capture and center students' experiences as first-hand accounts as to why these students leave engineering. This paper concludes with recommendations for engineering education and faculty, administrators, and staff for better supporting Asian American students during their journeys in engineering. This presentation will contribute to the scholarship in engineering education that explores the diverse experiences of Asian American students in engineering and more authentic approaches to the creation of inclusive learning environments for students from all backgrounds.

Sense of belonging among technology students in Finland

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This paper examines Finnish technology students' belonging in technology. The phenomenon is studied at the level of the field (belonging in the field of technology) and at the level of institution (belonging in one's study community). The data were collected within the annual student survey conducted by a professional organization for academic engineers in 2022, and analysed statistically. Results suggest that men strongly experience they belong in technology while women express some doubts, and non-binary respondents are even less certain of their belonging. Gender differences in belonging in the field of technology are more prominent than those of belonging in the student community.

Paper Session 1-02: Fostering Engineering Education Research 1

Time: Monday, 11/Sept/2023: 11:00am - 12:00pm · Location: EQ-116 Flat Room
Session Chair: Catherine Deegan

PREP - Pragmatic Research on Educational Practice

Benchmark, Samuel^{1,2}; Fainsilber, Laura^{1,2}; Olsen, Jan-Fredrik³; Sande, Olow⁴

¹Chalmers University of Technology, Sweden; ²University of Gothenburg, Sweden; ³Lund University, Sweden; ⁴Umeå University, Sweden

Ambitious university teachers often try things in their teaching and strive to understand the effect of the changes, but they often do not write about it. Hence, their ideas and lessons learned only reach their closest colleagues. We investigate if there is a need for new ways to encourage and support teaching practitioners in researching their teaching and sharing what they find. For this, we suggest a program named PREP – Pragmatic Research on Educational Practice (<https://research.chalmers.se/publication/532950>) with the goal of supporting university teachers to share their pedagogical ideas and experiments so that they collectively can learn and build on what is done by others. This concept is compared to other methodologies where the researcher and educational practitioner sometimes coincide, such as Design-Based Research, Design Experiments, Design Research, and Action Research and the relation to proven experience. Using a questionnaire and focus group discussion (n=20), we investigate what university teachers in engineering think hinders them from researching their teaching practice and to what extent they find the ideas from the PREP program supportive in studying their educational experiments and sharing what they do and find.

Who funds engineering education research? Content analysis of funding sources described in three top-tier engineering education research journals

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¹The University of Melbourne; ²UCL, London, UK; ³CEGIST, University of Lisbon; ⁴TUDublin

Engineering education research (EER) is becoming a globally connected field of inquiry but there is a lack of sustained funding opportunities available. Currently, it is not quantitatively known which entities are most prolific for providing funding for EER globally. This study attempted to map which entities were most commonly cited as providing funding for EER. Three top-tier EER journals were chosen, articles published in the journals during 2021 were identified. Metadata about each publication was downloaded from Scopus. Funding information for each publication was qualitatively analysed, then synthesised to provide a quantitative understanding of EER funding sources. There was a notable discrepancy between Europe and the USA. Many USA articles secured funding primarily from the National Science Foundation, whereas European articles were more likely to report funding from a range of different sources, including EU programs, state and national governments. This suggests that EER is given a higher priority in the United States and that the majority of this funding is channelled through the NSF. This has implications that growth of EER outside of USA may be restricted by limited funding opportunities.

Unlocking Deeper Insights: A Qualitative Approach to Evaluating STEM Outreach in Engineering Education

Wang, Yiduo; Schrock, Lauren; Andrews, Jane; Clark, Robin

University of Warwick, United Kingdom

Much previous research and evaluation has been conducted of STEM Outreach activities in schools using quantitative approaches. Surveys in particular are popular as they are low-cost and time-saving. However, quantitative methods are limited in that they do not generally generate deeper insights into students' experiences in STEM; usually lacking rich detail about the context and complexity of the data being analysed. Hence, this paper proposes a different approach to evaluating STEM outreach: a unique multi-method, qualitative approach.

Starting with the Research Question "How to qualitatively evaluate STEM outreach in Engineering Education?", this paper is grounded in ongoing doctoral research that addresses a substantial gap in knowledge pertaining to how STEM outreach is evaluated. This methodological gap became apparent during the Pandemic when STEM activities were offered, yet there was not a robust way of evaluating the children's experiences. This paper outlines a qualitative research design that employs a Multiple Case Study approach with Grounded Theory. It argues that a qualitative design can be used to acquire an in-depth understanding of data that is both insightful and unique. The paper adds to knowledge in the area of methodological design within engineering education research, and such data can then be used to inform the provision of future STEM outreach. Furthermore, the researcher's ongoing fieldwork experience is also reflected to identify the unique challenges in the methodology execution. The insights on how to address these challenges can support academics in Engineering Education Community to engage in qualitative research.

Epistemologies of Assessment Instruments

Fenner, Raenita¹; O'Neill, Peggy¹; Douglas, Kerrie²; Douglas, Elliot P.³

¹Loyola University Maryland; ²Purdue University; ³University of Florida

Understanding our epistemological perspective when conducting engineering education research is important for situating the knowledge claims we are making. Depending on that perspective, we may situate the knowledge claims as definitive, representing an absolute Truth, or as contingent, representing a contextualized truth. Traditionally, quantitative research has been identified as positivist, while qualitative research is diverse in its epistemological assumptions, ranging from positivist to interpretivist to Critical and the "posts." Thus, results from quantitative studies are often treated as generalizable, absolute, and decontextualized, while qualitative studies are treated as particular, contingent, and contextualized.

Assessment instruments, being quantitative, are associated with positivist forms of knowledge. We argue that it is more appropriate to treat quantitative assessments as interpretivist. Development of assessments is based on particularized knowledge that is created through a dialogue between the developers and the pilot participants. Interpretation of assessment results is dependent on the particular contexts in which they are used.

In this paper we describe the interpretivist roots of assessment using the example of our current project on developing an instrument for engineering quantitative literacy. In the first phase of this project we have used qualitative content analysis to identify the ways in which quantitative literacy is assessed in first-year engineering courses in the United States. This analysis is contextualized by the particulars of these courses, and the results are contingent on the interpretations we make as researchers. We discuss how this interpretivist perspective carries through the entire project as we create and implement a quantitative instrument.

Paper Session 1-03: Teamwork and Team Projects 1

Time: Monday, 11/Sept/2023: 11:00am - 12:00pm · Location: EQ-211 Flat Room
Session Chair: Tinne De Laet

Developing teamwork skills through simultaneous group project courses

Eloranta, Tuomo

Aalto University, Finland

Popularity of project-based learning (PBL) has led to a situation where engineering students take several group project courses at the same time. From student perspective this can generate considerable issues. Previous research has indicated that already single PBL courses can be challenging especially time and task management-wise and intuitively overlapping PBL courses compound this complexity. As existing literature on this topic is relatively sparse, the goal of the present study is to examine what kind of student challenges simultaneous PBL courses generate, how students navigate those and what kind of additional learning can it foster. The results should help PBL course teachers to consider the impact of overlapping PBL courses from student perspective and provide better support for them.

FROM GROUP WORK TO TEAM WORK: COMPARATIVE ANALYSIS IN THREE EUROPEAN INSTITUTIONS

Lermigeaux-Sarrade, Isabelle¹; Sarrade, Jean-Luc²; Perrin, Stephane³; Cimpan, Sorana³

¹EPFL, Switzerland; ²HES-SO (HEG), Switzerland; ³Univ Savoie Mont-Blanc, LISTIC, France

Addressing the complex challenges of sustainability demands for good teamwork abilities for future technicians and engineers. In our three institutions we adopted project-based learning to facilitate the development of these skills – but is this enough? Since group project-based learning involves dealing with complex technical tasks and at the same time learning to work as a team, we wondered how students handle this double challenge. By analysing their perceptions, we attempt to identify what teaching practices could be helpful to shift their experience from groupwork to effective teamwork.

In this paper, we present the differences and similarities in the way we implement group projects in our respective institutions. A common questionnaire was proposed to our students capturing their perception 1) of the value of group project learning, 2) of their ability to carry out such projects in the future, 3) of the group perception of a shared goal and 4) of the quality of interpersonal relations within their group. Finally, we present the results of this first iteration of data collection showing different group profiles. We discuss the teaching practices that may contribute to sustain students' motivation for groupwork and their confidence in their ability to achieve complex team projects, first in their academic context and then when facing challenges in their future employment within a changing world.

Exploring women's teamwork experiences in engineering education: a phenomenological analysis

Cruz Moreno, Sandra Ileri; Chance, Shannon; Bowe, Brian

Technological University Dublin, Ireland

Teamwork, project or problem based learning, and other collaborative learning strategies are often presented as approaches that benefit women and other minorities during their studies in Science and Engineering fields of education. This is based on the assumption that underrepresented groups will respond positively to the social integration and cooperation encouraged by these learning methods. However, research also shows that gendered stereotypical presuppositions about attributes and interests can influence the performance of team members and the tasks developed, potentially providing opportunities to sexism, racism, and other exclusionary social behaviours.

In this context, this paper describes a piece of an on-going research project that examines the experiences of women studying engineering and the extent to which collaborative learning methods have supported their education. The study utilizes phenomenology as the primary methodological framework for data collection and analysis. The paper provides a description of the methodology employed, drawing on a subset of data from 22 college students who were interviewed.

Insights gained from narratives on group work by women studying engineering at a university in Ireland offer valuable perspectives on their lived experiences, allowing for a reassessment of the effectiveness of certain collaborative learning practices. Furthermore, as phenomenological research has become increasingly popular in Engineering Education Research (EER), this paper contributes to the refinement of methodologies for EER scholarship.

Paper Session 1-04: Virtual and Remote Education Post Covid 1

Time: Monday, 11/Sept/2023: 11:00am - 12:00pm · Location: EQ-203 Flat Room
Session Chair: Louise Lynch

Rethinking Evolution of Active Learning in the Hybrid/Online Engineering Education in the Post-COVID-19 Era: A quantitative keyword co-occurrence analysis

Xu, Yiwen; Piyatamrong, Thitiwat; Nyamapfene, Abel
Centre for Engineering Education, UCL, United Kingdom

In response to COVID-19, education witnessed a rapid shift to online and virtual platforms, our previous research raised questions about the efficacy of these methods for hands-on practice and active learning experiences - crucial elements of engineering education. Emergent solutions like online laboratories and virtual field trips have led to the rise of a hybrid learning era in the post-pandemic context. This change necessitates a reassessment of active learning in hybrid/online engineering education. In this study, we examine recent literature on online and virtual education during and post-COVID-19 to redefine and reevaluate strategies for engaging students actively. We propose using VOSViewer to analyze the occurrence of keywords in post-COVID-19 literature to define a visualization between the interests in research and the content of key papers in situating active learning for hybrid/online education. We analyze the evolution of active learning theory, outline its characteristics in the new era, and propose a literature review focusing on how digital technology can synergize with learning approaches to foster active learning. We also address concerns related to hands-on practice and active learning and discuss innovations developed to mitigate these challenges. Our goal is to provide fresh insights and stimulate further research on enhancing active learning within hybrid/online engineering education in the post-pandemic era.

Generation Z and their use of learning management system in programming courses

Schultz, Ole; Blaszczyk, Tomasz
DTU Engineering Technology and Didactics, Denmark

Generation Z students have grown up with ICT (information and communication technology) and are therefore used to being online more or less simultaneously on different types of media. Universities have different kinds of Learning Management Systems (LMS) with different possibilities for engagement. In the Electrical Engineering B. Eng. program at the Technical University of Denmark (DTU) we use a system called Learn. It has features for setting up individual study plans as well as common plans. Features such as surveys, quizzes, peer reviews are built in. We are interested in the students' use of the LMS, their engagement and the relation to their achievement in the examination. The research questions we would like to answer are: How much do the students use Learn? What kind of materials do the students prefer? Is there any correlation between the use of materials on Learn and the grade? Is there any correlation between the score in quizzes and the grade? In this paper, we would like to describe and compare how much students use the materials in two different courses on the 2nd semester Digital Electronics and Programming (id 62734) and on the 4th semester Digital Design (id 62711). To answer these questions, we use data from Learn. And we conduct two qualitative surveys, one about students' motivation, (Sekala, A et. al, 2023) and the other one as a part of the final course-evaluations in spring 2023.

Transforming curriculums for an age of multi-modal education: a 5-phase approach

Blanford, Justine I.; Verplanke, Jeroen
University of Twente, Netherlands, The

The pandemic has accelerated the trend towards online and hybrid learning with many educational institutes pivoting their education to online learning environments and has subsequently transformed societal expectations. There have been many benefits associated with these changes (e.g., multi-dimensional interactions, flexibility and deep learning). As we move into more online education due to changing needs and demands from students, how best to adapt our education for multi-modal learning environments can be a challenge. Getting our education ready for a multi-modal age is bringing about disruptive changes forcing us to rethink what we teach and how we teach it. **Thus, the objective of this paper is to present a framework that will allow for the evaluation of curriculums and enable educators to create sustainable, flexible educational environments relevant for multi-modal learning environments while remaining at the forefront of educational needs.** In this paper, we present the 5-phase approach that we used to assess our programme and redesign our curriculum. The five phases include: Inventory, Analysis, Evaluation, Design and Implementation. We will present the highlights from our experience and the challenges we have had to overcome. The framework that we present is applicable to different computer science, spatial and data engineering programmes that require a mix of theoretical and hands-on practicals.

Digital learning resources, hybrid teaching and remote students - are our students actively engaged?

Bjørnland, Thea
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At the Norwegian University of Science and Technology, a new cross-campus statistics course for approximately 1000 engineering students was planned for the fall of 2020. Due to the pandemic, digital learning resources were developed to allow students to work from home or campus, individually or collaboratively. These resources include short learning videos, automatically graded exercise sets, and Jupyter Notebooks for Python coding. Since 2020, digital learning resources have been essential for teaching statistics to engineering students across three campuses, and remotely. To help students navigate digital resources, on-campus activities, and assessments, each week of the semester was structured according to specific learning paths. However, asking the students to watch videos and work on exercises before on-campus or digital lectures is no guarantee that they will do so. For this study, we use video and assessment statistics, along with survey results, to determine to what extent the proposed learning paths were followed and the perceived usefulness of the various elements that make up a learning path. In surveys, the engineering students at the Norwegian University of Science and Technology report great satisfaction with videos and digital assignments (along with scaffolding exercises) in the statistics course. By utilising digital user statistics, we observe patterns of engagement with digital resources that are closely tied to the proposed learning paths.

Paper Session 1-05: Climate Change and Sustainability 1

Time: Monday, 11/Sept/2023: 11:00am - 12:00pm · Location: EQ-204 Flat Room

Session Chair: Klara Kövesi

A crazy little thing called sustainability

Steuer-Dankert, Linda

FH Aachen University, Germany

Achieving the 17 Sustainable Development Goals (SDGs) set by the United Nations (UN) in 2015 requires global collaboration between different stakeholders. Industry, and in particular engineers who shape industrial developments, have a special role to play as they are confronted with the responsibility to holistically reflect sustainability in industrial processes. This means that, in addition to the technical specifications, engineers must also question the effects of their own actions on an ecological, economic and social level in order to ensure sustainable action and contribute to the achievement of the SDGs. However, this requires competencies that enable engineers to apply all three pillars of sustainability to their own field of activity and to understand the global impact of industrial processes. In this context, it is relevant to understand how industry already reflects sustainability and to identify competences needed for sustainable development.

This article therefore first presents an explorative qualitative study that provides information on the extent to which sustainability is addressed by engineers in central management positions in German industry (focus on manufacturing sector). Results show a need for teaching concepts in which future engineers increasingly deal with sustainability concepts and the global impact of their own actions. The survey indicates that the social pillar of sustainability, in particular, is often left out of the equation and, consequently, is rarely considered in industrial sustainability efforts. Based on these findings, an interactive teaching concept is presented that uses the design thinking approach to sensitize future engineers to all three pillars of sustainability.

Sustainability Leadership for the Energy Transition: A Case Study of Role-Playing to Enhance Authentic Learning

Heynen, Anthony Paul; Tonkes, Elliot J

The University of Queensland, Australia

To lead the energy transition, effective sustainability leadership requires a spectrum of skills, knowledge and understanding across technical, financial and even political disciplines. An innovative, authentic learning initiative has been designed and implemented in which Master of Sustainable Energy students conducted team-based role-playing activities, responding to a realistic, hypothetical energy policy scenario in the form of a government announcement and other mock collateral. Groups were assigned the personas of a range of industry stakeholders and prepared presentations (and accompanying media statements and position papers) for a mock online media conference. The initiative leveraged the diversity of the cohort, enabling constructive interactions and an appreciation of the impacts of energy policy on a variety of organisations and wider society. Entry and exit surveys affirmed that participants gained a deeper understanding of key issues, constraints, alternative views and approaches involved in navigating the policy pathways to sustainability. The teaching staff also observed a high level of student engagement. Challenges of group dynamics and teaching effort were felt to be outweighed by the benefits reaped by students, particularly in terms of deeper conceptual knowledge and an understanding of perspectives in the energy transition. The case study also found that the online nature of the media conference enhanced student innovation and engagement. The framework of the case study may nudge other educators towards greater use of role-playing activities in sustainability leadership pedagogy.

Student perspectives on sustainability in Engineering Education: multiple case study of European bachelor's programs in Industrial Engineering and Management

Trigueiros, Francisca^{1,2}; Kaipainen, Jenni^{5,6}; Silva, Frederico^{1,2}; Geising, Niklas^{1,4}; Tosun, Erdem Ata^{1,3}

¹European Students of Industrial Engineering and Management; ²University of Porto; ³Bilkent University; ⁴Technical University of Kaiserslautern; ⁵Tampere University; ⁶Politecnico di Milano

The global sustainability crisis is calling for engineers to take action. To enable and empower engineers to address this crisis, there must be a change in engineering education. Given the industry's key role in not only causing but also solving this sustainability crisis, it is especially crucial to improve how sustainability is addressed in industrial engineering and management (IEM) education. This paper examines (1) to which extent European IEM degrees are covering sustainability; (2) European IEM students' motivations to learn and work with sustainability topics; and (3) their perceptions of their degree's contribution to their knowledge and motivation regarding sustainability; and (4) which sustainability-related changes they would like to see in their degrees. Three IEM curricula covering different regions of Europe—Portugal, Germany, and Turkey—were analysed. The mixed-method analysis included a quantitative evaluation of the extent to which each course meets specific theory-based learning objectives pertinent to sustainability in engineering education. The analysis was complemented by students' perspectives, which were gathered through group discussions and interviews. The results reveal how sustainability is addressed in IEM education in different European regions, its impact on students' knowledge and motivation for sustainability issues, and how sustainability in engineering education should be developed based on students' perceptions. These findings contribute to the research on sustainability in engineering education and support university teachers in revising engineering study programs to provide adequate sustainability understanding and skills to students.

Integrating Sociotechnical Issues in the Introduction to Circuits Course

Finelli, Cynthia¹; Lord, Susan²

¹University of Michigan, United States of America; ²University of San Diego, United States of America

Engineers frequently encounter sociotechnical issues in their work, so it is critical that they are prepared to address complex, real-world issues that require both technical and social expertise. Engineering accreditation criteria further underscore the importance of understanding sociotechnical issues by expecting engineering undergraduate programs to address ethical, global, cultural, social, environmental, and economic considerations in student outcomes. However, most engineering instructors were educated with a deep technical focus, have little experience outside of engineering, and feel ill-equipped to integrate non-technical topics. As a result, engineering is often taught in the undergraduate curricula from a purely technical perspective, with an emphasis on calculations and mathematical modelling, and without mention of social issues.

In this paper, we outline a new project to help engineering instructors integrate sociotechnical issues into their classrooms. Applying proven principles of backward course design and working with a team of electrical engineering graduate students, we aim to develop and test several sociotechnical modules for the Introduction to Circuits course. Each module will be linked to technical topics addressed in the course, and each will emphasize a different social issue. We will prepare detailed teaching guides so instructors can easily use the modules in their own contexts, and we will assess the effectiveness of the modules.

Paper Session 1-06: Engineering Ethics Education 1

Time: Monday, 11/Sept/2023: 11:00am - 12:00pm · Location: EQ-112 Flat Room
Session Chair: Roland Tormey

A multimodal measurement of the impact of deepfakes on the ethical reasoning and affective reactions of students

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¹The Teaching Support Center (CAPE), Ecole polytechnique fédérale de Lausanne (EPFL), Switzerland; ²Center for Digital Education (CEDE), Ecole polytechnique fédérale de Lausanne (EPFL), Switzerland; ³Center for Learning Sciences (LEARN), Ecole polytechnique fédérale de Lausanne (EPFL), Switzerland; ⁴Multimedia Signal Processing Group, Ecole polytechnique fédérale de Lausanne (EPFL), Switzerland; ⁵Institute for Digital Technology Management, Berner Fachhochschule (BFH), Switzerland

Deepfakes - synthetic videos generated by machine learning models - are becoming increasingly sophisticated. While they have several positive use cases, their potential for harm is also high. Deepfake production involves input from multiple engineers, making it challenging to assign individual responsibility for their creation. The separation between engineers and consumers may also contribute to a lack of empathy on the part of the former towards the latter. At present, engineering ethics education appears inadequate to address these issues. Indeed, the ethics of artificial intelligence is often taught as a stand-alone course or a separate module at the end of a course. This approach does not afford time for students to critically engage with the technology and consider its possible harmful effects on users. Thus, this experimental study aims to investigate the effects of the use of deepfakes on engineering students' moral sensitivity and reasoning. First, students are instructed about how to rate the technical proficiency of deepfakes and the ethical issues associated with them. Then, they watch three videos: an authentic video, a high-quality deepfake and a low-quality deepfake of the same person. While watching these videos, the data related to their attentional (eye tracking) and emotional (self-reports, facial emotion recognition) engagement is collected. Finally, they are interviewed using a protocol modelled on Kohlberg's 'Moral Judgement Interview'. The findings can have significant implications for how technology-specific ethics can be taught to engineers while providing them space to engage and empathise with potential stakeholders as part of their decision-making process.

Civil and Architectural Engineering Students' Conceptualization of Good Engineering and its Implications for Ethics Education

Polmear, Madeline

Vrije Universiteit Brussel, Belgium

There are many arguments for the integration of ethical and societal issues in engineering education. From accreditation to industry pressure to societal expectation, ethics are considered an important part of "good engineering." However, what constitutes good engineering can be ambiguous, especially for university students with limited work experience. The ways in which students conceptualize what is means to do good engineering illuminates their values and priorities and shapes their understanding of ethics in engineering. The present study is part of a larger project that is exploring civil and architectural engineering students' conceptualization of ethical and societal responsibility and its development via formal and informal learning. Data collection and analysis are ongoing in the larger project, and the present study focuses on eight interviews with civil and architectural engineering students at one university in Belgium. The semi-structured interviews were conducted in-person, recorded, and transcribed. The analysis was designed to address how civil and architectural students conceptualize good engineering and the potential role of the engineering culture in this meaning-making. The data were examined through the lens of Cech's culture of disengagement: a framing for how engineers conceptualize their professional responsibility and understand what it means to be an engineer. Findings provide some evidence of the pillars of the culture of disengagement, but also diverge in terms of students' valuation of social competencies and societal concerns in their description of good engineering. The implications raise awareness around the culture of engineering and point to students' interest in using it for community benefit.

Teaching ethics as practical reflection in a project-based engineering course

Krüger, Marcel; Jäckle, Michael; Pfaff, Felix

Karlsruhe Institute of Technology, Germany

The implementation of ethics in engineering courses is often facing several intertwined problems. For example, with widespread moral relativism, the confusion of ethics with moralism on the one hand and with pro-contra discussions on the other, a degree of abstraction being too high, or the relativization of ethics as one method for decision-making among many others. Furthermore, in many cases, ethics is suspected of being artificially introduced into engineering.

In the context of a project-based course at German university, we took up these challenges and developed an innovative teaching format having the focus not mainly on theories and methods. Instead, we implemented ethics education as a practical reflection exercise here. Based on situations in their project life, we addressed aspects of their practice in open conversations with students that tend to be overlooked under conventional conditions: boundary conditions of their engineering actions, preconditions of their judgments as well as criteria of justifications for their decisions. Instead of reacting reflexively to problems, and thus blindly accepting the problem, we wanted to enable them to critically examine. In this way, we aimed to enable the students to adopt a responsible (since reasonable) attitude toward their actions and their boundary conditions.

In our contribution, we first discuss the preconditions: the project-based four-month full-time course with an industrial partner. Second, we explain our philosophical approach and justify it. Third, we describe the realization of our approach followed by the evaluation in two cohorts since 2021. Finally, we conclude our findings and outline next steps.

A critical realist investigation into the development of engineering ethics education

Martin, Diana Adela^{1,2}; Conlon, Eddie²; Bowe, Brian²

¹TU Eindhoven, The Netherlands; ²TU Dublin, Ireland

The paper reflects on the use of critical realism as a theoretical lens for examining the provision of ethics in engineering programmes and putting forward recommendations for the development of engineering ethics education. It is based on a large scale 4-year mixed methods study in which 23 engineering programmes from 6 higher education institutions in Ireland participated. The methods used include documentary analysis of programme documents, course syllabus and accreditation reports, interviews with instructors and members of accreditation panels, participant observation at accreditation events and a descriptive statistical analysis of the numerical grade used by engineering programmes to self-assess their provision of ethics.

The paper addresses two research questions: 1) what are the key challenges in the provision of engineering ethics education, considering the 23 programmes analysed? 2) what recommendations emerge to address these challenges? To respond to the research questions, given the stratified ontology presupposed by critical realism, the research study focused on 4 different levels of analysis: individuals (engineering ethics teachers), institutions (engineering programmes) and policy (national accreditation body).

The main insight of the paper is that change strategies need to address all levels and treat them as intertwined in order to develop comprehensively the education of engineering ethics.

Paper Session 1-07: Mentoring and Tutoring

Time: Monday, 11/Sept/2023: 11:00am - 12:00pm · Location: EQ-208 Flat Room

Session Chair: Sophia Economides

Descriptions of Peer Mentors as told by Undergraduate Engineering Student Mentees

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¹Minnesota State University Mankato, United States of America; ²University of Florida, United States of America

Peer mentorship is a relationship between two people who are at a similar level. In this study, the setting is academic, namely peer mentorship amongst undergraduate engineering students. Within peer mentorship, participants aim to help one another through various activities, such as sharing information, helping motivate, providing advice, lending support, etc. The outcomes of peer mentorship are generally positive and mutually beneficial for mentors and mentees, but the focus of peer mentoring research in undergraduate engineering has primarily been focused on implementing and evaluating formalized peer mentoring efforts, not necessarily on the needs of students who may be in these relationships. To better understand students' perceptions, students at a western institution in the United States were surveyed during Fall 2020, early in the COVID-19 pandemic.

Of the 223 completed student survey responses, 79 indicated that they currently had a peer mentor when provided a definition and examples of peer mentorship. These 79 students were asked to describe their peer mentor both in terms of attributes (e.g., race, gender identity, year in school, first generational status, and major) and characteristics (e.g., enjoyment of engineering, value placed on engineering, career interests, extracurricular interests, hobbies, and effort exerted in engineering). Analysis of these student descriptions can provide recommendations of what may be important to students when finding their own peer mentors or peer mentoring advisors when attempting to formally match mentors to mentees.

Customising best practice in studies advice for undergraduate engineering students

Morgan, Margaret; Mahon, Clare; McMurray, Robert; Brown, Alan; O'Gorman, Pearse; Burke, George; Holman, Ruth; Keenan, Michaela

Ulster University, United Kingdom

The attrition rates from undergraduate engineering programmes in the UK remains stubbornly high, despite the best efforts of course teams to engage and support students on their learning journeys. It is generally accepted that there is no single reason for attrition rates from engineering programmes being higher than from other vocational-type university programmes, but many academics believe that an effective Studies Advice system that works for students and staff, could lead to reduced numbers of disengaging and/or failing students.

Much has been written on effective approaches to the provision of Studies Advice at University, but it is not clear if the implementation of discipline specific approaches would yield better outcomes.

This practice paper describes work that is currently underway at Ulster University to examine engineering students' perspectives on the Studies Advice approach and to explore how best practice in the university sector might be effectively customised for engineering students. The work describes an initial scoping study, a co-creation exercise with students to establish their baseline understanding of the current system and their 'wish-list', and a follow-up focus group session where a number of discipline-specific interventions were explored.

Preliminary findings indicate that professional support departments could be more effectively integrated with academic support to provide a wrap-around or 'single contact point' for Studies Advice, that formal organised studies advice sessions should be explicit on programme schedules and that an informal 'buddy or mentor' student-to-student support system would be beneficial in addressing the UK engineering student attrition issue.

Realising a Centre for Educational Development: Experiences, Challenges, Lessons Learnt, and Future Ambitions

Lyng, Reidar; Korpås, Guri Sivertsen; Hansen, Gabrielle; Øien, Geir Egil Dahle

Centre for Science and Engineering Education Development (SEED), Norwegian University of Science and Technology

In order to develop high-quality engineering education with a focus on students' learning and contributions to a sustainable future, academic staff must themselves develop new skills, with a lifelong learning perspective to their own teaching. This requires coordination and support. In 2016, three faculties at our university decided to jointly finance a *Centre for Science and Engineering Education Development*. Typical aims are boosting educational quality, strengthen educational competence among academic staff, and build educational quality culture on the institutional level. In our case, the three faculties recognized a need to establish a stronger and more focused didactic perspective for the university's programme portfolio in technology, engineering, and science, beyond and in addition to the general pedagogical training already offered.

The centre's main contribution has been to provide various forms of training of and teaching for employees, indirectly affecting also students' learning experiences. Strategic advice on educational change, dissemination of results, and strengthening of international and national collaborations, networks, and arenas, have been important additional tasks. This paper reflects upon the centre's strategies, results, experiences, and challenges from the centre's start-up until today. We identify important lessons learnt and propose advice for others planning to establish similar centres. Among the topics covered are the capacity and recruitment challenges, coping with diversity in faculty cultures, and the need for anchoring activities and resource usage.

Finally, we will describe a recent upscaling of the centre's mandate, responsibilities, and capacity, designed to support our university's major ongoing educational reform 'Technology Education of the Future'.

Employment Pathways for Emerging Talent: Evaluating the Certificate in Computer and Data Science (CDS)

Salazar Gomez, Andres Felipe; Baqiati, Aikaterini; Walsh, Gillian; Cook, Lana; Masic, Admir

Massachusetts Institute of Technology, United States of America

This research paper presents the results of the first evaluation of the learning experience, challenges and opportunities of the Certificate in Computer and Data Science (CDS). Specifically, it evaluates two different real-life experiential learning opportunities (ELOs): supervised internships and self-guided projects.

MIT Emerging Talent, an initiative that expands upon the efforts of the MIT ReACT (Refugee Action Hub), provides talented learners a platform to advance their skills, leverage their expertise, access a professional career, and become leading change agents in their communities. The CDS is a 12 month-long online learning program that opens education to employment pathways for emerging talent, including refugees, displaced populations, and underserved communities worldwide. The program combines rigorous academic curriculum, immersive skills workshops, networking events, mentor support, and experiential learning opportunities to provide learners with the knowledge, hands-on skills and experiences needed to accelerate their learning and professional journeys.

Quality education, work readiness, networking, and local support are critical for emerging talent to overcome the challenges they currently face and grow personally and professionally. Programs offering such opportunities and their impact are still poorly studied. In this paper we present the complete CDS learning journey and results from surveys and interviews to learners and program staff regarding the supervised internships and the self-guided projects. The paper concludes with recommendations and future steps.

Paper Session 1-08: Skills Development for Sustainability

Time: Monday, 11/Sept/2023: 11:00am - 12:00pm · Location: EQ-117 Tiered Room

Session Chair: John Mitchell

Engineering skills and competences for a more sustainable world

Olbina, Dunja; Buzatu, Bogdan; Kheirawi, Ljilana; Domaltova, Maria

Board of European Students of technology, Belgium

In 2015, the member states of the United Nations agreed that the ideal vision of the world should be achieved by 2030. Halfway in the efforts to reach that vision, and considering the environmental issues we are surrounded by, the need for Higher Education to further incorporate sustainability topics into the curriculum is noticeable.

This paper presents the outcomes of the research through which we aim to make an impact on Higher Education institutions, and the ways they are educating and raising awareness on sustainability related topics. It presents an analysis of the data collected throughout a survey and focus groups, organised with the students from 63 technical universities all across Europe, in total counting 226 responses. The paper points out the relevance of engineering education on environmental sustainability in today's rapidly changing, modern world. It also identifies the sustainability-related topics that should be incorporated into the curriculum. Further, it points out the different engineering skills and competences needed for a more sustainable world and the ways in which they can be obtained. Some of the skills highlighted as the most important ones are: communication, time management and critical thinking,

The results show a critical imbalance between the practical and theoretical part of engineering education. It reflects on the possibilities of implementing modern teaching and learning methods, in order to create a more sustainable mindset in engineering, thus making the learning process more engaging and accessible.

Development in students' perceptions of sustainability and responsibility as relevant aspects of the role of engineers

Lemke, Clara; Ann-Kristin, Winkens; Marie, Decker; Elif, Inanma; Carmen, Leicht-Scholten

RWTH Aachen University, Germany

Engineering and technology-based solutions can address the global challenges associated with sustainable development. In this context, engineers have a substantial responsibility in achieving the Sustainable Development Goals (SDGs). Meeting the challenges of all SDGs influences economic, political and social aspects of human life. However, engineering students' understanding of sustainability is often limited to its ecological and economic dimension, not taking into account or even neglecting social issues. Therefore, teaching approaches in engineering education should address the different dimensions of sustainability and the responsibility of technological development concerning society.

This paper provides a case study on successfully addressing competencies related to sustainability and responsibility in the context of a mandatory lecture called "Engineering and Society" for undergraduate environmental and civil engineering students. With this work, we aim to discuss how engineering students can become aware of the relevance of social responsibility and sustainability through an introductory mandatory lecture. For this purpose, students' competency development and their knowledge acquisition related to social aspects of sustainable development are analyzed. It is investigated how far the lecture contributes to students' perception of sustainability and responsibility as relevant aspects of the engineering profession. To do so, on a quantitative level the self-assessment of competency development is analyzed, and on a qualitative level we analyzed the students' self-perception of the role of engineers and their statements on learning gains and knowledge gaps after the lecture.

Is "improving the quality of life" the only sustainability issue that is related to engineering? - Exploring engineering students' conceptions of sustainability

Luk, Lillian Yun Yung¹; Direito, Inês²; Mitchell, John³; Roach, Kate³

¹The University of Hong Kong, Hong Kong; ²University of Aveiro, Portugal; ³University College London, United Kingdom

UNESCO's (2021) report on engineering for sustainable development has emphasized the critical role of engineers in achieving the 17 Sustainable Development Goals (SDGs). Yet, there is a lack of clarity about the conceptualization or definition of sustainability (Moore et al., 2017), which makes it difficult to integrate sustainability into the curriculum. While Walshe (2008) conducted a study on high school students' conceptions of sustainability in the UK, there appears to be a lack of research conducted in the context of higher education. The study presented in this paper explores engineering students' understanding of sustainability in engineering and how it is influenced by their learning experience in the [programme/University]. Taking a mixed-methods approach, a survey was administered to 139 first-year engineering students followed by individual interviews with 10 students. The survey contained a section which asked students to indicate the extent to which ten different sustainability issues (e.g. creating economic growth, saving lives) are associated with the field of engineering (Klotz et al., 2014). It was found that 65% of the students indicated that "improving the quality of life" is "very much" related to engineering, but less than 50% of them indicated that the remaining nine sustainability issues are "very much" related. Follow-up interviews suggest diverse understandings of sustainability among engineering students, with individual differences in their perception of the learning experience at the university. Findings from the study have important implications for the integration of sustainability in engineering education and will be discussed.

On a Computer Science Master Program for Sustainable Development

Einaron, Daniel

Kristianstad University, Sweden

Sustainable development and the UN's Sustainable Development Goals have been pointed out as crucial for our common future, addressing several aspects of a world to be considered as sustainable. From a university perspective it is certainly interesting, and important, to see how research and education contribute to that context, which may be seen from both disciplinary, and multi-disciplinary perspectives.

A one-year Master Program in Computer Science for Sustainable Development, at Kristianstad University (HKR), Sweden, has a background in the UN's Agenda 2030, and in statements, claiming that 'at the edge'-techniques, from areas such as Artificial Intelligence, and Data Mining are crucial to approach each and one of Agenda 2030's 17 Sustainable Development Goals. With this background, that Master program, was initiated to provide, for students at a master level, challenging disciplinary subjects, as well as an interesting and valuable context to contribute to, with their technical skills. To furthermore approach the students' maturity in the field, the program is supported by courses regarding, on one hand (1), Sustainable Development, and how Computer Science generally may contribute, and on the other hand (2), advanced projects where concepts and techniques shall be practiced within research contexts. It shall also be mentioned that the program is open for students internationally, thus bringing further interesting values through the mutual sharing of experiences from international perspectives. This contribution intends to provide an overview of the program, as well as a more in-depth presentation of the two above-mentioned courses.

Paper Session 1-09: Built Environment

Time: Monday, 11/Sept/2023: 11:00am - 12:00pm · Location: EQ-118 Tiered Room
Session Chair: Yolande Berbers

Establishing a Timber-focused Competency Framework to Up- and Re-Skill Built Environment Professionals to Meet Sustainability Goals

Hitt, Sarah Jayne¹; Hairstans, Robert²; Connell-Skinner, Kirsty²; Binding, Tabitha³; Tamagnone, Gabriele¹

¹NMITE, United Kingdom; ²Edinburgh Napier University, United Kingdom; ³Timber Development UK

The UK's Construction Industry Training Board has recently estimated that over a quarter of a million new workers will be needed by 2027 to meet demand. Concurrently, government and industry sustainability goals such as the 2050 net zero target have significant implications for the construction sector. This has resulted in a situation where the demand for green skills in construction is so high that "a war for talent" has been sparked. It has also meant that the sector is looking towards more sustainable building materials, methods, and technologies, such as homegrown biogenic offsite manufactured (bio-OSM) timber.

To address this critical skills gap, the Timber Technology, Engineering, and Design (TED) Competency Framework was established by a coalition of academic and industry partners. This framework then informed the development of a flexible training course that can prepare the next generation of timber engineers with the knowledge, meta skills, and industry experience that can drive change towards sustainability in the built environment and inform a transformational approach in engineering education.

This practice paper describes the development of the Timber TED framework and the launch of the corresponding training programme in September 2022. It also reflects on the initial implementation across two cohorts, delivered at the Centre for Advanced Timber Technology at the New Model Institute for Technology and Engineering in Hereford, England, in partnership with Edinburgh Napier University and Timber Development UK. These educational initiatives demonstrate an innovative and replicable approach to engineering education for professional and lifelong learning and engagement with industry.

Exploring the reliability, time efficiency, and fairness of comparative judgement in the admission of architecture students

Van den Heuvel, Lotte; Bohm, Nina Lotte

Delft University of Technology, The Netherlands

It is common in architecture education to quantify the quality of assignments into grades, often done by one or two teachers using rubrics. However, this can have several downsides. It suggests an objective preciseness that is debatable for the creative assignments in the field of architecture, and the assessment is dependent on the judgement of only one or two people. Comparative judgement (CJ) offers an alternative to rubric-based assessment by applying pairwise comparison to student assignments, resulting in a ranking instead of a grade.

We used a mixed methods approach to compare the reliability, time efficiency, and fairness of CJ in the selection of students for an undergraduate architecture programme at Delft University of Technology in the Netherlands. Teachers involved in the rubric-based approach for student selection were asked to re-assess a random selection of the assignments using CJ. Reliability and time investments for both methods were compared, and the involved assessors were asked in a focus group setting which of the two methods they perceived as more reliable and fair. Comparing rubric-based assessment to CJ is new, as previous studies have only looked at these assessment methods in isolation.

Findings indicate that CJ can serve as a more reliable and time efficient alternative to rubric-based assessment. However, teachers still perceive rubrics as having higher reliability and fairness. Though this research is particularly relevant in the context of architecture, it contributes to wider discussions about reliable and fair assessment of creative student assignments.

PRELIMINARY MAPPING OF BACHELORS' RESEARCH TO ENHANCE DIGITAL CONSTRUCTION IN IRELAND

Chance, Shannon; McAuley, Barry

TU Dublin

This paper presents preliminary analyses to assess the content of student research conducted through a digital construction course offered to engineers and built environment professionals in Ireland since 2020. The course aims to upskill employed, mature students with a one-year intensive study period in Building Information Modelling (BIM/Digital Construction), and ultimately enable them to earn an honors-level Bachelor of Science degree. Obtaining this degree requires the student to produce a research dissertation, and the course helps students use research and research-thinking to answer pressing questions they encounter in the Architecture, Engineering, and Construction (AEC) context. The paper briefly discusses context of Technological University Dublin's BIM courses, the rationale behind offering these courses, and how they address the shortage of BIM knowledge in Ireland. Work reported in this paper involved the collection of the full text of all BIM BSc dissertations and preliminary, systematic content mapping—using titles and keywords provided by the student authors—to identify themes across the body of 59 BIM BSc dissertations submitted to date. This foundation will support subsequent work to assess the quality and usefulness of research from the BSc as well as MSc BIM courses, and BIM research published by university staff.

Designing of curricula of environmental engineering and constructions engineering for sustainability

Caporali, Enrica; Facciorusso, Johann Antonio; Gori, Riccardo; Palmisano, Elena

Department of Civil and Environmental Engineering, Università degli Studi di Firenze, Firenze, Italy

The experience carried out at the University of Florence, Department of Civil and Environmental Engineering, in designing two new undergraduate curricula in "Environmental Engineering" and "Civil and Building Engineering for sustainability", is reported. The bachelor in Environmental Engineering aims to train engineers capable of working in the field of protection of environment, territory and natural resources. The bachelor in Civil and Building Engineering for sustainability aims to train engineers capable of working in the field of structures, infrastructures, and constructions in general, as well as management and safety of construction processes. The development of the two curricula was based preliminarily on a national and international survey of degree programs of the same type and with shared learning outcomes. Subsequently, labour market needs were identified starting from discussions with all stakeholders, students and professors included. Teaching methods and methods for assessing students' preparation have also been revised and the teaching plan of both curricula is characterized in the third year by the presence of multidisciplinary laboratories, focused on the most characterizing themes of each programme and the different disciplines with integrative and specific in-depth characteristics. Finally, a thorough design of the two courses contents has been initiated, based on the definition of the general educational objectives and the specific disciplines.

Parallel Workshops 1-01: Parallel Workshops 1-01

Time: Monday, 11/Sept/2023: 12:15pm - 1:15pm · Location: EQ-208 Flat Room

Develop an Interdisciplinary Course using the Twente Interdisciplinarity Toolbox

MacLeod, Miles¹; Johnson, Coralie¹; Visscher, Klaasjan¹; van der Veen, Jan²

¹University of Twente, Netherlands, The; ²Eindhoven University of Technology, Netherlands

The ability to engage in interdisciplinary research and problem-solving are essential skills for contemporary engineers, particularly when it comes to addressing issues relating to sustainability, which cross disciplinary boundaries. The University of Twente has developed an interactive web-based system for assisting instructors in the design of interdisciplinary courses for engineers and scientists called the Twente Toolbox for Interdisciplinary Education. The toolbox maps out the landscape of different interdisciplinary course design structures and skill targets and learning goals. These are linked to specific in-class tasks and computational tools, for assisting students in obtaining those goals, as well as course design tools for instructors. In the session participants will receive guided instruction on how to use the system and will apply it to help develop a new course or to refine their interdisciplinary learning and explore alternative tools for improving an existing course.

Structure: For the session, participants will be presented with a short introduction to the website, then split into groups of 3 to try to consider one of three interdisciplinary educational design tasks (provided by us) within the framework of project-based or challenge-based learning. These design tasks will encompass setting ILOs, making decisions about student group structures and problem structures, and linking these to relevant students tasks and assessment tools. Design options and a step-wise design framework is provided by the website. The website provides linkages between design options and relevant students tasks to help scaffolding design decisions. An online mural application will be used to share outcomes and summarise findings.

Participants will also be asked to consider courses they are familiar with and they might be improved using the website material. They will also be asked to provide feedback on the website itself and where improvements might be made.

Target audience: Participants are ideally involved in the design and management of interdisciplinary educational courses or programmes based around project-based learning or challenge-based learning, but anyone interested in the topic can also be involved. As noted we provide sample cases to work in a hypothetical manner.

Outcomes: In the first place participants will gain familiarity with the toolbox system and how to use it from course design and improvement. Secondly participants will become familiar with different interdisciplinary course structures (designs) and the landscape of learning goals those designs suit. This will help conceptualize and position their own goals and designs, and recognize and consider alternative. Thirdly participants will gain awareness of a range of different student tasks relevant for interdisciplinary learning.

Parallel Workshops 1-02: Parallel Workshops 1-02

Time: Monday, 11/Sept/2023: 12:15pm - 1:15pm · Location: EQ-113 Flat Room

Structuring conversations around course design

Laperrouza, Marc¹; Lanarès, Jacques²; Sylvestre, Emmanuel²

¹EPFL, Switzerland; ²UNIL, Switzerland

Constructive alignment helps both students and teachers to achieve intended learning outcomes. The workshop proposes to introduce participants to the elements and mechanics of the pedagogical coherence canvas (PCC), a tool developed to improve constructive alignment throughout course design. Participants will familiarise themselves with the process by applying it to the design of a course or training. This hands-on workshop will help participants to develop a practical understanding of how to use the PCC to design a course following constructive alignment principles.

Parallel Workshops 1-03: Parallel Workshops 1-03

Time: Monday, 11/Sept/2023: 12:15pm - 1:15pm · Location: EQ-207 Technology Room

Using Augmented Reality Technology to Enhance the Learning Experience within an Engineering Laboratory

McDonnell, David; McDonnell, Alan; Vaughan, Brian

Technological University Dublin, Ireland

WORKSHOP PROPOSAL

This proposed two-session workshop will aim to introduce the engineering education community to the potentials of Augmented Reality (AR) within an engineering laboratory environment. Participants will get to experience the use of AR content to aid in the completion of engineering laboratory tasks and also how to create within the environment. The workshop will provide attendees with first-hand experience of operating and authoring AR content, replicating the engagement roles of both student and lecturer/content creator within a typical laboratory environment.

In this specific case, the AR technology introduced includes a fleet of HoloLens 2 devices, and the design and development of AR content using Microsoft Dynamics 365 Guides.

Session 1 "AR Learning Scenarios"

Participants will undertake some basic mechanical engineering tasks aided by previously created AR learning scenarios. These learning scenarios will cover topics such as 'Assembly of Mechanical Equipment', 'Shaft Alignment using Dial Gauges' and 'Shaft Alignment using Laser Equipment'.

Session 2 "AR Content Creation"

Participants will create their own AR instructional content and will undertake a variety of tasks within the AR environment such as 'Importing CAD models', 'Placement and re-positioning of AR Model Geometry', 'Development of Instructional Guides', 'Applying alternate visual representations to AR Model Geometry' and 'Introducing Images and Videos'. This part of the workshop will also explore the possibilities around multi-user AR experiences.

Each complete workshop will be of duration 1 hour, with a maximum of 8 participants. It is proposed to run four separate instances of the complete workshop at different times throughout the Conference proceedings.

LEARNING OUTCOMES

The motivation for the delivery of this workshop is twofold. In the first instance the workshop seeks to introduce the potential of Augmented Reality to a wider Engineering Education audience. Participants will benefit from experiencing pre-developed AR Learning Scenarios that are currently being delivered as part of engineering programmes on the TU Dublin Bolton St. campus. This project, to introduce AR Learning Scenarios into engineering

laboratories, is in its initial phases and it is a chance for participants to engage with the project at an early stage. Initial findings have proven to be very positive, from both a student and lecturer perspective.

The second aim of the workshop is to obtain feedback from other engineering educators across as wide a range of disciplines as possible. The conference workshop provides a great opportunity for the project researchers to obtain peer feedback at an early stage. This will help to ensure that the project will grow in the right directions and may also help to expand the scope of the project to encapsulate other fields of engineering.

BENEFITS TO ENGINEERING EDUCATION

The research project from which the workshop has been developed, seeks to implement AR technology to enhance the learning experience within multiple engineering laboratories. The pilot phase of this project is complete and the researchers are currently deploying AR Learning scenarios within full engineering laboratory sessions. The initial findings have been encouraging, with student feedback being largely positive. Students have reported positively regarding such things as carrying out a task at their own pace, and being able to review and repeat steps if necessary. From the lecturer's perspective, the increased efficiency within the laboratory sessions has been beneficial, reducing the need for intensive instructor-led sessions, allowing more time for deeper learning of the content being delivered.

From the participant's perspective, this is an opportunity to engage with an AR research project at its early stages, and potentially help guide the project into the future. For those educators contemplating the use of AR technology within their own discipline, the workshop offers them a hands-on experience of AR within an engineering laboratory. The workshop seeks to engage the participants through the use and creation of AR content, allowing participants to explore the potentials for their own teaching.

WORKSHOP OUTPUTS

Each participant will be surveyed before and after the workshop session, in order to capture their expectations, experience and thoughts for expansion of the AR Learning Scenarios. These findings will provide valuable feedback for the project researchers and help guide the project into the future. Some of the potential outputs from the workshop are:

- Participants will engage in a hands-on AR technology experience, opening up possibilities for their own teaching.
- Peer feedback for the research project, to help guide future research.
- Expanding the scope of the project, as well as encouraging collaboration with other conference attendees.
- Exploring the use of AR technology from a 'Training for Trainers' perspective.

Parallel Workshops 1-04: Parallel Workshops 1-04

Time: Monday, 11/Sept/2023: 12:15pm - 1:15pm · Location: EQ-212a-d (All)

Sustaining Engineering Education Research: Sharing Qualitative Research Data for Secondary Analysis

Case, Jennifer¹; Matusovich, Holly¹; Paretti, Marie¹; Lord, Susan²; Benson, Lisa³

¹Virginia Tech; ²University of San Deigo; ³Clemson University

As a qualitative researcher, do you have data sets that you didn't have time to fully explore? Do you wish you or someone else could spend more time with the data? Have you ever considered making your data available for secondary analysis in a limited way but don't want to post it to a big public repository? This workshop provides a chance to explore these questions together.

Qualitative researchers often collected extensive data sets that reflect hours of interviews and observations, and few of us ever fully explore a given data set before moving to the next project. But tapping this rich potential has thus far been challenging despite ongoing calls for data sharing by public funders of research. Concerns about ethics, participant confidentiality, misuses of data, and more are compounded by disciplinary and publication practices that value original data over integrative efforts based on secondary analysis. Additionally, institutional reward structures may discourage the kinds of integrated collaborations implied by broad data sharing. Yet secondary analysis can be an important tool for both knowledge-building and capacity building as it increases access to data.

As a result, data sharing is complicated for qualitative researchers. Changing the paradigm of single-use data collection requires actionable, proven practices for effective, ethical data sharing, coupled with sufficient incentives to both share and use existing data. To that end, this workshop draws on findings from a U.S.-based project on secondary data analysis (SDA) to enable participants to explore in detail what SDA is, why and under what conditions they might consider making their own data available for SDA, and what philosophical considerations and practical steps are involved in such data sharing. We are particularly interested in sharing this workshop with participants at SEFI to broaden the global conversation and engage with researchers working in European context where the debates and policy on data and data privacy as well as open access are substantially more advanced. We are also keen to engage with international researchers from a range of funding contexts to collaboratively explore the possibilities for data sharing beyond national boundaries to support equity and sustainability in our global community. Importantly, data sharing and SDA is not a one-size-fits-all endeavor, and posting data to public repositories is not the only option. Instead, this workshop is designed to help participants think more creatively, expansively, and critically together about the role of SDA in engineering education research.

The workshop will include an overview of SDA and findings from our project, practical information from the research teams conducting our two pilot SDA projects, and opportunities to explore SDA in the context of participants' own existing or planned data sets. Hand-on activities will help participants examine their own data sets to consider if and how they might (or might not) be amenable to data sharing, and opportunities for discussion throughout the hour will help situate SDA discussions within and across different national contexts.

SIG Workshop 1-01: SIG Workshop 1-01

Time: Monday, 11/Sept/2023: 12:15pm - 1:15pm · Location: EQ-112 Flat Room

Using Technology to Teach/Learn Mathematics, How Are we as Teachers Fostering Mathematics Education Mobility?

L. Dias Rasteiro, Deolinda Maria¹; Hernández-Álvarez, Luis^{2,3}; González De La Torre, Miguel Ángel²; Pose Díez de la Lastra, Alicia⁴

¹Polytechnic of Coimbra, IPC/ISEC; ²Institute for Physical and Information Technologies (ITEFI), Spanish National Research Council (CSIC);

³Computer Security Lab (COSEC), Universidad Carlos III de Madrid; ⁴Bioengineering Department, Universidad Carlos III de Madrid

Mathematics education plays a critical role in developing analytical thinking, problem-solving skills, and logical reasoning abilities among students. With the rapid advancements in technology, the integration of Information and Communication Technology (ICT) has opened up new possibilities for teaching and learning mathematics. In the field of engineering education, the use of ICT tools and methodologies has gained significant attention due to their potential to enhance mathematical understanding and application within an engineering context. This workshop delves into the state of the art in teaching mathematics, emphasizing the integration of ICT tools and techniques in engineering education and their evaluation by the workshop attendees.

SIG Workshop 1-02: SIG Workshop 1-02

Time: Monday, 11/Sept/2023: 12:15pm - 1:15pm · Location: EQ-116 Flat Room

How can Continuing Engineering Education approaches meet societal and industry needs for future-focused, lifelong learning skills and competences?

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¹Glasgow Caledonian University, United Kingdom; ²Department of Technical Education, Faculty of Economic and Social Sciences, University of Technology and Economics, Hungary

MOTIVATION AND LEARNING OUTCOMES

The focus on lifelong learning and Continuing Engineering Education (CEE) has gained new impetus in a post-COVID world (Ossiannilsson 2022). Additionally responding to rapid technological changes, and where new competences are required to address the “wicked” problems of the next decade, such as UN Sustainable Development Goals, will require education and re-education (UNESCO 2021). Moreover, previous forms of CEE, such as postgraduate taught qualifications, are not necessarily responsive enough to the needs of all individuals, organisations and society. Consequently, new forms of learning, such as micro-credentials, credit-rating, industry training programmes and certification, and flexible programmes, are emerging.

In this European Year of Skills, it is important that different stakeholders (academia, university, lifelong learners) come together to share how they are approaching meeting these challenges, how this CEE ecosystems are developing, and how we can work together to develop models that respond effectively to these needs and opportunities.

At the end of the workshop, participants are expected to experience the following outcomes:

- An elaborated understanding of skills needs in different countries and institutions and approaches to CEE
- Shared understanding of challenges and opportunities around CEE to address required skills needs
- Emergent models of CEE practice to be refined and shared within own institutions

BACKGROUND AND RATIONALE AND RELEVANCE

The Continuing Engineering Education eco-system is complex, due to the different range of stakeholders involved – governments, professional bodies, trade unions, companies, engineers, as well as education and training providers – as well as the plethora of types of learning (informal, non-formal and formal) and the ways that these types of learning can be undertaken (such as in-person, on-line, credit-bearing).

Recent developments, such as micro-credentials, are seeing pan-European approaches being adopted (EU 2022), including through consortiums of European universities, such as EuroTeQ (2023), and projects around micro-credential projects, such as MicroHE and MicroCredX, that examine the demand for micro-credentials, (data) systems to support, as well as balancing needs of employers, society, individuals and educational/training institutions (Microcredentials 2023).

However, such approaches focus more on non-formal and formal learning, and do not fully embrace informal and experiential learning. Experiential learning, and recognition of prior learning are important aspects, of supporting up- and re-skilling of engineering practitioners.

It is this broader context of approaches to skills and competency development that this workshop seeks to gather some initial data to inform future collaborative research.

WORKSHOP DESIGN

The focus of this workshop will be to encourage knowledge sharing and ideation within groups on the following questions:

1. What approaches are our organisations/institutions and partners taking to address these future-focused skills needs?
2. What are the challenges and opportunities that you see for CEE to develop the required future-focused skills?
3. What models (of design, partnership and delivery) do we need to meet these challenges (whether adaptations or creating models)?

This workshop aims to gather stakeholders from industry, academia and learners together that are interested in up- and re-skilling in STEM and want to share and enhance models of collaboration (design and delivery) that will develop the required competences in a suitable agile and responsive manner.

The 60-minute workshop will be divided into three sections:

1. Welcome and sharing of mapping of skills landscape trends over last decade, based on initiatives of European and International Organisations (EU, OECD, WEF and UN) from industry and academia, particularly around skills for sustainability (15 minutes)
2. Group discussions of approaches to CEE aligned to particular skills, considering opportunities, challenges, and models (25 minutes)
3. Sharing and discussion by groups (15 minutes)

SIGNIFICANCE FOR ENGINEERING EDUCATION AND ATTRACTIVENESS OF THE WORKSHOP TOPIC

Sharing and evaluating the range of approaches to support practicing engineers through Continuing Engineering Education have the potential to enhance engineering education more broadly. Specifically, the examination of these forms can also spark discussions around how to offer more personalisation and encourage a broader consideration and recognition of skills and competency development within education.

This workshop aligns particularly to the conference themes of engineering skills and competences, lifelong learning for a more sustainable world, and engagement with industry and innovation. It also relates to virtual and remote education in post Covid world.

TARGET AUDIENCE, PARTICIPANT KNOWLEDGE REQUIRED, TARGET NUMBERS OF PARTICIPANTS AND RESTRICTIONS ON SIZE IF APPROPRIATE

The workshop is of interest to:

1. industry (around how they currently support up- and re-skilling of their employees and their future needs);
2. labour and unions (around approaches to ensuring just transition);
3. practitioners and those implementing policy within the university context around Continuing Engineering Education; and
4. professional engineering bodies that required ongoing Continuing Professional Development of registered and licensed engineers.

The workshop is available to those that are new to this area, and where their institution may be developing approaches, as much as it is to those with experience.

The intended workshop size would be 20-30 with a mix of industry participants, labour representatives and university personnel (academics and policy makers). The workshop could work with larger numbers, as greater use of post-workshop sharing and dialogue would be used.

ENHANCEMENT OF KNOWLEDGE AND DIALOGUE ON THE WORKSHOP TOPIC

It is intended that the outputs of this workshop will feed into the agenda for the CEE/LLL SIG annual meeting at the conference, seeking industry and labour representatives to be part of SIG co-ordinating committee.

Based on these combined discussions and knowledge sharing, we intend to develop these discussions into a workstream of the Continuing Engineering Education/Lifelong Learning Special Interest Group with the participating attendees the workshop. A collaborative online space will host the initial outcomes from the workshop and be used to share, and to engage other interested institutions and individuals in this work.

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SIG Workshop 1-03: SIG Workshop 1-03

Time: Monday, 11/Sept/2023: 12:15pm - 1:15pm · Location: EQ-203 Flat Room

How diverse are global perspectives on Diversity, Equity, and Inclusion in Engineering Education?

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Key words

Diversity, equity and inclusion; engineering education networks; diverse perspectives; global south / north

Motivation and learning outcomes

By the end of the workshop, participants will have attained the following objectives:

1. Participants will have an increased awareness of how Diversity, Equity, and Inclusion [D-E-I] is understood and implemented in a variety of engineering education contexts around the globe.
2. Participants will have a deeper insight into what elements are foregrounded in D-E-I policy and practices in their own institutional context and what is common or left out in comparison with engineering education contexts elsewhere.
3. Participants will jointly formulate recommendations to people in D-E-I leadership positions in engineering education.

Background, rationale and relevance

Diversity has increasingly become highlighted within engineering education today in Europe (Direito et al. 2021) and beyond (London, Murzi, and Litzler 2022). The SEFI SIG Gender & Diversity has recently been renamed as Diversity, Equity and Inclusion, broadening the definition from a focus on gender to embrace other aspects including but not limited to language and cultural background, religion, physical ability, and socioeconomic status (SEFI, n.d). In the process of redefining the SIG's mission, it has become clear that definitions of D-E-I may vary considerably between different contexts and institutions. Therefore, it is relevant for the engineering education community to share and examine how these terms are understood and implemented in their own institution and in other contexts around the globe. This has been recognized by the SEFI SIG Diversity, Equity and Inclusion, which puts forward the current workshop as its designated SIG workshop for the annual SEFI conference of 2023.

Workshop design

Prior to the workshop, the SIG D-E-I will conduct a short survey on the topic and disseminate it through the SEFI Newsletter (c.f. the final section of this proposal). The workshop session is structured in the following steps:

1. Introduction of workshop objectives and procedure; distribution of materials (5 mins);
2. Collecting perspectives on D-E-I from the participants: each participant briefly notes down their institutional definition and their personal perspective on it (5 min; template provided);
3. Collecting perspectives on D-E-I from the panelists: a select and diverse panel articulates their views on this issue from their respective experiences and contexts. The panel will be composed of representatives of SEFI, the American Society for Engineering Education (ASEE), the Research in Engineering Education Network (REEN), the South African Society for Engineering Education (SASEE), and one or two other engineering education societies and groups from around the world, representing the global north and global south (20 min);
4. Examining perspectives on D-E-I in four groups: participants examine their personal and the panelists' perspectives in small and diverse groups and formulate tentative recommendations to people in D-E-I leadership positions in engineering education. The four authors will act as facilitators for one of the groups (20 min; template provided);
5. Examining perspectives on D-E-I individually: each participant considers their initial perspective on diversity (see step 2) and briefly notes down in what ways the workshop has confirmed and/or changed these perspectives (5 min; template provided);
6. Arrangements regarding the analysis and dissemination of the output by the facilitators; conclusion of the workshop (5 min).

Taken together, these activities will support participants to reach the stated learning outcomes. More specifically, steps 3 and 4 enable outcome A; steps 2, 4 and 5 promote outcome B; and step 4 aligns with outcome C.

Significance for engineering education and attractiveness of the topic

As highlighted above, not only is D-E-I a hot topic in engineering education in terms of importance, it is also an increasingly controversial one (see e.g. Saul 2023). Together, participants of the workshop will unpack D-E-I definitions and demands in different contexts, making an important contribution not only to their own and a SEFI context, but to a global context as well. Input from the globally diverse expert panel will challenge existing interpretations. The ensuing activities and input, both during and after the workshop, can contribute towards a unique contribution to the field.

Target audience

The workshop welcomes participants who are interested in the topic and eager to learn and discuss more; no prior knowledge of D-E-I is required. The workshop can cater any number of participants as long as break-out corners can be provided inside or outside the assigned room for the small group activity (step 4).

Enhancement of knowledge and dialogue on the workshop topic

Prior to the conference workshop, the SIG D-E-I will collect definitions of diversity and SEFI members' views on them through a short survey in the SEFI Newsletter. This output will feed the dialogue during the workshop.

Shortly after the workshop, the results will be reported on the SEFI SIG *Diversity, Equity and Inclusion* website page. They will also provide the input for a SEFI@work webinar that will be organized in the course of the following months with a wider audience beyond SEFI2023 attendees. Finally, it is noteworthy that the theme of the workshop ties in with the National Science Foundation CAREER grant project objectives of one of the authors, namely to explore how different leaders around the world perceive and understand D-E-I and what we can learn from that. That project will provide one additional channel for integrating and disseminating the results of the workshop beyond Europe.

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SIG Workshop 1-04: SIG Workshop 1-04

Time: Monday, 11/Sept/2023: 12:15pm - 1:15pm · Location: EQ-315 Flat Room GD

Future Perspectives of Capacity Building in Engineering Education

Griffiths, Jennifer Ann¹; Jalali, Yousef²; Kálmán, Aniko³; Kövesi, Klara⁴; Langie, Greet⁵; Lönngren, Johanna⁶; Mitchell, John¹; Polmear, Madeline⁷

¹University College London, United Kingdom; ²EPFL, Switzerland; ³Budapest University of Technology and Economics, Hungary; ⁴ENSTA Bretagne, France; ⁵KU Leuven, Belgium; ⁶Umeå University, Sweden; ⁷Vrije Universiteit, Belgium

Motivation and learning outcomes

This workshop will encourage sharing of Capacity Building (CB) practices in Engineering Education across the SEFI community and open dialogue to shape how SEFI can support this through the CB SIG. Participants will have the opportunity to discuss their own experiences of CB, also known as pedagogical training or professional development, and compare and contrast this to others' experiences. They will consider where CB has been beneficial for themselves and their colleagues. Participants will also be asked to consider areas that will require CB in the future, feeding into ideas for pan-European support that SEFI might provide including consideration of the environmental facilitators and barriers for CB.

- Participants will develop an understanding for the wide variety of ways in which CB can be organised in higher education institutions across Europe, which can provide inspiration for improving current practices at participants' own institutions.
- The workshop will support a community of practice for educators who are involved with and/or leading CB activities at their institutions or within the broader SEFI network

Background rationale and relevance

Engineering educators understand that the world is changing quickly and the engineers of the future need to ethically balance technology, sustainability and the demands of growing populations in a world where large-scale projects are becoming the new normal, communication is often instant and cultures are mixing more widely. Engineers require new competencies, especially with the growing importance of engaging with the Sustainable Development Goals (SDGs) (Diaz Lantada 2020, 1814). These include e.g. dealing with conflicting values; decision-making using incomplete complex data; transdisciplinary collaboration, and increasing competition for resources.

But how do we make sure that we, as educators, build our capacity to support the development of future engineers? How do we ensure engineering educators at all stages of their career have the appropriate pedagogical skills and knowledge to shape education sustainably and successfully?

CB is considered important for engineering educators (Chen et al. 2021, 900), but activities are governed and delivered in many different ways (Kövesi et al. 2022, 379). Moreover, an individual's access to CB may be limited by pre-existing structural factors, job role, the time available for personal development, and employers' recognition of its importance (Perez Foguet and Lazzarini, 2019, 772). Finally, educators who have participated in pedagogical development often face structural challenges that may hinder them implementing new pedagogical approaches in their practice - which can lead to reduced motivation to engage in further development opportunities.

(Chen et al. 2021) and (Hebles et al. 2021) indicate that CB is most successful when participants have opportunities to reflect, interact, rehearse and try out pedagogical practices. This workshop asks participants to share their experiences related to these opportunities, discussing how we can build a SEFI community of practice that supports the CB needs of engineering educators and educational institutions. We will examine differences in local practices, exploring whether and how a pan-European approach could add value, shaping future direction of European Engineering Education CB, and providing inspiration for participants to take back to their own institutions.

Workshop Design

The workshop will begin with an overview of CB practices (Kövesi et al. 2022). Participants will then spend a few minutes investigating CB at their own institutions before moving into small group discussions to identify aspects of CB that they consider to have worked well, those that have had little effect, and where they see future challenges and opportunities for CB. The workshop will conclude with short summaries of group discussions. Participants will be asked to document their thoughts on a padlet (or similar) which they will have access to in order to facilitate the growth of the SEFI CB community.

Significance for engineering education and attractiveness of the workshop topic

Connecting to this conference's theme, it is increasingly apparent that we cannot educate future engineers with fluency in the SDGs without tackling competence development. Few engineering educators are comfortable teaching SDGs due to few being experts; there are tensions that occur when educating students for an unknown future requiring different types of knowledge and competencies than those traditionally taught in engineering. High quality sustainability education requires new approaches such as active learning, project-based learning, and stakeholder collaboration, creating an urgency to build educators' capacity to deliver in these ways. There is a need for pedagogical support to build confidence in emerging areas such as AI, sustainability, transdisciplinary education, and stakeholder collaboration.

Nevertheless, although growing, there remains a scarcity of literature on this important topic and opportunities for discussion with peers are rare. As a result, opportunities for interactions among individuals interested in the field are essential to build a community of practice centered around sharing experiences and learning (Wenger, 2000).

Target Audience, Participant knowledge required

This workshop is open to anyone with experience of, and interest in, taking part in or delivering CB activities. We especially welcome anyone who has considered how they can measure the success of activities within an institution. The participants will be invited to share their personal experiences and views of engagement with CB to build a picture of what works and what is needed by Engineering Educators over coming years to ensure they can develop the engineers of the future.

There are multiple facilitators available and so a large workshop is possible.

Enhancement of knowledge and dialogue on the workshop topic

The workshop will open dialogue and develop a network of colleagues who can support each other, sharing ideas and resources for successful CB within their own institutions and across Europe. It is also an opportunity for colleagues to become part of the CB SIG community. Attendees will enhance their knowledge of diverse CB structures and practices across institutions, and take away ideas for how they can implement (even small) changes to CB in their local settings. Discussions from this workshop will be captured in a co-created Padlet and notes taken by the facilitators and used to inform planning for the CB SIG's future activities.

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SIG Workshop 1-06: SIG Workshop 1-06

Time: Monday, 11/Sept/2023: 12:15pm - 1:15pm · Location: EQ-002 Lecture Hall

Techniques in Teaching Engineering Ethics and Professional Responsibility

Barakat, Nael¹; Børsen, Tom²; Hardebolle, Cecile³; Kovacs, Helena⁴; Martin, Diana⁵; Väättäjä, Heli⁶

¹University of Texas at Tyler; ²Aalborg University; ³Ecole Polytechnique Fédérale de Lausanne; ⁴EPFL Centre for Learning Sciences; ⁵Eindhoven University of Technology; ⁶Lapland University of Applied Sciences

Abstract:

Engineering education have evolved to include engineering ethics and professional responsibility as an integral part of the curriculum. Accreditation requirements emphasize this part by including the broader impact of engineering, especially ethics, as a major part of student educational outcomes. As a result, engineering educators and instructional designers have developed innovative techniques and methods to deliver engineering ethics during undergraduate engineering education and beyond. This is despite the inherent challenges associated with any engineering curriculum, particularly capacity and integration. When it comes to curriculum capacity, engineering curricula are always jam-packed with content which makes adding any more content another optimization problem during instructional design. Meanwhile, components' integration is always needed to help combat and reduce the problem of knowledge and skills' compartmentalization taking place cognitively and practically among students due to many inherent factors. Furthermore, the integration problem is augmented by the challenge of teaching a non-technical content as part of a technical course or curriculum. Therefore, teaching engineering ethics and professional responsibility takes extra effort to be included and integrated in engineering.

Many techniques and methods exist to teach engineering ethics. Also, many experts have been teaching ethics for a while. However, many new instructors and engineering trainers have joined the workforce. The goal of this workshop is to refresh the basic concepts and foundational ideas for teaching engineering ethics and professional responsibility, as well as an overview of available techniques and levels of engagement, which could be employed by different instructors based on their own curricular context. The workshop will expose participants to foundational topics and relevant techniques in teaching engineering ethics and professionalism. Participants will be engaged in active learning guiding them to plan their offering of engineering ethics to engineering students, at their respective institutions and curricular context, with consideration of the unique cultural and societal aspects of different geographical locations, and with a view on how to integrate engineering ethics across the curriculum as an essential part of engineering knowledge.

Topics covered include:

1. Fundamentals of engineering ethics education.
2. Techniques and methods to teach engineering ethics.
3. Design and planning different modules for classroom delivery.
4. Assessment and evaluation integration.

Workshop structure:

1. The frame: Goal and limitations of teaching engineering ethics.
2. The Content: Selection of material and delivery technique.
3. The Product: Building an integrated teaching module (content, delivery, and assessment).

Target Group:

The workshop is directed towards engineering and STEM educators and administrators, as well as practicing professional engineers who would like to explore effective ways to teach engineering ethics.

Workshop Time and Style:

1 hour of interactive learning

Paper Session 1-10: Sustainable Development - Curriculum and Programme Approaches

Time: Monday, 11/Sept/2023: 2:30pm - 3:30pm - Location: EQ-002 Lecture Hall
Session Chair: John Mitchell

A three-year academic track towards literacy in Sustainable Development - A Computer Science Study Program Case

Klonowska, Kamilla; Teljega, Marijana; Einarson, Daniel

Kristianstad University, Sweden

The 3-year Computer Science Bachelor study program at Kristianstad University, Sweden, aims to integrate not only academic competencies and skills in subject courses but also critical thinking skills on how Computer Science can contribute to achieving the sustainable development goals.

At the first year's first course the students are trained in understanding the sustainable development goals and how computer science can be applied to help achieve them. As part of this course, students write an academic report, which is followed by discussions on a seminar, allowing students to exchange ideas and perspectives on the subject.

At year two, students work in teams to develop applications that address one specific sustainable development goal, which requires them to think critically about how to design and implement effective solutions. By working on projects that address real-world sustainability challenges, students are exposed to a wide range of perspectives and are challenged to consider multiple solutions to complex problems. The students' communicative abilities and the ability to solve problems and work in groups are developed in a clear progression through the education.

At the third and last year, students are focusing on one, by teachers, defined project, clearly addressing one specific sustainability goal. Here IT supports for health and quality of life aspects. Students work in larger groups, putting demands on cooperation, report writings, and oral presentations.

This contribution aims to provide overviews, as well as, in depth-presentations of the covered courses. Investigations of students' attitudes will furthermore be presented.

RESULTS OF SURVEYS AMONG PUPILS, STUDENTS AND EMPLOYERS ON INTERESTS IN AND CONTENTS OF STUDY PROGRAMMES IN CIVIL ENGINEERING, GEODESY, ENVIRONMENTAL SCIENCES AND SUSTAINABLE MOBILITY IN GERMANY

Lohbeck, Anke¹; Strauch, Karsten¹; Oeser, Markus^{1,2}

¹Federal Highway Research Institute, Germany; ²Deputy Head of the Council of Civil Engineering, Surveying and Environmental Engineering

The shortage of skilled workers in the engineering sector threatens the development and sustainable transformation of the economy in Germany. In this context, the current decline in the number of first-year students in civil engineering, environmental engineering, geodesy and traffic engineering appears all the more alarming. Surveys which can provide basic data for the elimination of the shortage of skilled workers in engineering and the increase in the number of first-year students in the above-mentioned degree programmes were started in 2022 among pupils, students and representatives of the authorities. Furthermore, one of the surveys was used to analyse the potential for an additional course for "sustainable mobility".

All three surveys were conducted under the overarching aspect of consistency in order to obtain a cross-stakeholder picture. A central focus was on the topics of sustainability and digitalisation, including the extent to which sufficient preparations are made in the educational environment and which requirements are really considered necessary (also in the future) in the respective activities.

Based on these results, among others, the orientation of a planned agency for reducing the shortage of skilled workers in the road and transport sector was adjusted accordingly. The aim is to establish a coordinating institution that focuses specifically on the gap between academic education and the requirements of innovative and modern employers.

Sustainable energy-efficient living – a first-year project-based workshop for energy engineers

Kitzig, Melanie¹; Lang, Martin²; Dorschu, Alexandra¹

¹Hochschule Ruhr West, University of Applied Sciences, Germany; ²University of Duisburg-Essen, Germany

For many engineering students a lack of study motivation plays a significant role in their drop-out process (Heublein, 2017). Therefore, students' motivation to study should be encouraged as early as possible. A proven strategy for increasing the study motivation is the integration of project-based learning (PjBL) into the course of studies (Kolmos & de Graaff, 2014).

This paper introduces a PjBL-workshop concept which was developed for first-year energy engineering students at a university of applied sciences in Germany. During this one-semester workshop, the students are working weekly as student trainees in a fictitious engineering office. Guided by the teacher as the project lead, the students are developing a concept for integrating various renewable and sustainable energy systems in a single family house. Each week they take on subtasks of a different work package supporting other employees of the engineering office. During their time as student trainees they have to face authentic engineering challenges like constructing a photovoltaic plant or dimensioning a battery system. Progress and results are documented in a project diary.

First insights of initial implementations of the concept led to a closer focus on the aspect of the perceived authenticity of the PjBL-setting (engineering office) by the students. Therefore, besides the conceptual and contentual design of the workshop, this paper will also address the creation of the authentic setup of the engineering office. Future research in this ongoing study will examine the influence of the perceived authenticity on various aspects such as the motivation to study.

ENG+ | ETHICS FOR SUSTAINABLE DEVELOPMENT IN ENGINEERING PROGRAMMES A PRAXIS REPORT OF TU BERLIN'S THINK TANK TECHNOLOGY REFLECTION

Ammon, Sabine; Derda, Mareen; Hildebrandt, Tim; Kühne, Stefan; Klein, Nadine

TU Berlin, Germany

Many technical universities alike, TU Berlin is in a future-oriented process of programme transformation to invite a holistic perspective on technology which includes critical thinking and ethical reflection. To this end, TU Berlin recently issued a general study guideline calling for an orientation of all programmes toward sustainable development. Accordingly, students should know about the historical, social and cultural contexts of science and technology and learn to reflect on the ethical consequences of their actions. Together with training in good scientific practice, this content should comprise 12 ECTS in each respective BA and MA programme. With only minor integration of this content in the current curricula to date, this transformation presents a significant challenge since courses need to be realigned as well as replaced. To find an answer, TU Berlin's engineering faculty initiated a think tank in spring 2022, bringing together students, teachers and administration to search for ways of integrating ethics as well as science reflection and technology reflection to foster sustainable development. In our contribution we present a first outcome, namely the integration framework ENG+ for programme design which allows for the incorporation of ethics and strengthening of core values such as diversity, sustainability, and good scientific practice. In the ENG+ framework, we introduce the strategies of advancing and complementing as well as six corresponding measures for integration – emphasising, empowering, embedding, enabling, enriching, and encountering. We explain how they jointly contribute to the overarching ENG+ concept which brings together ethical reflection and sustainable development.

Paper Session 1-11: Engagement with Industry and Innovation 1

Time: Monday, 11/Sept/2023: 2:30pm - 3:30pm · Location: EQ-116 Flat Room
Session Chair: Sonia M. Gomez Puente

LMATE: An innovative bachelor degree connecting Mathematics and Industry

Aleixo, Sandra Maria^{1,2}; Martins, Sandra Gaspar^{1,3}

¹Instituto Superior de Engenharia de Lisboa do Instituto Politécnico de Lisboa (ISEL-IPL); ²Centro de Estatística e Aplicações da Universidade de Lisboa (CEAUL); ³Centro Interdisciplinar de Ciências Sociais da Universidade Nova de Lisboa (CICS.NOVA)

The bachelor degree in Mathematics Applied to Technology and Enterprise (LMATE) has an innovative structure, working in partnership with industry, involving a transdisciplinarity curriculum plan, with a solid mathematical base including extensive knowledge in statistics, optimization, modeling and programming (Python, R, etc.), along with training in engineering, physics and management.

LMATE presents three differences in relation to other applied mathematics portuguese bachelors degrees: it was constructed upside down towards the usual, once partner entities (enterprises, public entities and research centers) were consulted on relevant mathematical contents to solve their problems, instead of being created exclusively by the academy; in its curricular plan has optional curricular units from several engineering areas; and is the only bachelor degree in applied mathematics that has an internship integrated.

As LMATE performance evaluation measures the following can be listed: the number of partner entities has increased to 37 currently; demand has been far greater than the offer of vacancies, reaching around 800%; average entry grades have been increasing (from 12.6 to 15.2); and more than 70 of the 176 students who entered in the six years of LMATE have graduated, having done internships in partner entities.

Based on a follow-up study of students who have already finished LMATE to assess the quality of the knowledge acquired and its employability, it is concluded that many of finalists enroll in master's degrees, the majority just after LMATE; others enter the labor market straight away, but all feel that LMATE provided them with adequate preparation.

Using systems thinking to design education to make a difference – a progress report

Elliott, Bruce J; Ersoy, Merve; Green, Zena

University of Birmingham, United Kingdom

The Birmingham Centre for Rail Research and Education (BCRRE) delivers research and education to benefit the international rail industry, including an MSc programme which is designed to equip students with the skills needed to lead multidisciplinary engineering projects. The authors are trying to apply some of the systems thinking taught in the programme to the programme itself. It is established practice to maintain learning outcomes for an educational programme and we do that, but we describe how we are trying to improve the information available to us about what the industry wants and the varying needs of our student population. Our information-gathering processes are not just passive feedback loops but are actively focussed on areas of interest. We are also using the V diagram (a systems engineering concept) as a framework for maintaining line of sight to the full set of feedback information in order to assemble a richer picture to support more balanced decision-making. We describe how our approach is already producing richer input which we are using to improve our programme and why we are encouraged that our approach can make a positive difference to achieve a better educational experience in engineering disciplines.

'There's a machine on the team': employers' perspectives on graduate employability in digitised workplaces

Winberg, CHRIS¹; Winberg, Simon²

¹Cape Peninsula University of Technology, South Africa; ²University of Cape Town, South Africa

The implementation of digital technologies across engineering fields is changing the nature of professional work. Digitised work presents both technical and social challenges; it is therefore timely to consider the implications of the digital transformation of work for engineering education. In this study the focus is on the technical engineering knowledge and professional skills that employers have identified as desirable for productive work practices in digital environments. The research question guiding the study is: What knowledge and professional skills do employers in digitized workplaces value in engineering graduates? The study drew on Legitimation Code Theory's Specialization dimension to reveal the underpinning principles of how knowledge and skills are integrated in digital environments. Structured interviews with employers were analysed to categorise the knowledge and skills that were highly regarded in environments that had implemented digital and related technologies. The study identified three levels of engineering knowledge valued by employers: 1) using non-specialised digital technologies, 2) applying advanced digital technologies; and 3) developing and/or adapting advanced technologies; the study also identified three kinds of social change in digitised workplace (that imply changing professional skills): 1) minor changes in professional skills, 2) more complex changes due to the in the ways in which work is accomplished, and 3) the transformation of workplace relationships. The paper argues for a shift from a skills discourse that assumes a separation between engineering knowledge and professional skills to one that captures the dynamics of socio-technical integration in digitised practice.

Assessment of online accreditation of Engineering programs: A Cultural-Historical Activity Theory (CHAT) analysis

Nyembwe, Kasongo Didier¹; Mojisola, Tajudeen^{1,2}; Simpson, Zach¹

¹University of Johannesburg, South Africa; ²Air Force Institute of Technology, Nigeria

This paper shows how Cultural Historical Activity Theory (CHAT) can provide a practical framework for online accreditation of engineering programmes in South Africa. Far from being inaccessible, CHAT can provide engineering accreditation bodies with a conceptual framework and theory of change for online accreditation of engineering programs. Within the context of program accreditation in South Africa, the paper leverages CHAT to comprehend the dynamic interplay of digital technologies as deployed during online accreditation including, amongst others, video conferencing, social media and cloud storage, and how these affect online accreditation of engineering programmes. It is concluded that theory-based research and practice need not remain at a conceptual level but can be used to create concrete solutions to problems, such as the adverse effect of COVID-19.

Paper Session 1-12: EDI 2 - Women in STEM

Time: Monday, 11/Sept/2023: 2:30pm - 3:30pm · Location: EQ-211 Flat Room
Session Chair: Catherine Deegan

Digitalisation as an Opportunity for Women in STEM: Researching the Nexus of School, University and Labour Market

Jeanrenaud, Yves; Wimmer, Anna-Kathrin

Ludwig-Maximilians-Universität Munich, Germany

In Germany, women are still dramatically underrepresented in the fields of STEM, especially in engineering: less than 25 percent of engineering students are female. Correspondingly underrepresented are women in engineering positions, too. Research has shown that diversity in the work force is crucial to develop successful solutions for a complex and sustainability-oriented world.

Therefore, our ongoing research project (01FP22M01), funded by the Federal Ministry of Education and Research (BMBF), focusses on the underrepresentation of women in STEM, especially in mechanical and plant engineering. Using mixed methods of qualitative interviews and quantitative online surveys with female pupils, students and employees, as well as industry representatives, to create a comprehensive and multi-perspective picture of the conditions of engineering education and jobs. Thus, we can show what enables or hinders the recruitment, networking and initiative of women in engineering.

This practice paper therefore highlights the environment of engineering education and professional formation along the life course and the application of educational concepts in the light of digitalisation. However, because the research project is currently at the stage of implementing the survey and interviews, first empirical results are not yet available. Therefore, this paper will present the research project's background, the methodological approach and nonetheless focus on digitalisation and conceptualises how to shed light on the use of digital technologies in engineering education and professional development throughout careers.

Supporting Women in Engineering & Technology Through a Collaborative Practice and Support Network Using Targeted Interventions

Looby, Michelle; Armstrong, Marie; Beagon, Una; Dunne, Emma M; Hensman, Svetlana; Higgins, Farrah; Kelly, Paula; Killane, Isabelle; Lynott, Susan; McMahon, Orla; Pahlevanzadeh, Bahareh

TU Dublin, Ireland

Despite ongoing efforts to recruit and retain women in third level engineering programmes in Ireland, there is still a lack of diversity in these programmes with typically fewer than 20% of students being female. This paper will describe the evolution of a female focused university wide network called WITU (Women in Technology United), which aims to retain female students in engineering and technology programmes, and to increase the number of gender minorities coming onto these programmes. It is also a response to the Sustainable Development Goals, particularly, SDG 4 (quality education), and SDG 5 (gender equality), and addresses actions highlighted in a recent Athena Swan review in our university. The network was formed in 2020 and extended to become University wide during lockdown, which in itself presented specific challenges.

This paper describes the activities of the WITU network which runs events and celebrations for female students on our engineering and technology programmes such as 'Meet & Greet' events for incoming year 1 students, scholarship workshops, coding camps and International Women's Day celebrations. The events are run collaboratively with students, academics, and employer networks, with participation from recent female graduate role models, who are contributing to the wider engineering community.

The paper will describe these events and their impact on participants. Outcomes and feedback from participants show the critical role of these types of targeted interventions in supporting women and gender minorities and address some of the most pressing global challenges relating to the above-mentioned SDGs.

Supporting women in Science, Engineering and Technology programmes: A TU Dublin approach

Shoemaker, Leslie; Feeney, Sharon

TU Dublin, Ireland

The under-representation of women studying engineering in higher education is gaining increasing attention in Universities throughout Europe and other jurisdictions. This has led to under-representation of women in many of the professions in the Science, Engineering and Technology fields also. Numerous initiatives and programmes are being developed in universities to gain more information about the embedded issues in these disciplines that inhibit female applicants or lead to unsuccessful outcomes in university programmes. One such initiative that has been developed and piloted in Technological University Dublin (Ireland) is a mentoring programme called 'Equality in Science and Technology by Engaged Educational Mentoring (ESTeEM)'.

This paper reflects on the development of the ESTeEM programme, which is a unique, award-winning mentorship programme for female students, including non-binary and transwomen in Science, Engineering, and Computing programmes. The ESTeEM programme has been piloted to students pursuing programmes at many levels in the university, including craft-based apprenticeship programmes, through to Higher Certificate, Honours Degree and Postgraduate programmes in Engineering, Science, and Computing. This paper outlines the origins of the ESTeEM programme, the experience of the facilitator and participants from the pilot programmes, as well as the initial contributions to the wider University community, through strategic priorities being achieved, in addition to increased participation and success of women, non-binary and transwomen successfully pursuing Science, Engineering and Technology Programmes. Finally, the paper concludes with lessons learned and suggestions for further roll-out and development of the ESTeEM programme.

The experience of women in engineering apprenticeships | A scoping review

Herron, Joy; Bowe, Brian; Gallery, Richard; Beagon, Una Beagon

TU Dublin, Ireland

This scoping review aims to synthesise the existing literature on the experience of women in engineering apprenticeships, identify research gaps, and highlight areas for future research. Apprenticeships are not only required to address the current skills shortage in the engineering profession which threatens to impede our ability to deliver on our sustainability goals and restrict economic growth they are also a proven pathway for women to enter engineering programmes. Despite growing social and political interest in increasing gender diversity in the workforce, data shows that women remain significantly underrepresented in engineering apprenticeship programs.

This review examines studies from the SCOPUS and JSTOR databases between 2002 and 2022 and utilises the PRISMA-ScR extension checklist for scoping reviews. Results were analysed using a thematic synthesis approach producing high-order themes and key messages. The findings highlight several challenges faced by women in engineering apprenticeships including limited access to information and opportunities, poor recruitment practices, negative attitudes and beliefs, discrimination, and a lack of role models.

Despite the challenges, this analysis identifies several strategies that support the success of women in engineering apprenticeships notably mentorship, targeted recruitment and supportive policies and practices.

These findings enhance our understanding of the experiences of women in engineering apprenticeships and can inform policy and initiatives aimed at improving gender equity and be of use to other stakeholders interested in improving the recruitment and retention of women in apprenticeships.

2023 Draft Book of Abstracts

Paper Session 1-13: Climate Change and Sustainability 2

Time: Monday, 11/Sept/2023: 2:30pm - 3:30pm · Location: EQ-203 Flat Room
Session Chair: Ceri Almrott

STEM education and research at the University of Aruba for sustainable development of Small Island Developing States: Case studies on energy efficiency and waste management.

de Agustin Camacho, Alba^{1,2}; de Droog, Mieke²; van Petegem, Wim¹

¹KU Leuven; ²University of Aruba

SISSTEM “Sustainable Island Solutions through Science, Technology, Engineering and Mathematics” is a higher educational programme created in 2019 at the University of Aruba in response to the need for engineering education and research in Small Island Developing States (SIDS). In this contribution, the SISSTEM programme is introduced, and how SISSTEM equips engineering students with hard and soft skills while addressing local sustainability challenges is showcased through two case studies.

The first case study presents a bachelor course that combines sustainability theory with a teamwork project in which students conduct an energy audit to a local institution. With this course, students acquire skills to support the energy transition in Aruba. The second case study focuses on the involvement of university students in the creation of a citizen science mobile phone app to tackle waste challenges. This case study presents how students can become agents of change to contribute solving waste management challenges on the island.

Overall, these two case studies showcase how by combining theory and project-based education, students learn to integrate STEM knowledge into multidisciplinary solutions to complex sustainability challenges. In fact, given the cross-cutting nature of sustainability transitions, educating students in integrating the natural environment, technical, social, and economic aspects in engineering solutions is key to increase resilience of islands. As such, at SISSTEM, students acquire hard skills related to their engineering specialisation, as well as soft skills such as integration of disciplines, contextualization, and collaboration.

Sustainability and Innovation: Exploring the Relationship between Sustainability and Companies' Engagement in Innovation Ecosystems in the German Engineering Industry

Johannsen, Thies

TU Berlin, Germany

This study identifies sustainable companies in the engineering industry in Germany and investigates their engagement in innovation ecosystems based on varying collaborative formats and transfer pathways. To this end, 200 medium and large companies were interviewed. For the analysis of the data, the study operationalised sustainability and identified sustainable companies based on responses concerning their environmental, social, and economic performance. These results were then cross-referenced with activities within innovation ecosystems.

Results are consistent with the state of research and indicate that sustainable companies are more engaged in innovation ecosystems than non-sustainable companies. This suggests that companies considered sustainable are more likely to contribute to solving grand societal challenges through innovations. For engineering educators, it highlights the relevance to promote sustainability and innovation as part of engineering education and prepare students for cooperative and collaborative activities in their careers.

Management education in an engineering environment. The case of BME.

Szalmáné Csete, Mária; Lógó, Emma; Bodrogi, Bence; Koltai, Tamás

Budapest University of Technology and Economics, Faculty of Economic and Social Sciences

Engineering higher education institutes need to integrate new skills and competences into their practice and curricula to accelerate the sustainability transition.

This paper introduces the interdisciplinary upskilling of engineering students studying in engineering programs at the Budapest University of Technology and Economics (BME), which has been provided by the Faculty of Economic and Social Sciences (GTK) since 1998. The BME GTK delivers an educational experience that fits into the environment defined by the engineering faculties at BME. The BME GTK has experience of more than a quarter of a century in engineering education related to socio-economic and management upskilling, which can contribute to the common knowledge considering engineering education development solutions of the sustainability transition.

This study focuses on assessing the socio-economic and management related courses of engineering students at BME provided by the nine departments of the GTK. The analyses examine the non-engineering skills of BME engineering students over the past ten years. The sample includes all the compulsory and elective courses available for engineering students. Based on the assessment results, the most significant management and socio-economic courses, and the related non-engineering interdisciplinary skills, both in bachelor and master levels, between 2012 and 2022 can be identified. The analysis allows monitoring of the management education's role in an engineering environment in the last decade. Furthermore, it provides an excellent basis for strategic decisions on future educational development considering sustainability challenges.

The role of Earth system literacy in sustainability education for engineers

Basu, Sudeshna

University College London, United Kingdom

Engineers should be able to demonstrate sustainability competencies transcending their specialised discipline. But all cross-disciplinary sustainability competencies are not targeted adequately in engineering education and are often mismatched with competencies required by engineers in their professional roles. Future engineers should have an understanding of the environment alongside technical knowledge, with all engineering design and product showing consideration to sustainability. The study of the Earth system is relevant to the understanding of environmental issues and the interplay between the sub-systems of the Earth (atmosphere, geosphere, biosphere and hydrosphere). Yet, integration of Earth system literacy in the engineering curriculum has received minimal attention. This paper discusses the sustainability competencies in engineering education and, investigates if they can be addressed through Earth system literacy where weak or lacking. Based on two geology courses delivered to engineering students focusing on the sustainable management of different Earth resources with an understanding of their formation and extraction, it is evident that Earth system literacy can strengthen system thinking and, strategic and normative competencies in engineers. Most importantly it can target anticipatory competency that is not addressed adequately in conventional engineering courses.

Paper Session 1-14: Fostering Engineering Education Research 2

Time: Monday, 11/Sept/2023: 2:30pm - 3:30pm · Location: EQ-204 Flat Room
Session Chair: Gareth Thomson

(Re)defining engineers' resilience: Part I An exploratory study into how engineering educators understand and teach resilience

Wint, Natalie; Direito, Inês

UCL Centre for Engineering Education, United Kingdom

In recent years 'resilience' has increasingly been framed as a positive attribute that can play a role in the success of university students. The need for students to develop and demonstrate resilience seems particularly pertinent within engineering education. Firstly, engineering degrees are often associated with heavy workloads. This, alongside high rates of attrition and increases in mental health issues, suggests a need for students to demonstrate resilience. Secondly, engineering degrees prepare students for a profession, and it is likely that courses place emphasis on graduate attributes such as resilience. Finally, the rate of technological advancement and societal change places additional demands on graduates to adapt to career changes.

Despite the emphasis on the benefits of demonstrating resilience, there is a lack of research focusing on how it is understood and taught within engineering education. In this work we take a qualitative approach to understanding how engineering educators conceptualise resilience; whether they feel a responsibility to help students develop resilience; their approach to doing this; and their general perception about the resilience levels of students. In so doing, we make use of data collected from semi-structured interviews with thirteen individuals involved in the education of engineers. Interview transcripts were analyzed using reflexive thematic analysis (RTA). We find that the conceptualisation of resilience in engineering education varies, thus impacting the design of effective interventions.

(Re)defining engineers' resilience: Part II reflexive accounts of doing reflexive thematic analysis

Wint, Natalie

UCL Centre for Engineering Education, United Kingdom

This work accompanies another paper which describes interpretivist qualitative research that made use of data from semi-structured interviews pertaining to how engineering educators conceptualize resilience and support students in its development. In that work, we utilized reflexive thematic analysis (RTA) for several reasons. Firstly, it is considered a useful method for under-researched areas. Secondly, its flexibility allows for inductive and deductive theme generation. Finally, it is considered a reasonably accessible method which we believe is important when considering 1.) the varied audience of engineering education research (EER) and 2.) the relative lack of consensus as to acceptable theoretical frameworks or methodologies for use within the space. In taking this approach, and in acknowledging its flexibility, I consider what that means for the process. RTA is not accompanied by a distinct theoretical framework, meaning researchers must clearly communicate methodological decision-making. In situating myself as an interpreter of meaning I recognize the need to share the role I play in knowledge production. Finally, being relatively new to qualitative research, I wanted to document my struggles and capture ways my practice has developed. I, therefore, document my reflexive process in relation to the six-stage process proposed by Braun and Clarke.

An embodied cognition approach to collaborative engineering design activities

van Helden, Gitte^{1,2,3}; Zandbergen, Barry¹; Shvarts, Anna⁴; Specht, Marcus^{2,3}; Gill, Eberhard¹

¹Faculty of Aerospace Engineering, Delft University of Technology, The Netherlands; ²Leiden Delft Erasmus Centre for Education and Learning, The Netherlands; ³4TU Centre for Engineering Education, Delft University of Technology, The Netherlands; ⁴Freudenthal Institute for Science and Mathematics Education, Utrecht University, The Netherlands

Higher educational institutions have broadly adopted Collaborative Engineering Design (CED) activities to prepare students for complex problem-solving in multidisciplinary settings. These activities are non-linear and mediated by various social practices and tools. Therefore educators might struggle in facilitating the achievement of specific learning goals. Embodied cognition is an approach that explains non-linear behaviour through organism-environment interactions and might therefore provide educators with insights on how to prompt students towards desired actions in CED activities. According to embodied cognition, we learn through actions that emerge as a response to a problem (task) and environmental constraints. Educators can guide students' behaviour by proposing tasks and adapting the environmental constraints of a learning situation, thus creating a field of promoted action. In this paper, we outline the progress of a design-based research in which insights from embodied cognition are implemented to promote desired student behaviour in CED activities. We report on the results of our problem-exploration phase. A systematic literature review and focus groups with students revealed that students are often hesitant to adopt new practices and tools that could potentially improve their collaborative design process. Next, we propose three theory-based design principles in which the task and environmental constraints are leveraged to foster the adoption of practices and tools and apply them to CED activities. Finally, we will share preliminary observations of the learning processes triggered by the designed activities and outline the directions for future research.

How to characterise performance in engineering freshmen's modelling tasks?

Charles, Sophie^{2,3,4}; Peyret, Nicolas^{1,2}

¹ISAE-Supméca, France; ²Laboratoire QUARTZ EA 7393; ³CY Cergy Paris Université; ⁴Laboratoire BONHEURS EA 7517

This paper presents a study aiming at characterising engineering freshmen's performance in modelling tasks, as well as the strategies they adopt to execute them, before and after taking a 3-D modelling course. 97 freshmen in a French engineering school were asked to produce 3-D models of a part, using three views and the product development platform Onshape. The accuracy of their models was assessed using geometrical, dimensional and functional criteria. The students' performance was also investigated with regards to their modelling strategies. We characterised more specifically the strategies they adopted to constrain the overall length of the part, and pierce the central pin. We complemented this experiment with spatial visualisation and spatial orientation tests, to explore the potential relation between modelling performance and spatial ability. We identified two strategies for piercing the pin and three for defining the total length of the part. We observed that the latter was linked to the students' spatial ability, unlike the pin piercing strategy. We observed a significant increase in the number of students who adopted an efficient strategy to define the length of the part after the 3-D modelling course. This increase seems to indicate that more students were able to take into account visual information regarding size. We nevertheless observed a lack of progression in the ability to dimension this element accurately. This confirms the unchanging need for teaching students, as well as pupils, how to read and interpret 2-D information.

Paper Session 1-15: Innovation in T&L 1 - Laboratory

Time: Monday, 11/Sept/2023: 2:30pm - 3:30pm · Location: EQ-112 Flat Room
Session Chair: Mark Michael McGrath

Integration of agile development in standard labs

Huening, Felix; Mund, Cindy

University of Applied Science Aachen, Germany

In addition to the technical content, modern courses at university should also teach professional skills to enhance the competencies of students towards their future work. The competency driven approach including technical as well as professional skills makes it necessary to find a suitable way for the integration into the corresponding module in a scalable and flexible manner. Agile development, for example, is essential for the development of modern systems and applications and makes use of dedicated professional skills of the team members, like structured group dynamics and communication, to enable the fast and reliable development. This paper presents an easy to integrate and flexible approach to integrate Scrum, an agile development method, into the lab of an existing module. Due to the different role models of Scrum the students have an individual learning success, gain valuable insight into modern system development and strengthen their communication and organization skills. The approach is implemented and evaluated in the module vehicle systems, but it can be transferred easily to other technical courses as well. The evaluation of the implementation considers feedback of all stakeholders, students, supervisor and lecturers, and monitors the observations during project lifetime.

A DIGITAL LEARNING ENVIRONMENT TWIN OF A LAB ON PROTOTYPING TO GIVE ENGINEERING STUDENTS DIGITAL ACCESS 24/7

Riess, Christian; Walter, Michael S. J.; Tyroller, Maria; Nierlich, Robert

University of Applied Sciences Ansbach, Germany

Students not always enjoy an in-depth practical learning experience with adequate hands-on during their academic education. In many fields, traditional laboratories are common learning spaces that are, however, not accessible 24/7 and the students' task is mostly pre-defined, resulting in a short and very "passive" active learning. To overcome this limitation and to provide a broader availability and to foster individual learning experience, we transformed a lab from this analog world into a digital learning and teaching environment twin. The laboratory on product design with an extensive machine park (3D-printers, CNC-carving machines, laser cutter, hand tools, etc.) is digitized and finally linked with the real-world lab. All student activities arising in the lab are transferred to the digital environment and accessible 24/7. This digitalization is implemented in Moodle incorporating mostly open-source and browser-based software to control the various machines. This results in a digital copy of the lab, its equipment, that follows the underlying product development processes and includes feedback loops and assessment levels for the individual progress of students – the "digital learning environment twin".

In this paper, we illustrate the methodological approach on the established digital learning environment twin of the lab. Furthermore, we detail the transfer of analog manufacturing process to the digital world and their combination to provide a continuous digital workflow. The paper closes with an analysis of feedback (by both students and lecturers) as well as on the usability of the new digital twin.

A survey to evaluate laboratory activities across an undergraduate engineering degree programme: data from five years showing repeatability and sensitivity

Johnson, Peter

Imperial College London, United Kingdom

Laboratory activities are an essential part of an undergraduate engineering education. This paper focuses on evaluating the student experience of laboratory activities. We present a laboratory-specific survey used with large cohorts of students (200) about laboratory activities across an undergraduate Mechanical Engineering degree programme. The key question we try to answer is whether the results of the survey can be used to inform teaching decisions such as which activities need improvement; how to improve them; and to validate these interventions.

We present nine common questions that were used to evaluate activities across a programme. We present five years of data for five of the activities we assess – specifically those from the first year of the programme. The data covers pre-pandemic, lockdown, and post-lockdown periods. The data includes activities that have remained consistent, and activities where changes have been implemented.

For consistent activities, data show good repeatability, adding confidence to the method. The effects of interventions can also be detected. We define a significant change as being a multiple of the standard deviation, across years, when no interventions were used. We discuss the validity of the survey and conclude that, in practical terms, it is useful for informing teaching decisions.

Reflections on Engineering Home Lab Kit Use in a Post Pandemic Environment

Ross, Joel; Lancaster, Sean; Selwyn, Becky; Richards, Greg; Jones, Sarah; Hardman, Dominic; Saunders, James

Faculty of Engineering, University Of Bristol, United Kingdom

Laboratory experience in engineering significantly impacts upon how students view their courses. Whilst there may be nostalgic memories of what this offered the educator on their own route through further education, it is often far from the modern reality: time bound, pre-configured, minimal student agency over input variables, and something of a data grab and dash.

Home Lab Kits (HLK), one of the innovations whose use was accelerated as a COVID-19 mitigation, have provided some long-term improvements in the educational lab experience of undergraduate engineering students in the School Civil, Aerospace, and Mechanical Engineering (CAME) at the University of Bristol. The HLKs provide an experience that allows for: independent play and exploration, development of extracurricular experimentation, and time to problem solve and learn from mistakes. This paper reports on both the educator experience and the student voice for a large common team-taught engineering lab unit delivered to ~550 students.

Students report that they have "used [HLKs] for a number of [their] own projects", that they are a "great way to get people excited about what we're actually learning about" and "made [them] feel like an engineer".

Whilst HLKs provide for less prescriptive laboratory classes, they can also lead to students being worried about less structured problem solving. However, combined with well-designed taught elements, they can produce an exciting buzz of real-time investigation and collaboration with students.

Paper Session 1-16: Student Recruitment and Retention

Time: Monday, 11/Sept/2023: 2:30pm - 3:30pm · Location: EQ-208 Flat Room
Session Chair: Balázs Vince Nagy

Study success and failure of STEM students and the connection to their learning habits

Mumenthaler, Fabian; Jermann, Patrick; Hardebolle, Cécile; Tormey, Roland

École Polytechnique Fédérale de Lausanne, Switzerland

With the educational expansion, ever more students start a tertiary degree. At [name of university], an engineering school, the number of bachelor students increased from 3'713 in 2010 to 6'330 in 2022. However, in [country name], a considerable number of students fail to achieve their first university degree – and failure rates are even higher at engineering schools. A weak mathematics background is often identified as the main reason for dropout. In this paper, we are interested to test whether inadequate learning habits are also responsible to some extent for first-year dropouts. To this end, we matched admission data with self-assessed data about learning habits. These learning habits include time management, effort regulation, and the learning strategies of elaboration and organization (204 N 823). These scales are based on one of the most often used instruments for self-regulated learning, the Motivated Strategies for Learning Questionnaire, and have been shown to correlate with academic success in various fields (Credé & Phillips, 2011).

Using logistic regressions, we find that time management and elaboration are correlated with higher probabilities of study success. Furthermore, higher scores in all learning habits but organization are related to a lower probability to repeat the first year of a bachelor's degree. Thus, together with better math skills, learning habits contribute to more and faster success in STEM fields and thus to higher student retention.

Exploring Engineering Students' Perception of Their Career Preparedness in a Systemic PBL Context in Denmark

Markman, Anna Overgaard; Christiansen, Svend Haukrog; Du, Xiangyun

Aalborg University, Denmark

The demand for graduates who are well-prepared for employment remains a persistent concern. This study aims to examine the perceptions of career preparedness among engineering students in a systemic problem-based learning environment, employing a gender perspective. The data for this study was collected through two focus group interviews conducted with engineering students in their eighth semester. The collected data was then coded, resulting in the identification of three main categories: (1) professional competence development, (2) career anticipation, and (3) gender role. The findings of the study reveal that collaboration with external companies and the provision of practical support play a vital role in enhancing career preparedness among engineering students. However, the students demonstrated limited considerations regarding their future career plans. Furthermore, notable differences were observed between male and female students in terms of their perceptions of their acquired technical-professional skills. Based on the study's outcomes, recommendations are provided for the engineering programme. These recommendations emphasize the importance of offering adequate support to female students, with a particular focus on recognizing their strengths.

Using Machine Learning Methods to Develop Person-Centered Models Predicting STEM Major Choice

Nagy, Marcell¹; Main, Joyce²; Molontay, Roland¹; Griffith, Amanda³

¹Budapest University of Technology and Economics; ²Purdue University, United States of America; ³Wake Forest University

Understanding the factors that influence the choice of a STEM major is important for developing effective strategies to increase participation in STEM fields and meet the growing demand for skilled workers. This research is based on the nationally representative data of 25,206 students surveyed in the High School Longitudinal Study of 2009 (HSL:09). The HSL:09 includes longitudinal data from 9th-grade students through their postsecondary study. First, we use machine learning to predict who is going to opt for a STEM major. Then we use interpretable ML tools, such as SHAP values, to investigate the key factors that influence students' decisions to pursue a college STEM major. We identified with a relatively high degree of accuracy the students who will later choose a STEM major, namely our CatBoost classifier achieved an AUC score of 0.791. Moreover, by interpreting the model, we find that having a science or math identity, as well as demographic characteristics, such as gender and race, play important roles in the decision to pursue a STEM major. For example, Asians are more, females are less likely to consider a STEM major, on the other hand, we also find that gender and race do not influence students' science or math identity.

Paper Session 1-17: Sustainability in Engineering Education 1

Time: Monday, 11/Sept/2023: 2:30pm - 3:30pm · Location: EQ-117 Tiered Room
Session Chair: Klara Kövesi

Tools to reshape engineering education to prepare students and professionals to be globally responsible

Truslove, Jonathan¹; Hitt, Sarah Jayne²; Crichton, Emma¹; Kraus, John¹; Upton, Juliet³

¹Engineers Without Borders UK, United Kingdom; ²New Model Institute for Technology and Engineering (NMITE); ³Royal Academy of Engineering

This paper describes the development of two tools that support educators to prepare the engineers of today and tomorrow for the simultaneous, deeply interconnected challenges that the 2023 Global Risks Report emphasises as a 'polycrisis'. This picture is worsened when considering the Institution of Engineering and Technology in 2021 found that only 7% of 1,000 UK engineering companies with a sustainability strategy had the staff with the skills to fulfil it. Against this backdrop, meeting our commitments with integrity, upskilling the current workforce urgently, and ensuring degree courses are future-fit are crucial. In response, these two new actionable tools aid educators in exploring and accelerating curriculum change. First, the Global Responsibility Competency Compass is an articulation of the essential skills, knowledge and mindsets required by the globally responsible practices society needs today. The Compass is designed for everyday professionals in the engineering sector looking to effectively navigate the complexity, uncertainty, and challenges of our age. Second, the Reimagined Degree Map, helps educators develop robust action plans to consider the broader purpose of engineering education and design relevant learning. The Map supports the translation of intention into tangible changes by designing regular learning about engineers' understanding of their global responsibilities and how to navigate through them. This presentation will describe the context and process of the tools' development and present feedback from key stakeholders and early adopters. Early results suggest the tools can support educators in collaboratively embedding sustainability and global responsibility as a core tenet across higher engineering education.

Can designing for Mars stimulate our thinking about designing more sustainably for Earth?

Berthoud, Lucy¹; Norman, James¹; Good, Ella²; Kent, Nicola²

¹University of Bristol, United Kingdom; ²Independent artists

This work describes the use of an arts-based project to stimulate creative thinking about design and sustainability for engineering students of all disciplines and years. 'Building a Martian House' was a public art project where a house designed for Mars was built in the centre of the city of Bristol, UK. It was conceived by artists, designed by the public, architects and engineers and built by construction companies. In this work, a workshop for students was developed and run based on this art project. Its aim was to use the challenge of designing for Mars as a provocation to thinking about sustainability in designing for Earth. This workshop was run for two hours for thirty-five students from different years and disciplines and involved two exercises to stimulate creativity. Students completed a pre-and post-workshop questionnaire as feedback. An important part of the workshop was the viewing of an exhibition of sixty images from the Martian house project. These images covered the design, development and building process of the Martian house and artefacts within it. Feedback from the questionnaires indicated that the workshop fulfilled some of the aims, it was interactive and guided, offered teamwork and independent design opportunities and provoked thoughts about resource utilisation and sustainable design.

Student Engagement in Sustainability Issues Through Video Production: A Multimodal Critical Consciousness-Based Approach to Engineering Education

Mejia, Joel Alejandro; Montero, Luis

The University of Texas at San Antonio, United States of America

The formation of engineering students should prioritize both technical skills in engineering and a critical awareness of the designed world. This qualitative methods study aimed to analyze the extent to which a teaching approach, based on the in the integration of Freire's critical pedagogy and Multimodal literacy frameworks, promotes first-year engineering students' development of critical consciousness. Drawing from Paulo Freire's work on critical pedagogy, the critical consciousness framework emphasizes that individuals and their practice in community awaken critical awareness of their surroundings, including the interconnectedness that exists between economic, social, political, cultural, historical, and environmental factors. To this end, we designed an activity for students to research and create videos that illustrate the interconnectedness that exists between these factors. The activity provided an opportunity to build, express, and shape their thoughts regarding the connections between the designed world and its implications on society (i.e., who wins, who loses, who is involved, etc.). Preliminary analysis identified that multimodal video production allowed students to investigate and express their own interpretations of socio-political and sustainability issues related to the use of precious minerals, specifically cobalt. Furthermore, students included descriptions of their proposals for reducing child labor abuse in cobalt mining and identified the environmental impacts of excessive use of cobalt in technological devices. Overall, this research suggests that integrating critical consciousness and multimodal literacies can be an effective strategy for promoting engineering students' formation in terms of engineering design, literacy, sustainability, and social awareness.

Sustainability in Engineering and Engineering Education: A Comparative Study of German and Saudi Arabian Industries"

Asad, Talha Bin; Bairaktarova, Diana

Virginia Tech, United States of America

Sustainability has become a major concern in the fields of engineering and engineering education. Organizations such as UNESCO have defined goals for sustainable development in engineering. As engineers design, develop, and implement products and processes that impact the environment and society, their role in promoting sustainable development is vital. Addressing sustainability in engineering curriculum is needed to equip engineers with the knowledge, skills, and attitudes required to develop sustainable solutions in their respective areas, and it involves merging the teaching of technical skills with a systems-based approach that considers the broader environmental and economical context of engineering. This requires collaboration between different disciplines and stakeholders, including engineers, educators, policymakers, and industry.

This study investigates the industry practices regarding sustainability goals and measures in two countries. Another point of inquiry is to find practical recommendations from engineers and project managers to inform engineering education curriculum in terms of knowledge and awareness of sustainability.

Qualitative case study protocol was followed in this research, and participants from Germany and Saudi Arabia were interviewed online. Thematic coding was performed to extract meaning making descriptions from the interview transcripts.

In response to the interview prompts, the participants shared their perspectives of sustainability in their area of engineering. Their recommendations towards the curriculum development included making UN sustainability goals a part of engineering curriculum, while still teaching students to adopt a 'lean product development approach' in their course projects, so that they learn the practical implementation of sustainability in engineering projects as well as in life.

Paper Session 1-18: Education with Artificial Intelligence 1

Time: Monday, 11/Sept/2023: 2:30pm - 3:30pm · Location: EQ-118 Tiered Room
Session Chair: Sefi Session Chair

FROM CURRICULUM TO CAREER: ANALYSING THE CONTRIBUTION OF DELFT UNIVERSITY'S ROBOTICS MSC PROGRAMME TO THE CAREER PATH OF ITS ALUMNI

Saunders-Smiths, Gillian; Bossen, Linette; de Winter, Joost

Delft University of Technology, Netherlands, The

The increasing global demand for robotics expertise led the Delft University of Technology to launch a two-year Master of Science programme in Robotics in 2020. The programme was designed to educate versatile robotics engineers capable of overseeing the entire process from conception of robotics systems to implementation. The curriculum integrates disciplines such as machine perception, artificial intelligence, robot planning and control, human-robot interaction, and ethics, and emphasises personal development through a course called Portfolio, which was later rebranded as Vision and Reflection. The effectiveness of the programme was evaluated by conducting a survey among the first cohort of students. The online survey, completed by 21 alumni, assessed the programme's alignment with graduates' career paths and their perceptions of the programme. Most respondents (81%) secured employment, with 69% in robotics, and all others had consciously chosen different fields. On average, graduates found jobs in under a month. Common job titles were Robotics Engineer and Software Engineer. However, graduates least appreciated the original Robot & Society and original Portfolio courses. The recently rebranded Vision and Reflection course is expected to improve student engagement by focusing on meaningful reflection rather than documentation. Overall, the programme received positive feedback, with 88% of respondents saying it provided a comprehensive robotics education, and 94% stating they would choose it again. However, the evaluation was limited to the more successful half of the cohort, indicating the need to assess the experiences of the remaining graduates, who took over 2.5 years to complete their degrees.

AI for Leadership: Implementation and Evaluation of an AI Education Program

Bagiati, Aikaterini; Salazar-Gómez, Andrés F.; Bachmann, Annalyn; Kennedy, Kathleen D.; Breazeal, Cynthia

Massachusetts Institute of Technology, United States of America

AI education is rapidly becoming the next frontier when it comes to solving the world's grand challenges; however, ways to introduce AI to large complex organizations are still vastly understudied. To address this gap in 2021, Massachusetts Institute of Technology (MIT) entered into a collaboration with the US Air Force (USAF). The goal of this relationship is to develop, study, and evaluate different learning modalities and online/in-person experiences to introduce AI to the diverse USAF workforce. The USAF is a very complex organization and its employees vary in terms of educational and cultural backgrounds, as well as in their work related needs, demands and restrictions. The initial program started in 2021 and a pilot study took place. The pilot evaluated the content, pedagogy, and educational technology used in 3 different learning journeys designed for 6 different learner profiles. Findings from 2021 guided improvements for future iterations. The updated iteration of the learning journey was introduced to the second cohort of the program in 2022. Cohort 2 included 200 USAF leaders, managers and decision makers, and the learning journey consisted of a combination of synchronous and asynchronous online experiences, as well as an in-person active learning component offered on campus to a subgroup of the learners. This research paper will introduce the updated iteration of the program, the evaluation of the learning journey, as well as the overall learner experience.

Exploring the Application of ChatGPT in Mechanical Engineering Education

Puig-Ortiz, Joan; Pàmies-Vilà, Rosa; Jordi Nebot, Lluïsa

Department of Mechanical Engineering, Universitat Politècnica de Catalunya Barcelona, Catalonia, Spain

In the past decade, the integration of artificial intelligence (AI) in education has emerged as a growing trend. ChatGPT is a chatbot system based on the GPT-3 language model of artificial intelligence that appears in November 2022. It is developed by OpenAI, and it represents a significant advancement in the field of generative AI. This technology has the ability to generate highly coherent written content, which closely resembles human-created texts.

The integration of ChatGPT into the educational process requires adaptations in pedagogical methods. Nowadays, we have an additional tool available for both educators and students that must be used with responsibility. Rather than merely preventing plagiarism, the primary concern for educators is to foster critical engagement with the system.

While this technology is not yet equipped to solve targeted mechanical engineering issues, it can offer valuable support in certain tasks. ChatGPT is a versatile language model and due to its capacity for producing lines of code in various programming languages, it holds particular potential for use in engineering contexts.

This study showcases the potential of ChatGPT to enhance the teaching and learning of mechanical engineering by proposing a framework of academic activities structured in a four levels pyramid format: 1) Knowledge Retrieval and Comprehension, 2) Application and Analysis, 3) Synthesis and Evaluation, 4) Creation and Innovation.

The study also identifies current limitations, and gathers feedback from participating students. Overall, ChatGPT represents a challenged tool for education, provided it is used responsibly and in line with principles of inclusivity and equity.

Insider action research on AI needs within the EIT InnoEnergy ecosystem

de Waard, Inge; Gonzalez, Albert; Gelan, Anouk

EIT InnoEnergy, Europe

This practice paper describes an ongoing insider action research within the EIT InnoEnergy ecosystem. Its goal is to inspire teaching staff from the seven EIT InnoEnergy double degree Master of Science programmes to integrate Artificial Intelligence (AI) tools and knowledge into their courses based on joint learning. This insider action research runs from 2023 to the end of 2024. In late 2022, a problem statement of 'AI tools for Education' was identified by EIT InnoEnergy teachers as being crucial for their future learning and teaching processes. To align the needs of teaching staff with the complexity of emerging AI tools, a decision was made to plan a hybrid insider action research method. The outcome of this research will be two-fold: one resulting in an AI toolkit covering three teaching staff needs, and two getting a better understanding of the processes involved in taking up a learning innovation at different engineering partner universities spread across Europe within the EIT InnoEnergy ecosystem. This paper shares the first phases of the insider action research and an overview of the individual AI initiatives taken by teaching staff at different partner universities that is the result of a first qualitative data analysis coming from initiatives shared by the insiders (i.e., teaching staff). Action research methodology was chosen to inspire teaching staff to take an investigative and experimental attitude to the new AI technologies while allowing all actors to support each other and grow towards an AI integration in courses and curricula.

Parallel Workshops 2-01: Parallel Workshops 2-01

Time: Tuesday, 12/Sept/2023: 8:00am - 9:00am · Location: EQ-116 Flat Room

Engineering Education Research: Writing for Publication

Broadbent, Rebecca¹; Daniel, Scott²; Edström, Kristina³; Bernhard, Jonte⁴; Chance, Shannon⁵; Mitchell, John⁶; van den Bogaard, Maartje⁷; Saunders, Fiona⁸; Beagon, Una⁵; Main, Joyce⁹; Knight, David¹⁰

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In this interactive workshop, facilitated by a team of editors from the European Journal of Engineering Education, the Journal of Engineering Education, and IEEE Transactions on Engineering, participants will have the opportunity to network with other scholars in the field, learn about the journal publication process, and how best to navigate it.

It will also serve as an informal opportunity for scholars at all stages of their publication journey to share their experiences, both positive and negative, directly with journal editors. Participants will take away a co-created document with shared insights about writing for publication and enhanced professional networks.

Motivation and learning outcomes

The process of getting an article published in an academic journal can be difficult to navigate. Authors typically wonder what editors and reviewers seek, how to focus their manuscripts, and how to expand conference papers to a level acceptable for journal publication.

After the workshop, participants will:

- Be able to describe the Engineering Education Research academic journal publication process from submission to publication.
- Understand how to identify the right journal for their work.
- Understand how to use the journal review criteria to write effectively.
- Be better equipped to submit successful manuscripts and revisions for publication.

Background and rationale and relevance

Understanding academic journals and finding the appropriate journal for your contribution to the field of Engineering Education Research can improve the academic publishing experience for all. Given that these are skills which we can and need to develop as researchers, this workshop aims to provide an overview of the academic publishing process to make this process transparent and attainable. Discussion will help stimulate reflection and develop key writing skills, whilst providing everyone with the opportunity to share their experiences and help foster a supportive community.

Workshop design

This interactive session aims to help authors (new and experienced) develop their knowledge and understanding of academic journals and effective manuscript writing for publication. Whether you are a student, Early Career Researcher or established researcher, this workshop provides a space to discuss your experiences and challenges, as well as generate strategies for future submissions. In addition, editors from top Engineering Education Research journals will share their tips for improving the Engineering Education Research publishing experience.

Workshop outline

Note that the following timings and facilitation techniques will be flexible and malleable dependent upon the number of participants and the logistics of the room.

- 10 minutes - Welcome and Introductions – Getting to know each other (facilitators and participants).
- 5 minutes – Think-Pair-Share/Quickfire Discussion – What is the best aspect of authoring? What would you like to know as a new author? What is the most daunting aspect of authoring?
Collating “what you would like to know” and “what is most daunting” to then seed discussion in the next activity
- 20 minutes – Group Discussion with each group facilitated by an editor - Strategies for authoring (these will be focused by the outcomes of the initial group discussion regarding daunting aspects of authoring)
Break-out groups will collaborate on an online shared document to collate and distill workshop discussions and insights
- 15 minutes – Synthesis – Discussion of results from each group.
- 10 minutes – Wrap Up and Top Tips from the Editorial Teams.

Through these dialogues, participants will co-create an enhanced understanding of strategies for success in academic publishing. Key takeaways from the workshop include the broader networks from having worked with a variety of scholars and journal teams, and the co-created document with workshop insights.

Significance for engineering education

This workshop will demystify the publication process for prospective authors. It will broaden the pool of potential contributors, making engineering education research more accessible for the diverse community engaged in this field. In turn, by hearing from this broader pool of contributors, the editorial teams from leading journals will have insights into the perspectives and experiences of both established authors, and new authors embarking on their academic journeys.

Target audience

The intended audience for the workshop includes students, early career researchers, as well as more established researchers interested in mentoring their peers on their publication journeys.

The maximum workshop size will be 60 participants, or less depending on the room layout and size.

Parallel Workshops 2-02: Parallel Workshops 2-02

Time: Tuesday, 12/Sept/2023: 8:00am - 9:00am · Location: EQ-112 Flat Room

Teaching Competencies

Bengmark, Samuel

Chalmers University of Technology, Sweden

Motivation and learning outcomes

The goal of this workshop is that all participants shall enrich their understanding of what teaching competencies can entail and get new perspectives on their strengths and areas of improvement as engineering educators.

Background, rationale, and relevance

Research shows that teachers' abilities are essential for students' learning (Darling-Hammond, 2006; Hattie, 2008). However, there is no consensus on what teaching skill means and how it is detected. Is it that the teacher listens to the students, that the teacher explains well, or that the teacher uses modern methods and tools for teaching and can describe the teaching in an informed way? Or is it that the teacher is very knowledgeable and shows love for the subject, or that the teacher continues to develop?

At Chalmers University of Technology, we use a model of teaching competencies developed in connection with a double degree program leading to degrees in both engineering and education. The model is hierarchical and consists of nine sub-competencies grouped into three competencies. This model will be described and tested against the participants' experience as part of the workshop.

Workshop design

In this workshop, we will search for answers to the following question: What competencies are needed to succeed in teaching engineers? We will start by allowing the workshop participants to draw on their own teaching experiences and individually list teaching competencies they see as essential in teaching. Each selected competence is noted on a separate sticky note. The participants will then, in small groups, discuss and compare their noted competencies to clarify for themselves and the other group members what each competency entails. At the same time, the groups combine the individual answers into a joint compilation by grouping competencies referring to the same competencies.

After this group work, the workshop leader will present the model of teaching competencies used at Chalmers. The model will also be briefly compared with other models from the literature (Darling-Hammond, 2006; Niss, 2003; Koehler & Mischra, 2009).

The workshop participants then use the Chalmers model as a framework onto which they map the competencies their group has identified. This is done by placing the sticky notes on an A2 poster handed out at the workshop, where the model is illustrated.

The workshop continues with a common discussion about the relationship between the Chalmers model and the competencies suggested by the participants. Have the participants suggested teaching competencies that do not fit into the Chalmers model? Are there parts of the Chalmers model that are considered superfluous? Here we collectively look for answers to the workshop question.

The workshop ends by discussing ideas on why and when a model for teaching competencies is useful. We also let the participants self-estimate their teaching competency profile according to the Chalmers model in an anonymous digital poll and reflect on the aggregated result.

Significance for engineering education and attractiveness of the workshop topic

A scientific model, often called just a model, is a description that helps grasp some aspects of reality [5]. As teachers of engineering subjects, we know how essential and useful models are, even if they are simplifications of the phenomenon. They can be used for creating understanding, predictions, development, and a common viewpoint.

A model of teaching competencies can similarly be a tool for developing engineering educators. The engineering educator can use it to identify individual aspects that need improvement. For the engineering educator community, it can contribute with a common language to use when talking about our development. A model of teaching competencies may also add a perspective in the process of identifying pedagogical competence or lack thereof when developing, promoting, or hiring staff.

Enhancement of knowledge and dialogue on the workshop topic.

There is an ongoing discussion within the engineering education community about engineering competencies, i.e. the competencies our students need to develop. This is included in one of the themes of this conference, SEFI2023. In the same way, we argue that there is value in getting a better idea of what competencies we, the educators, need to develop. In this workshop, we want to contribute to that discussion by focusing on the competencies needed for teaching engineers.

The goal is that the workshop discussion will enrich the participants by making them reflect and be explicit about their ideas on teaching competencies, but also by getting to know a model that is already in use at Chalmers. There it is used both in a mentor program for new staff and as a basis for program development in a combined engineering and teacher education program.

Finally, we also want to add to the collective understanding of teaching competencies for engineering educators by using the workshop participants' knowledge and experience to challenge the suggested model to develop it further.

Target audience, participant knowledge required, target numbers of participants and restrictions on size if appropriate.

The target group for this workshop is people with experience in teaching engineers at the university level. The discussion will not be restricted to any specific subject. The workshop leader teaches mathematics and will primarily use examples from that subject but hopes that the participants will contribute with examples also from other engineering subjects.

There is no restriction on the number of participants.

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Parallel Workshops 2-03: Parallel Workshops 2-03

Time: Tuesday, 12/Sept/2023: 8:00am - 9:00am · Location: EQ-203 Flat Room

Getting started – hands-on producing lecture films

Pfennig, Anja

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Lecture videos are more and more implemented in higher engineering education to be used widely by students because very often literature only presents results but not how to get there. Lecture videos may close this gap and visualize the sometimes obvious but still hard-to-understand scientific background. To attract students and become a fully accepted learning material these videos need to be of a certain standard. Based upon our 8 years of experience it is important is to involve students directly into the concept and making-of (peer-to-peer approach), because students' needs and their perspectives on teaching material are directly included in the videos. To encourage lecturers in engineering this workshop provides a short guidance to look at the peer-to-peer approach and more important basic needs and requirements of the lecture film production and "just get started". Good lecture videos may successfully be produced with low threshold.

Parallel Workshops 2-04: Parallel Workshops 2-04

Time: Tuesday, 12/Sept/2023: 8:00am - 9:00am · Location: EQ-315 Flat Room GD

Teaching in student-centred active learning spaces: How relational, pedagogical, spatial, and technological aspects intertwine and affect the learning environment

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Norwegian University of Science and Technology, Norway

Motivation and Learning Outcomes

Higher educational institutions internationally have shown a growing interest in developing learning spaces that support student-centred learning approaches. For engineering education, this development aligns well with an increased emphasis on cross-disciplinarity and a system-thinking approach. However, research and our own experiences as teachers and evaluators of such learning spaces suggest that teachers who enter these learning spaces need support, as the complexity of the teaching situation becomes more apparent, compared to the traditional lecture hall. In this workshop, we will investigate this complexity together with the participants.

Participants can expect to leave the workshop with a better understanding of:

- a conceptual framework that will assist the participants in navigating through the complexity of teaching in student-centred learning spaces.
- how to plan, implement and evaluate one's own teaching in such learning spaces (Do's and Don't's).

The take-home message from this workshop is an appreciation for how the relational, pedagogical, spatial, and technological aspects intertwine and affect the learning environment in spaces designed for student activity.

Background and rationale

Higher educational institutions internationally have shown a growing interest in developing learning spaces that support student-centred learning approaches. This increased interest can be explained by a variety of factors: For one, institutions need to optimize the use of their limited physical space. usage of campus. Furthermore, traditional higher education institutions are grappling with the challenge of maintaining a vibrant campus in an increasingly digital world, and attractive learning spaces coupled with appropriate teaching and learning activities might play an important role in this respect. Finally, the emergence and development of these learning spaces has followed an increased awareness among faculty of the potential associated with student-centred and innovative teaching and learning approaches (e.g. Freeman et al., 2014).

However, the emergence of these student-centred learning spaces has elucidated the complexity of the teaching and learning situation, as both teachers and students are expected to take on more involved roles in these learning spaces. The complex interdependence between spatial, pedagogical, relational, and technological aspects and affordances become more tangible, compared to the traditional lecture hall. Our observations suggest that teachers and students who enter these spaces need support, in order to adapt to these new roles. We follow Leijon et al. (2022), who state that: "Space cannot be isolated as a single cause to positive learning outcomes, but people, space, interaction and learning are intertwined" (p. 15). One conceptual tool in this respect is the Pedagogy-Space-Technology (PST) framework, developed by Radcliffe et al. (2008). This framework emphasizes the interdependence of pedagogy, space, and technology – which is of critical importance concerning development and appropriate use of such learning spaces. It suggests that the design of effective learning spaces requires consideration of not only the pedagogical approach being used but also the physical space and technological tools that will support the learning process. The PST framework offers a holistic approach to designing learning environments.

Workshop Design

In this workshop the participants will actively engage in discussions of how to use learning spaces designed for student activity. The outline for the workshop is as follows:

- A brief introduction, where we focus on student-centred learning spaces in general: typical technological, spatial and infrastructural affordances associated with these types of spaces. (15 min)
 - o This introduction will be exemplified with visual representations of different learning spaces, which we will examine together with the participants.
- Participants are divided into small groups, where they will draw upon their own teaching experiences, discussing how and to what extent the different learning spaces could facilitate their students' learning processes. (15 min)
- Our team will facilitate these group discussions, and we hope to gain answers to questions such as (15 min):
 - o What is the teacher's role?
 - o What do we expect from the students?
 - o How should we facilitate for learning, and what are our responsibilities?
 - o What are the potential opportunities and constraints of these spaces?
- The workshop is finalised with a plenary discussion where we summarise the group discussions. (15 min)

Significance for Engineering Education

As engineering education are moving toward emphasising cross-disciplinarity and a system-thinking approach (Crawley et al., 2014), there is an increased need to facilitate a study culture where students work actively in collaboration with each other to solve authentic problems, where the teacher takes on the role as a facilitator for the students' learning processes. In this perspective, the space and the infrastructure surrounding the students' learning processes become important.

Over the years, our own university has developed a range of student-active learning spaces specifically designed to facilitate student-centred teaching and learning in an engineering context. These spaces are designed with a variety of collaborative features such as group stations, work surfaces, and technology. Our team has extensive experience in utilizing, improving, and evaluating the affordances of these spaces, and we have been involved in instructing teachers on the pedagogical use of these spaces.

Target Audience

The target audience for this workshop are teachers, educational developers, and leaders in education who wish to both share and expand their knowledge on the use of spaces for student-active learning. No prior knowledge about this topic is required. We aim to attract about 30 participants to this workshop, but if more people find this workshop interesting, we welcome everyone who has an interest in the teaching-learning-space nexus.

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Parallel Workshops 2-05: Parallel Workshops 2-05

Time: Tuesday, 12/Sept/2023: 8:00am - 9:00am · Location: EQ-208 Flat Room

Preparing Teachers for Culturally Diverse Engineering Classrooms: Sharing Experiences and Activities

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¹Chalmers University of Technology, Sweden; ²KU Leuven, Belgium

Diversity and inclusion are essential goals in both attracting more diverse students to engineering institutes and retaining them. This workshop aims to build on the discussions from the SEFI SIG Diversity, Equity and Inclusion-Workshop at this conference, with a particular focus on the internationalised classroom and cultural diversity. Both student and teacher groups are becoming more culturally diverse, yet teachers are seldom prepared for this changing student group. At the same time, teachers play a crucial role in the successful integration of these students into the formal and informal curriculum. This workshop aims to assist participants in formulating their own activities for the culturally diverse engineering classroom.

The workshop is divided into two parts: (1) setting the scene and (2) teaching activities in the culturally diverse engineering classroom. In the first part, participants will be asked to share their own experiences and practices in their own diverse teaching environments, using a brief questionnaire on internationalisation at home activities, trialled nationally in Finland (Weimer et al, 2019). Internationalisation at home is commonly defined as “the purposeful integration of international and intercultural dimensions into the formal and informal curriculum for all students within domestic learning environments” (Beelen and Jones, 2015, p.69). The results of this questionnaire will be used to give an overall picture of current activities and practices and at the same time, to introduce possible activities for the integration of such dimensions into the culturally diverse engineering classroom.

In the second part, participants will explore possible activities for the diverse classroom, using inspiration from an on-going research project co-funded by the Swedish Foundation for International Cooperation in Research and Higher Education (*Educating the educators: professional development of academics for internationalisation at home, 2023- 2025*) and examples from current faculty courses and workshops at the facilitators’ home universities. These activities will focus on ways that teachers can facilitate a more integrated classroom, taking a culture-as-construct approach (Handford et al, 2019), through more purposive use of group work for example (Bergman et al, 2017).

The target audience for this workshop is anyone involved in engineering education, including teachers, administration, and management interested in issues of diversity, inclusion, and equity. By the end of the workshop, participants will have a toolkit of ideas to facilitate the culturally diverse engineering classroom applicable to their institutional setting.

Parallel Workshops 2-06: Parallel Workshops 2-06

Time: Tuesday, 12/Sept/2023: 8:00am - 9:00am · Location: EQ-207 Technology Room

Using Q methodology to explore key competencies of interdisciplinary engineering education

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¹University of Twente, Netherlands, The; ²Eindhoven University of Technology, Netherlands, The

Overview of workshop

Interdisciplinary engineering education (IEE) is a promising outlook that potentially reforms the practices of educating engineers for a sustainable and inclusive future. However, IEE practices see a challenge of clarifying and aligning learning goals and assessments. Fundamental questions rise regarding both what IEE is and how it positions regarding present perceptions and practices of engineering education. Opinions and attitudes of different stakeholders involved in engineering education shape the meaning, practice and future development of IEE. Embedded in the goal of investigating different ideas about what interdisciplinarity entails in deciding educational content and designing curricula of engineering education, this workshop introduces Q-sort method that is fruitful for exploring different opinions and the underlying patterns. To explore how IEE may mean differently for different people, we take competency as an indicator and invite workshop participants to together devise a list of competencies that IEE may cover. Participants will then learn about Q-methodology and try it out by ranking the competencies according to the instrument. This task will force participants to prioritize certain competencies over others thus confront participants with the question: What is central for engineering education, which has elements that have been traditionally emphasized but is now going through an interdisciplinary transition?

Theoretical foundation

Engineering education has generally acknowledged two aspects of competencies that overarch knowledge, skills, attitudes, values and behaviors: disciplinary competencies that address content, especially deep understandings of disciplinary knowledge and mastery of skills, of specific engineering topics; and generic competencies that concern general work performance in professional engineering settings and daily challenges, transferable across particular vocational and life contexts. An interdisciplinary transition in engineering education brings about modification and complement to the traditionally addressed competencies, involving various types of disciplinary expertise as well as transversal cognitive and social capacities. While the scope of disciplinary competencies expands beyond traditionally emphasized technical elements, generic competencies in IEE transcend relatively homogeneous engineering contexts and stress broader socio-technical complexities in engineering practices. However, opinions

vary regarding what IEE entails in competency development, namely which competencies are key to IEE. Q methodology has been fruitfully used in disciplines and fields where human subjectivity is at stake, including in educational research. In this case, we apply it to detect differences and general patterns of conceptualizing IEE, for which emphases, priorities and focuses of competencies are placed differently.

Activities

The workshop will consist of 5 sections: 1. Introducing IEE and a framework of how interdisciplinarity modifies competencies that engineering education addresses (presentation), 2. Devising a list of IEE competencies (interaction), 3. Introducing Q-sort methodology, rationale and technique (presentation), 4. Trying out Q-sort based on the devised competency list (hands-on task, interaction), 5. Introducing Q-sort analysis using results from a previous Q-sort study on IEE competencies (presentation).

Target audience

This workshop is relevant to engineering education and interdisciplinarity in general. It will be of special interest to engineering educators who are engage in interdisciplinary education and innovative curriculum design.

Parallel Workshops 2-07: Parallel Workshops 2-07

Time: Tuesday, 12/Sept/2023: 8:00am - 9:00am · Location: EQ-113 Flat Room

LGBTQ+ Safe Zone Ally Workshop

Chavela Guerra, Rocio; Farrell, Stephanie

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ABSTRACT

Lesbian, gay, bisexual, transgender, and queer (LGBTQ+) individuals have historically faced harassment, exclusionary behavior, and discrimination in many aspects of their lives, including in educational settings. This workshop will equip participants with the knowledge and tools to (1) recognize the negative impact of bias and heterosexual/cisgender privilege on the experiences of LGBTQ+ individuals; (2) recognize challenges faced by LGBTQ+ individuals in STEM fields; (3) identify strategies for creating an inclusive and affirming environment; and (4) formulate a plan to become an ally for LGBTQ+ individuals. The workshop is open to students, faculty, and the professional community in STEM fields and assumes a basic understanding of LGBTQ+ concepts and terminology. By becoming Safe Zone allies, STEM professionals can help create a more diverse and talented engineering workforce and promote diversity and inclusion within the field.

1 MOTIVATION AND LEARNING OUTCOMES

Despite significant progress in LGBTQ+ rights and representation in recent years, individuals who identify as LGBTQ+ still face discrimination and marginalization in many areas of society, including in educational settings. In higher education, studies have shown that LGBTQ+ students are more likely to experience harassment, exclusion, and a hostile campus climate than their heterosexual peers (Rankin, Weber, Blumenfeld, & Frazer 2010). Research also indicates that a negative campus climate can impact the academic performance, mental health, and overall well-being of all students, particularly those from marginalized groups (Greathouse et al. 2018). Therefore, creating an inclusive and supportive campus climate is essential for the success of all students.

As STEM fields have historically been male-dominated and heteronormative, LGBTQ+ individuals in these fields often face unique challenges and barriers to achieving equality. Thus, our abbreviated Safe Zone workshop aims to address the following learning outcomes:

1. Recognize the negative impact of bias and heterosexual/cisgender privilege on the experiences of LGBTQ+ individuals.
2. Recognize challenges faced by LGBTQ+ individuals in STEM fields and recognize how engineering culture can act as a barrier to inclusion and equality.
3. Identify strategies for creating an inclusive and affirming environment for LGBTQ+ individuals on college campuses.
4. Formulate a plan to become an ally for LGBTQ+ individuals.

2 BACKGROUND AND RATIONALE

The concept of Safe Zone workshops can be traced back to the 1980s and the LGBTQ+ community's fight for equal rights and recognition. During this time, some universities and colleges began establishing LGBTQ+ resource centers to provide support and resources for LGBTQ+ students, faculty, and staff. However, these centers were often insufficient to create a safe and inclusive environment for LGBTQ+ individuals on campus.

The Safe Zone program, which originated in the 1990s, has been successful in creating an inclusive campus environment for LGBTQ+ individuals by training faculty, staff, and students to be allies and advocates for the LGBTQ+ community. The program has since been adopted by numerous institutions, with Safe Zone ally training and institutional policy changes affecting a gradual positive change in climate for LGBTQ+ individuals (Mack 2014).

Despite these initiatives, progress in STEM departments has been slower than in other disciplines (National Academies of Sciences, Engineering, and Medicine 2019). Research has shown that aspects of STEM culture serve as impediments to advancing LGBTQ+ equality in our disciplines, which translates into a chillier climate for LGBTQ+ individuals in STEM (Cech 2013, 2015; Cech & Waidzunus 2011).

Therefore, there is a pressing need to create more Safe Zone allies in STEM who can recognize and mitigate the barriers faced by LGBTQ+ individuals in these fields. Our proposed workshop aims to equip participants with strategies for creating a more inclusive and affirming environment for LGBTQ+ individuals in STEM departments and beyond.

3 WORKSHOP DESIGN

This workshop is designed using best practices (LGBT Resource Professionals) to achieve changes in attitudes, knowledge and supportive behaviours of STEM professionals toward LGBTQ+ students and colleagues. The one-hour agenda includes topics related to:

1. Heteronormativity, bias, and heterosexual/cisgender privilege
2. Aspects of engineering culture that serve as a barrier to inclusion and equality for LGBTQ+ individuals
3. Strategies for creating an inclusive and equitable environment for LGBTQ+ students and professionals
4. Formulating a plan to become an LGBTQ+ ally

Prior to the workshop, participants will receive a primer on basic LGBTQ+ concepts and terminology. Workshop activities will promote understanding and empathy and provide opportunities to practice responding to bias. At the end of the workshop, participants will use what they have learned in the workshop to formulate a plan to become an active supporter of LGBTQ+ students and colleagues.

4 SIGNIFICANCE FOR ENGINEERING EDUCATION AND ATTRACTIVENESS OF THE WORKSHOP TOPIC

Safe Zone ally training can help create a more inclusive and supportive learning environment for LGBTQ+ students, faculty, and staff. Like many other STEM fields, engineering has historically been less welcoming to LGBTQ+ individuals, and they may face challenges such as discrimination, harassment, and marginalization. Consequently, LGBTQ+ students and professionals are more likely to leave STEM than their non-LGBTQ+ peers (Cech & Waidzunus 2021; Hughes 2018).

By participating in this workshop, engineering educators can gain a deeper understanding of the challenges that LGBTQ+ individuals may face in their academic and professional careers and learn strategies to create a more inclusive and supportive environment. The workshop will help practitioners to identify and challenge their own biases and assumptions and provide them with the tools to create a welcoming and affirming environment on campus.

Achieving a critical mass of Safe Zone-trained professionals can help engineering schools and departments send a message that they are committed to promoting diversity and inclusion within the field. This can positively impact the recruitment and retention of LGBTQ+ students, faculty, and staff and contribute to creating a more diverse and talented engineering workforce.

5 TARGET AUDIENCE & PARTICIPANT KNOWLEDGE REQUIRED

This abbreviated Safe Zone Ally Training is an interactive, research-informed workshop for students, faculty, and the professional community. The workshop content and materials have been developed and refined by a community of STEM professionals specifically for a STEM audience. The workshop assumes a basic understanding of LGBTQ+ concepts and terminology around sex, gender, and sexual orientation. Participants will be provided with a resource in advance of the workshop to review these concepts.

6 ENHANCEMENT OF KNOWLEDGE AND DIALOGUE ON THE WORKSHOP TOPIC

Safe Zone workshops are interactive training sessions intended to raise awareness for LGBTQ+ inclusion in STEM and create a visible network of allies to foster a supportive atmosphere for LGBTQ+ individuals. Our abbreviated Safe Zone workshop will provide participants with an awareness of biases and assumptions that may affect interactions with LGBTQ+ individuals. Participants will also learn how to recognize discrimination and privilege and the impact they have on the experiences of LGBTQ+ individuals. In addition, the workshop will explore the specific aspects of engineering culture that can act as barriers to LGBTQ+ equality in STEM fields.

Through interactive activities and discussions, participants will develop empathy and understanding of LGBTQ+ experiences and learn tangible strategies for creating a more inclusive and affirming environment for LGBTQ+ individuals in STEM departments and beyond. By becoming Safe Zone allies, participants can contribute to a campus culture that values diversity, fosters inclusivity, and supports all students' intellectual and social development. A post-workshop survey will be sent to capture participants' insights and feedback.

7 ACKNOWLEDGMENTS

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Parallel Workshops 2-08: Parallel Workshops 2-08

Time: Tuesday, 12/Sept/2023: 8:00am - 9:00am · Location: EQ-204 Flat Room

How to make calculus assignments not boring? Designing calculus assessment with the constructive, contextual, collaborative, and self-directed principles of problem-based learning.

Boussé, Martijn^{1,2}; Phillips, Gavin¹; Jongen, Stefan¹; Bevers, Lonneke¹

¹Faculty of Science and Engineering, Maastricht University, the Netherlands; ²Department of Advanced Computing Sciences

Engineers use science, technology, and math to solve problems. Usually, engineering students follow calculus, a core discipline in engineering programs, as one of their first mathematical courses. This course lays the foundation for courses such as thermodynamics, kinematics, and fluid mechanics. There are three key tools in calculus: limits, derivatives, and integrals. Students need to learn how to use these *and* how to apply them in order to become great problem solvers. However, as one of the most challenging courses in engineering programs, students have difficulties to master these learning outcomes. One reason could be the traditional teaching and learning methods that neglect the fundamental principles of Problem-Based Learning (PBL).

The aim of this workshop is to introduce the attendees to the PBL system employed at Maastricht University. In particular, we briefly highlight our vision on assessment, including meaningful assessment and the constructive, collaborative, contextual, and self-directed (CCCS) principles of PBL. In the first part of the workshop, we illustrate the principles via three examples that were developed for a calculus course in the BSc Circular Engineering at Maastricht University consisting of a curve sketching assignment, an integration competition, and an integral application. The first assignment challenges the students to create their own exam question about curve sketching by means of a multi-step assignment involving function design, developing grading and solution manuals, and (peer) review, improving student confidence. The second assignment is a competition where student teams attempt to solve as many integrals as possible in a short amount of time according to a particular grading scheme. The assessment encourages fine-tuned skills, teamwork and tactics, improving students' interaction. For the third assignment, we propose an assignment where student teams have to come up with a well-founded and rigorous solution to a particular issue related to circular engineering, which they have to design themselves (!), using integral tools, improving students' motivation in the process.

The second part of the workshop will provide an opportunity for attendees to explore how they can apply these principles to the assessment components in their own courses. Through an interactive and collaborative exercise, attendees will attempt to identify the CCCS principles, evaluate if they already apply them, and if not, explore strategies to incorporate them. The workshop organizer will provide feedback during the process. In the end, we will bring several ideas back to the main session for a general discussion and conclusion.

Parallel Workshops 2-09: Parallel Workshops 2-09

Time: Tuesday, 12/Sept/2023: 8:00am - 9:00am · Location: EQ-212a-d (All)

Reflective Practice in STEM Degrees to Support Adaptability and Lifelong Learning

Thomson, Gareth¹; Kovesi, Klara²

¹Aston University, United Kingdom; ²ENSTA-Bretagne, France

Reflective learning might be defined as “*practice which involves the development of learning and understanding through self-review to help determine progress against goals and future learning needs*”.

Reflective practice has been identified as an important and emerging aspect of Engineering Education (Sepp et al., 2015) in particular with regard to the personal, interpersonal and professional skills needed alongside technical competencies (Sepp et al., 2015). Similarly, Berglund’s (2018) empirical study provided evidence of engineering students’ skills development in their personal effectiveness (personal management), social and interpersonal competence (teamwork and communication), and the engineering professional role (engineering roles) through reflective practice. This work highlighted the potential benefits of reflective practices on engineering students’ professional development laying the foundations to help graduates habitually identify and work toward development needs while progressing through their careers.

Eshuis et al. (2022) identified that while students often appreciate the importance of reflective practice as part of their learning and career preparation they were often not always satisfied with the tools or assessments used. Reflective reports were often regarded as the least meaningful in the eyes of the students. Reflective conversations with tutors were preferred by some indicating the important supportive role of teachers in this process. Similarly, Morgan et al. (2021:13) observed, despite an acknowledgement of the value of reflective practice, engineering students’ showed reluctance and a generally low level of true reflection beyond simple reporting of facts. Therefore, teachers play an important role for giving clear assignment and guidance by supporting students’ all along of their reflective practice in a persistent way (Cosgrove et al., 2014) (Wallin et al. 2016).

This workshop also follows on from a recent survey by the authors of engineering academics (n=50) which aimed to investigate the use of, attitudes towards and approaches used to encourage reflective practice as part of the educational process.

Why should I attend ?

This workshop will particularly appeal to academics involved in or keen to find out more about supporting students to develop their approaches to reflective learning, to better develop ownership of their own learning processes and to foster skills to support lifelong learning.

What will we do ?

We will get together to briefly explore the results of the survey. We will then examine ways to implement reflective practice taking account of these community experiences while also being aware of practical and pragmatic concerns. Using a world café type approach we will pose questions and prompts to help examine and develop strategies to support students at different phases in their development.

What can I take away from the experience ?

You will take away ideas for future approaches to support your own students which offer opportunities for them to develop skills in reflective practice but which are also practical and pragmatic in terms of curriculum fit.

2023 Draft



SIG Workshop 2-01: SIG Workshop 2-01

Time: Tuesday, 12/Sept/2023: 8:00am - 9:00am · Location: EQ-211 Flat Room

Who, What, How? Tackling skills challenges: future relevance, stakeholder differences, and teaching hurdles.

Cooke, Neil¹; Manzini, Raffaella²; Benedetti, Matteo Di³; Wint, Natalie⁴; Griffiths, Jenny⁴; Torres, Francesc⁵; Johannsen, Thies⁶; Winkens, Ann-Kristin⁷; Tilley, Emanuela⁴; Hawwash, Kameel¹

¹University of Birmingham, United Kingdom; ²Università Carlo Cattaneo - Liuc, Italy; ³Sheffield University, UK; ⁴University College London, UK; ⁵UPC, Barcelona, Spain; ⁶Technical University Berlin, Germany; ⁷RWTH Aachen University, Germany

WHAT ARE THE CURRENT CHALLENGES IN TEACHING ENGINEERING SKILLS?

Our goal is to teach a diverse cohort of engineering students who will bring a variety of perspectives to the profession. This will result in more inclusive and creative engineering products, services, and solutions. We must teach a growing number of emerging technical competencies in areas like immersive technologies, digital twins, additive manufacturing, visual analytics, cyber security, AI, and systems complexity. Moreover, employers place increasing value upon professional skills which compels us to teach these too.

Accelerating our need to better teach professional skills is the emergence of a new technical competence - AI. While this will significantly transform the way engineers design, optimise, and innovate solutions while applying their critical and analytical technical acumen, it also highlights the need for engineers to develop those people-centric skills which are less likely to be replaced by chatbots, solvers, and content generators. These skills include empathy, emotional intelligence, teamwork, interdisciplinary, lifelong learning, critical thinking, cultural awareness, ethical sensitivity, social responsibility, and the innovation and entrepreneurship mindset.

'Skills' are often interchangeably referred to as competencies, outcomes, and attributes. This can result in contradictory views as to what is meant by skill, how skills are taught and developed, and how students demonstrate proficiency; each engineering education stakeholder has their own definitions. Consequently, we hit several barriers when instructing students. Namely, these include: unclear motivation, pedagogical shortfalls, institutional inertia, perceived lack of space in curricula, and fear of a negative response.

STRUCTURE

In this workshop run by the Engineering Skills SIG, you will have the opportunity to discuss and learn about the current challenges we encounter to teach engineering skills. We will run the workshop loosely based on the "world café" participatory method with aims to share knowledge, build relationships, and discuss new ideas. The room is split into three areas for small groups of 4-5 persons to sit together and informally discuss these questions with a member of the SIG hosting each table. There are 3 consecutive rounds of conversation so you can visit multiple tables. Each area in the café is focussed on one of these questions:

• **What?** Here we will discuss which skills are most relevant for future practitioners. We maintain exhaustive lists of skills which might be considered too long to be of use to either educators or students. For example, the EU EntreComp framework for outlining the innovation and entrepreneurship mindset has 15 competences along an 8-level progression model! Is there a way to rationalise such inventories and make them more comprehensible? In order to develop effective educational activities for senior STEM students, it is of particular interest to define and agree on what are the few key skills required to develop early in a technical career.

• **Who?** In this area we will focus on the differences in the way that various professional skills are conceptualised by professional engineering institutions, engineering educators, employers, and students. Such differences can be problematic for a number of reasons. For example, disparities in the way that educators and industry perceive a skill can result in ineffective teaching interventions which do not develop graduates to the degree expected by employers. We will discuss how such issues can be overcome. Participants will be asked to provide examples of skills mismatch and suggest strategies to overcome these issues.

• **How?** This area will discuss the facilitators and barriers in designing and delivering skills education. This might be related to designing an appropriate curriculum and/or the appropriate activities embedded in current curricula, educating students in a broad range of skills, or assessing skills. For example, how can we solve the reflection paradox to satisfy the requirement for students to reflect on their professional skill learning? Since STEM students, in general, are very focused on technical issues, discussions will also be directed at how they can be motivated to improve their self-awareness, soft skills, and self-management skills to launch a successful career in the technology market.

At each table, we will propose questions to stimulate the discussion and you'll have the freedom to focus to share your own areas of interest and experience.

SCHEDULE

This 60-minute session is structured as follows:

- Introduction to the engineering skills SIG, workshop, and the world café method (10 minutes)
- First round of conversations (10 minutes)
- Second round of conversations (10 minutes)
- Third round of conversations (10 minutes)
- Wrap-up: Table hosts share some of the main highlights from each discussion (10 minutes)

WORKSHOP TAKE AWAYS

After attending the workshop participants will be able to:

- Identify different understandings and meanings of skills and competencies (ref. What?)
- Identify professional skills that are valued by educators from different disciplines/countries (ref. What?)
- Reflect on differences in conceptualising skills by different stakeholders (ref. Who?)
- Define facilitators and barriers in designing and delivering skills education (ref. How?)
- Reflect on their capabilities to teach and assess professional skills (ref. How?)

You will be provided with an opportunity to develop networks with those who are interested in similar skills to yourself, this forming a basis for future collaborative work. Key discussion points will be summarised and made available to you through the conference proceedings and via email if requested. It will include a list of next steps and inform future work within the Engineering skills SIG and wider SEFI community.

Paper Session 2-01: EDI 3 - Gender in Engineering Education

Time: Tuesday, 12/Sept/2023: 9:00am - 10:00am · Location: EQ-002 Lecture Hall
Session Chair: Ines Direito

Engineering Society: The Role of Intersectional Gender and Diversity Studies for a Sustainable Transformation on the Case of Interdisciplinary Engineering Education

Bosen, Jennifer; Bernhard, Sebastian; Fauster, Evamaria; Decker, Marie; Lämmerhirt, Miriam; Leicht-Scholten, Carmen
RWTH Aachen University, Germany

Technological innovations are impacting societies in manifold ways and can accelerate a transformation towards sustainability. To enable a sustainable transformation through engineering, engineers educated to create technological solutions for global challenges must be educated in sustainability principles as postulated under 'Education for Sustainable Development' (ESD) in the Agenda for Sustainable Development. In technological fields, the ecological as well as the economical perspective of sustainability are often addressed, but as recent research has highlighted, sustainability needs to be addressed holistically; this means including the social dimension to a greater degree and applying an intersectional understanding of gender and diversity throughout all spheres of sustainability. It is therefore imperative for engineering students to learn and understand where gender and diversity are necessary for sustainability, how diversity dimensions intersect, and which intersections are particularly relevant for novel technologies and societal development. Accordingly, this paper sketches an interdisciplinary approach for applying intersectional gender and diversity studies in the context of a sustainable transformation of engineering education. We draw on our experience of having educated engineers accordingly for a decade at a research group (anonymised for review) at RWTH Aachen University. Selected examples from our teaching practice are presented and six general maxims are deduced that make engineering education more sustainability-oriented, inclusive and diverse. As we will conclude, fostering innovative and inclusive engineering education needs interdisciplinary teams adhering to our proposed six maxims in order to accelerate a gender- and diversity sensitive sustainable transformation.

Evaluating the Fairness of the Undergraduate Supports Survey: A DIF Analysis of Gender and Year-in-School

Gentry, Adrian Nat¹; Holloway, Eric¹; Martin, Julie²; Li, Tiantian¹; Douglas, Kerrie¹

¹Purdue University, West Lafayette, IN, United States of America; ²The Ohio State, Columbus, OH, United States of America

It is well established that access to social supports is essential for engineering students' persistence and yet access to supports varies across groups. Understanding the differential supports inherent in students' social networks and then working to provide additional needed supports can help the field of engineering education become more inclusive of all students. Our work contributes to this effort by examining the reliability and fairness of a social capital instrument, the *Undergraduate Supports Survey* (USS). We examined the extent to which two scales were reliable across ability levels (level of social capital), gender groups and year-in-school. We conducted two item response theory (IRT) models using a graded response model and performed differential item functioning (DIF) tests to detect item differences in gender and year-in-school. Our results indicate that most items have acceptable to good item discrimination and difficulty. DIF analysis shows that multiple items report DIF across gender groups in the *Expressive Support scale* in favor of women and nonbinary engineering students. DIF analysis shows that year-in-school has little to no effect on items, with only one DIF item. Therefore, engineering educators can use the USS confidently to examine expressive and instrumental social capital in undergraduates across year-in-school. Our work can be used by the engineering education research community to identify and address differences in students' access to support. We recommend that the engineering education community works to be explicit in their expressive and instrumental support. Future work will explore the measurement invariance in *Expressive Support* items across gender.

Exploring the variation in gender balance on undergraduate engineering courses in UK universities

Bellingham, Kate; Mitchell, John E; Guile, David; Direito, inês

UCL, United Kingdom

The underrepresentation of women in engineering remains a persistent issue despite efforts to attract more female students. The percentage of UK engineering undergraduates who are female is published annually, however no institutional breakdown is given. This scoping study aims to inform the direction of future research by investigating the nature and possible causes of the distribution of female engineering undergraduates across the UK HE-sector. Student data gathered from UK universities by the Higher Education Statistics Agency (HESA) for 2019/20 is explored using Tableau. Overall, 16% of UK engineering undergraduates are female but this varies from 5% to 36% for individual universities, with more prestigious institutions generally having a higher percentage. The findings suggest some association between gender balance and the level of qualifications prior to university: in general, the higher the academic achievement on entry to a university the better the gender balance at that institution while the percentage of women appears to be independent of the number of engineering undergraduates at a university. The HESA data also confirm that certain disciplines attract more women and consequently the subject areas offered by a university can influence its gender balance in undergraduate engineering. The literature offers several possible explanations for these findings, but further study is needed to investigate the differences in female representation at a more granular level, acknowledging the agency and individuality of both the universities and the students.

Fostering gender dimensions for inclusiveness in STEP fields

Lourens, Ann Sharon; Truter, Nicole

Nelson Mandela University, South Africa

Statistics from the Engineering Council of South Africa indicate that a large number of women who enter the engineering sector leave their careers in the early stages because they felt isolated and experienced discrimination in this traditionally male-dominated industry. Furthermore, research on global trends have highlighted the importance of an inclusive atmosphere as a result of the increase in the proportion of female decision-makers, racial and ethnic background differences, persons with disabilities and generation gaps with resulting different learning styles and needs. Literature also suggests that workforce diversity that maximises inclusion and minimises resistance, allows organisations to create change that fosters the human potential of their employees to the extent that diversity could be an organisation's competitive advantage.

To assist with fostering a culture of inclusion a Leadership Development Programme (LDP) was designed for early to mid-career male and female employees in Science, Technology Engineering and Production (STEP) fields by the Women in Engineering Leadership Association (WELA) at a South African university. The focus of the four-day programme included leadership, communication, diversity, being a team player, lean management and tools for effective problem-solving in addition to a two-day practical team exercise in a simulated working environment.

Paper Session 2-02: Teamwork and Team Projects 2

Time: Tuesday, 12/Sept/2023: 9:00am - 10:00am · Location: EQ-116 Flat Room
Session Chair: Roland Tormey

THE “EAGLE” APPROACH TO TRAIN ELECTRICAL ENGINEERS WITH COLLABORATIVE PROBLEM-SOLVING SKILLS

Poormohammadi, Fereshteh¹; Van Deyck, Merijn¹; Deckers, Martijn¹; Saboer, Abdul³; Wang, Bowen²; Mehrjousesht, Pouya³; Zhang, Zhenda⁴; Symons, Arne²; Pas, Pieter⁵; Bodard, Alexander⁵; Van Rooij, Hans⁵; Verhelst, Marian²; Bertrand, Alexander⁵; Vazquez Sabariego, Ruth¹; Patrinos, Panagiotis⁵; Coppens, Peter⁵

¹ELECTA, ESAT, KU Leuven, Belgium; ²MICAS, ESAT, KU Leuven, Belgium; ³WaveCore, ESAT, KU Leuven, Belgium; ⁴IMEC-COSIC, ESAT, KU Leuven, Belgium; ⁵STADIUS, ESAT, KU Leuven, Belgium

Engineering education plays a critical role in addressing the ever-increasing environmental and societal challenges, and collaborative problem solving (CPS) is a vital skill for engineers to tackle such complex multidisciplinary challenges and develop high-quality solutions. The EAGLE project at KU Leuven exemplifies CPS implementation in electrical engineering education, providing students with real-world connections and deep learning opportunities to develop teamwork, problem-solving, and negotiation skills.

This paper presents the development and implementation of EAGLE, a year-long hands-on, multidisciplinary challenge in which teams of 10-12 students design and develop an autonomous drone capable of flying to a remote landing station. It focuses on the project organization, innovative coach-based teaching and grading system, and the multi-dimensional evaluation and grading processes employed.

The insights gained from the EAGLE project can offer valuable lessons for future project-based learning initiatives and encourage the adoption of innovative teaching and learning approaches in engineering education. By sharing our experiences, we aim to inspire other educators to integrate real-world projects into their curricula, emphasizing the significance of hands-on learning, teamwork, and CPS in engineering education.

Engineering students' dynamic and fluid group practices in a collaborative design project

Bernhard, Jonte¹; Davidson, Jacob Gorm²; Ryberg, Thomas²

¹Linköping University, Sweden; ²Aalborg University, Denmark

There is a growing interest in engineering education that the curriculum should include collaborative design projects. Collaboration and collaborative learning imply a shared activity, a shared purpose, and mutual interdependence to achieve intended learning outcomes. The focus, in this study, is on engineering students' collaborative group practices. The context is a design project in the fifth semester of the problem-based Architecture and Design programme at Aalborg University. Students' collaborative work in the preparation for an upcoming status seminar was video recorded in situ. Video ethnography, conversation analysis and embodied interaction analysis were used to explore what interactional work the student teams did and what kind of resources they used to collaborate and complete the design task.

In this paper we report from a one-hour period where a group of four engineering students do final designs in preparation for the status seminar. Using recorded video, we have analysed students' fine-grained patterns of social interaction within this group. We found that the interaction and collaboration was very dynamic and fluid. It was observed that students seamlessly switched from working individually to work collaboratively. In collaborative work students frequently changed constellations and would not only work as a whole group, but also would break into subgroups of two or three students to do some work.

Our results point to the need to investigate group practices and individual and collaborative learning in design project groups and other collaborative learning environments in more detail and the results challenge a naïve individual-collaborative-binary.

Emotional Labor Experienced in Team-Projects: A Comparison of Engineering and Hospitality Students

Kotluk, Nihat¹; Tormey, Roland¹; Germanier, Rachel²; Darioly, Annick²

¹Ecole polytechnique federale de Lausanne EPFL, Switzerland; ²Les Roches Global Hospitality Education, Switzerland

Team projects are an integral part of the student learning experience. However, emotions can significantly affect student performance during team projects. Students use different emotion regulation strategies, such as surface-acting (emotive dissonance) and deep-acting, to regulate their emotions during team projects. These strategies can result in different 'emotional labor' levels, leading to emotional exhaustion, dissonance, and burnout. The level of emotional labor may also vary depending on the discipline and the nature of the work. This study thus investigated if engineering and hospitality students have different levels of emotional labor in team projects. Data were collected using a modified Emotional Labor Survey from 174 hospitality and 90 engineering students in team projects at two European universities. The results showed a statistically significant difference in emotive dissonance between hospitality and engineering students. Engineering students experienced more emotive dissonance than hospitality students, suggesting they may need more support in regulating their emotions during team projects. These findings have important implications for educators. By understanding students' different emotional labor levels, educators can design interventions to help students regulate their emotions and improve their performance in team projects. Further research is needed to investigate emotional labor in engineering education.

Teamwork Skills Development in Engineering Education: a Holistic Approach

Kimpton, Callum; Maynard, Nicoleta

Monash University, Australia

Engineering is a profession grounded in teamwork with the need for engineering students and professionals to possess the ability to integrate their work efforts seamlessly and effectively towards a common goal. This in turn necessitates the need for a **comprehensive, tailored, and relevant overarching conceptual framework** to be constructed to ensure that our subsequent generations of engineers are equipped to efficiently tackle existential societal problems including anthropogenic climate change and the multi-faceted nature of sustainable development.

This paper motivates, details, and presents a conceptual framework for implementing successful engineering teams in tertiary engineering projects. The emergent conceptual framework presented is currently a work in progress based on the findings and recommendations of current literature. We plan to undertake student interviews with both first year and capstone students to refine our framework thereby ensuring the credibility of the framework.

The final theoretical framework is composed of four key themes, these being team composition, team dynamics, creative leadership and team culture. The theoretical composition and relevance of their component sub-themes are discussed further in our work in addition to the unique interplay that occurs at the nexus of said themes and sub-themes. Ultimately this paper does not only define and outline a holistic conceptual framework to be used as a heuristic device for implementing successful engineering teams, but it additionally highlights current gaps in the relevant literature thereby provoking critical fields of future research.

Paper Session 2-03: Fostering Engineering Education Research 3

Time: Tuesday, 12/Sept/2023: 9:00am - 10:00am · Location: EQ-211 Flat Room
Session Chair: Gavin Duffy

Mapping the engineering education research landscape across Europe

Wint, Natalie¹; Valentine, Andrew²; Williams, Bill^{3,4}; Murphy, Mike⁴

¹UCL, London, UK; ²University of Melbourne, Melbourne, Australia; ³CEG-IST, Instituto superior Técnico, Universidade de Lisboa, Portugal Lisbon, Portugal; ⁴TU Dublin, Dublin, Ireland

The growth of Engineering Education Research (EER) has led to claims about it becoming a globally connected field of inquiry. This paper presents data on the development of EER within seven European countries, with the aim of contributing towards understanding of the field. Data was collected from participants of a workshop held at the SEFI 2022 Annual Conference which was entitled "[Placeholder]". Participants were asked to comment on the presence of formal research groups and PhD Programmes, as well as incentives and funding opportunities within the context. In most countries, there was a reported absence of formal EER groups and EER PhD programmes and in some cases, PhDs focusing on EER were included within general science and engineering programmes. In most cases incentives were associated with teaching awards and interventions and funding opportunities appeared to be small and isolated. In few cases was EER considered to be as valued as disciplinary research. The overall portrait that emerges from the data collected suggests that EER within European countries does not benefit from a national support infrastructure, but rather is typically carried out by individuals or small groups of researchers.

COMMUNITY-BUILDING AMONG PHD STUDENTS IN ENGINEERING EDUCATION RESEARCH: THE SEFI SUMMER SCHOOL AND AAEE WINTER SCHOOL

Langie, Greet¹; Willey, Keith²; Gardner, Anne²

¹KU Leuven, Belgium; ²University of Technology Sydney, Australia

Engineering Education Research (EER) is a rapidly evolving and increasingly valued research field. This supports the number of PhD students to grow steadily, but unfortunately, they are often limited to a few within the large engineering faculty/department, having different backgrounds and interests. Additionally, the research methodologies needed by EER researchers are usually different from the classical technical engineering research (TER) methodologies. This translates into a need for specific training and opportunities to get to know each other better in order to promote international collaboration and develop a community of practice. SEFI and the Australasian Association for Engineering Education (AAEE) both organized a summer/winter school for EER PhD students in 2022, attended by 34/14 participants respectively (note: attendance at the AAEE winter school is not limited to PhD students). We have designed a survey to elicit a mixture of background information (facts), perception data (opinions), and evaluative data (evaluation of the school).

By using confirmatory factor analysis on half of the items and descriptive statistical analysis of all data, we aim to provide insights into the success factors of these schools. Both schools attracted a diverse group of EER-PhD students in different areas. The SEFI summer school excelled in building an inclusive and international research community, whereas the AAEE winter school was superior in gaining domain-specific knowledge needed for EER research. The results contribute to a more nuanced understanding of the issues experienced by researchers who are beginning their career in EER and support organizers in designing international research schools.

The Challenge of Postdoc'ing in the US: Perspectives from International Engineering Postdoctoral Scholars

Mendez, Sylvia¹; Watson, Kathryn¹; Tygret, Jennifer²

¹University of Colorado Colorado Springs, United States of America; ²Illinois College, United States of America

An intrinsic case study explores the challenges shared by international engineering postdoctoral scholars about working in the United States (US). Little research has been devoted to their experiences despite their stark increase in the postdoctoral labor force over the last decade. Semi-structured interviews were conducted with eight engineering postdoctoral scholars hailing from Canada, China, Colombia, Iran, Italy, and Thailand. Participant interviews were analyzed inductively and resulted in four themes: (1) Immigration concerns; (2) Strains to find a community; (3) Pressure to publish and secure funding; and (4) Inadequate career counseling. The identified themes could be particularly instructive to Ph.D. advisors outside the US whose students may pursue postdoctoral positions in the US, Ph.D. recipients, US postdoctoral advisors, and US college and university international offices.

A framework for investigating the application of educational theories in engineering education research

van der Werf, Vivian^{1,2}; van Helden, Gitte^{1,3,4}; Schleiss, Johannes⁵; Saunders-Smiths, Gillian⁶

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Grounding the design of educational interventions and their analysis in theory allows us to understand and interpret results of interventions and advance educational theories. Moreover, building an understanding of *which* educational theories are used and *how* they are used can build a consensus among researchers and mature the research in a field. In this paper, we investigate the extent to which educational theories are used to ground the design, analysis, and evaluation of learning activities in engineering education. For this purpose, we developed a coding instrument to determine: (1) which educational theories are expressed in studies investigating learning activities and interventions, and (2) the extent to which these theories inform (a) the design of an intervention and (b) the analysis of that intervention. The instrument was applied to a sample of 12 studies from an existing literature review on collaborative engineering design activities to demonstrate the relevance of the developed framework. Results reveal that most studies refer to educational theory, primarily pedagogical approaches such as project-based learning. Furthermore, half of the time, the design of learning interventions is grounded in theory, however, the evaluation of those interventions is often not connected to educational theories.

Paper Session 2-04: Virtual and Remote Education Post Covid 2

Time: Tuesday, 12/Sept/2023: 9:00am - 10:00am · Location: EQ-203 Flat Room
Session Chair: Hannu-Matti Järvinen

The Potential of Metaverse Technology in E-Learning: Case of Engineering Students

Badaoui, Rozali¹; Kovesi, Klara²; Tannoury, Layla¹

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Metaverse technology integrates virtual and augmented reality, has significantly impacted many industries, and opened up new opportunities for educators and learners alike. This article focuses on its potential to transform e-learning, especially in engineering education, and highlights the importance of understanding engineering students' attitudes toward adopting new technologies. This study sheds light on the potential of e-learning in general, and the metaverse in specific, to engage and motivate students.

We conducted a quantitative online survey (n=120) to collect data from engineering students. The analysis of collected data explores and evaluates the students' awareness and acceptance of the metaverse in e-learning. Our results demonstrate that engineering students have a good awareness, a positive attitude, and motivation towards using new technologies and highlight a good opportunity for the metaverse to enhance engineering students' online interactions and participation compared with traditional e-learning methods.

We have identified several challenges and opportunities in using the metaverse in e-learning, including the need for new competencies, specialized hardware and software, and data privacy and security concerns. The paper concludes with recommendations for future research, emphasizing the benefits, e-learning's potential, and challenges of the metaverse in e-learning.

Experiences and learning outcomes of using virtual reality in building services engineering education

Posio, Juho²; Maljamäki, Petteri¹; Haavikko, Marko²; Tepsa, Tauno¹; Yäätäjä, Heli¹

¹Lapland University of Applied Sciences, Finland; ²Rovaniemi Municipal Federation of Education, Finland

Virtual Reality (VR) is a promising learning environment in vocational and higher education as it enables learning by doing. We developed a digital twin (DT) for learning the most common maintenance procedures of an air-to-water heat pump using game engine technology, targeted for students and professionals in the building services engineering industry. 22 HVAC (heating, ventilation and air conditioning) students participated in a user study to evaluate their experience with the DT, their usage preferences, and learning outcomes. Results of an online post-test questionnaire show that participants found the use of the DT easy and useful for learning maintenance procedures, regardless of their previous experience with VR devices or video gaming. More than half of the participants reported preferring to use the DT before practicing with the physical device. Learning outcomes measured with eight questions indicate that most of the students learned the tasks and safety issues correctly and in correct order (72-95% answered correctly). However, the questions measuring the learning related to adjusting the pressure was challenging for almost all students. The functional and task correspondence as well as the visual similarity of the digital twin to the real-world context is important for learning outcomes. The reported perceived usefulness by students for using VR in learning the maintenance procedures was related to realism of working with the digital twin, illustrating the maintenance procedures and tasks, as well as safety issues in the learning phase. The transfer of learning to real maintenance situations could be tested on the physical device.

Assessment of Different Platforms for Online Virtual Lab Demonstrations

Clarkin, Owen M¹; Morrissey, Anne¹; Obeidi, Muhannad Ahmed¹; Ryan, Alma²

¹Dublin City University, Ireland; ²Gaelscoil Chill Mhantáin, Ireland

As we move to a more sustainable world, expansion of education is key to the eradication of poverty (SDG1) and societal inequalities (SDG10). Global expansion of tertiary education offers opportunities to deliver Sustainable Development Goals goals by providing wide access to education in flexible learning environments. However, the quality of education (SDG4) must be maintained and enhanced as it is key to a partnership for the goals (SDG17). While achieving these SDGs can lead to an increase in learning online, there is also a move, within the education sector, to a constructivist approach and a more active learning environment. Interactive virtual learning environments (e.g. Virtual Reality) can offer considerable potential in the integration of active learning in an online environment

With this background in mind, the objective of this study was to evaluate the hardware and software resources currently available for effective delivery of remote virtual laboratory learning against nine technical, social and design criteria. At the same time, it is also important to consider sustainability in this evaluation including carbon (SDG13) and ecological footprints (SDG14/15). Hardware options examined were the Computer, Google Cardboard, Meta Quest 2 and Microsoft HoloLens 2, while the software platforms examined were H5P Virtual Tours, 3D Vista Pro, Dynamics 365 Guides and a professionally created VR platform. The main findings were that there is no 'one-size-fits-all' system and each system has its own advantages and disadvantages depending on the resources available at the institution and the type and level of knowledge and/or skill being delivered.

Changes in higher education communication practices and tools - through the pandemic towards new communication models

Nurminen, Mikko Ilari¹; Järvinen, Hannu-Matti²; Viteli, Jarmo²; Rantanen, Petri¹; Saari, Mika¹

¹Tampere University, Pori unit, Finland; ²Tampere University, Finland

The COVID-19 pandemic has significantly impacted traditional modes of communication in higher education institutions, leading to a shift towards remote communication and digital tools. This scientific paper examines the changes in higher education communication practices and tools resulting from the pandemic. The paper analyzes the challenges and opportunities presented by this shift and the ways in which teachers have applied communication models familiar from contact teaching to distance education. A previous review of published literature on adaptations in higher education institutions identified key factors for a successful transition to novel distance education communication practices and tools. These factors included effective use of digital platforms, skillful faculty with additional training and support available, and consistent efforts to maintain engagement and community building in the online environment. To determine how teachers have been able to adapt their communication practices and tool use at both the course and curriculum levels in response to the pandemic and whether they see these changes as welcome and lasting, a questionnaire survey was conducted at Tampere University. The results of the survey demonstrated how local experiences reflected the broader changes and contribute to the ongoing discussion about teachers adopting new communication models. However, some teachers expressed a desire to return to pre-COVID-19 practices, as they perceived contact learning as more engaging and effective. Therefore, the authors propose the creation of communication models by teaching staff for their own contexts as a tool for discussing and designing teaching-related communications.

Paper Session 2-05: Sustainability - Student Perceptions

Time: Tuesday, 12/Sept/2023: 9:00am - 10:00am · Location: EQ-204 Flat Room

Session Chair: Jye Benjamin O'Sullivan

Investigating the perceptions of Science and Engineering University educators and students around sustainability integration and the role of digital tools

Giannopoulos, George¹; Kioupi, Vasiliki²; Oti, Alfred³; Vakhitova, Tatiana³

¹Department of Physics and Astronomy, United Kingdom, UCL; ²Institute of Education, United Kingdom UCL, United Kingdom UCL.; ³ANSYS Ltd, United Kingdom

Last year we presented the first phase of our on-going research project - a collaboration between researchers at UCL and Ansys Ltd. on sustainable digital transition in education. The results of the first phase were published in proceedings of the 25th International Conference on Interactive Collaborative Learning.

We developed a framework to explore how technology companies, with a focus on education, approach sustainability in education through their products and their practices and what makes them impactful, focusing on a specific case of Ansys Granta EduPack.

The framework was the amalgamation of two previous analyses that explored i) how learning outcomes associated with the UN Sustainable Development Goals could be used to foster ways in which learning for sustainability can be implemented in Higher Education, and ii) how the same learning outcomes translate to concepts of *capital* used by companies to assess sustainability impact.

In this part of the study, we present the second phase of our project, the development of two questionnaires for university students and educators based on the framework, described earlier. The questionnaires focus on assessing sustainability awareness and involvement of staff and students of Science and Engineering Departments in sustainability activities, using a *Whole Institution Approach*.

In this paper we present preliminary data from the piloting of the questionnaires during a materials education workshop organised by Ansys Ltd in Cambridge UK. In the third phase of this research project the questionnaires will be shared more widely with staff and students in science and engineering focused faculties internationally.

Measuring social impacts in engineering education to improve sustainability skills

Nierle, Elisabeth; Pieper, Martin

FH Aachen, Germany

In times of social climate protection movements, such as Fridays for Future, the priorities of society, industry and higher education are currently changing. The consideration of sustainability challenges is increasing. In the context of sustainable development, social skills are crucial to achieving the United Nations Sustainable Development Goals (SDGs). In particular, the impact that educational activities have on people, communities and society is therefore coming to the fore. Research has shown that people with high levels of social competence are better able to manage stressful situations, maintain positive relationships and communicate effectively. They are also associated with better academic performance and career success. However, especially in engineering programs, the social pillar is underrepresented compared to the environmental and economic pillars.

In response to these changes, higher education institutions should be more aware of their social impact - from individual forms of teaching to entire modules and degree programs. To specifically determine the potential for improvement and derive resulting change for further development, we present an initial framework for social impact measurement by transferring already established approaches from the business sector to the education sector. To demonstrate the applicability, we measure the key competencies taught in undergraduate engineering programs in Germany.

The aim is to prepare the students for success in the modern world of work and their future contribution to sustainable development. Additionally, the university can include the results in its sustainability report. Our method can be applied to different teaching methods and enables their comparison.

MAPPING THE SUSTAINABLE DEVELOPMENTAL GOALS AND STUDENT PERSPECTIVES ON SKILLS DEVELOPMENT USING ALTERNATIVE ASSESSMENTS FOR ENGINEERING EDUCATION

McKennedy, Janet; Bedri, Zeinab

Technological University Dublin, Ireland

Student-created video and in-class debate were introduced in the assessment of education for sustainable development (ESD) in an environmental engineering module. This work was undertaken with a group of structural and civil engineering students in their stage 3 of study for a level 8 degree. There were 63 students registered for this course: 40 civil and 23 structural. Prior to any intervention, a linking exercise was undertaken to map the words in the module descriptor to the Sustainable Development Goals (SDGs). This informed the design of the assessments.

After completion of the respective assessments, student surveys were used to understand the student perspective on the use of these techniques. Students perceived acquisition of skills was analysed and qualitative questions relating to the attainment of knowledge were reviewed.

The Student-created video was a summative individual assessment worth 5% of the final mark while the in-class debate was a formative assessment where students were required to work in groups of 4/5.

A Way to Get Students Consider Ethics and Sustainability in IOT Projects

Sarrade, Jean-Luc¹; Lermigeaux-Sarrade, Isabelle²

¹HES-SO (HEG), Switzerland; ²EPFL, Switzerland

Sustainability and ethical topics can be embedded and assessed in existing technical courses within an engineering curriculum. This article describes how we integrated a reflection on the importance of ethical and environmental aspects of connected objects through team-based project learning with computer science students in the second semester of their Bachelor degree. Small groups of three people were given different projects, in which they had to implement the technical concepts learned in class, using both virtual and physical components. The projects followed realistic scenarios chosen at random, each of them using a specific set of sensors and built to question either personal data collection, ethics and sustainability issues. At the end of the project, each group had to demonstrate their connected object proof of concept during an oral presentation and to do a group written report. The project is one of the elements of the continuous assessment for this module.

After mapping the different projects and their associated sustainability and ethical topics, we present how the initial assessment grid of the project evolved into a three-folded version. The final grid explicitly invites students to explore sustainability and ethical aspects in their reports, in addition to the technical aspects, and includes a group peer review section. Examining to what extent students developed an original reflection on sustainability and ethical aspects of their projects, we finally suggest possible extensions and improvements, and list some context elements that are to facilitate future implementations.

Paper Session 2-06: Engagement - Society and Communities

Time: Tuesday, 12/Sept/2023: 9:00am - 10:00am · Location: EQ-112 Flat Room
Session Chair: Diana Adela Martin

Centering Meaning-Filled Design Within Engineering Education: Recommendations on how to integrate interdisciplinary architectural design charrettes, community engagement, sustainability principles, and adapted Agile methodologies into a student-centered, project-based engineering program

Gillette, David D; Haungs, Michael; Fowler, Thomas

California Polytechnic State University San Luis Obispo, United States of America

The Liberal Arts and Engineering Studies program (LAES), is a hybrid engineering and humanities degree housed in both the engineering and liberal arts colleges. LAES requires the same required math and science courses of standard engineering degrees, adding upper-level concentrations split equally between advanced engineering and humanities courses.

LAES was designed for retaining and recruiting a diversity of students in engineering, and to address recent innovations in industrial practice, technology design, and community-centered education. Through fifteen years of trial and error, the LAES program has developed a set of meaning-filled design guidelines for project work, combining engineering and humanistic problem solving with sustainable environmental practice integrated throughout every aspect of design, production, and use. In partnership with Cal Poly's architecture program, LAES has worked on many projects that exist within the complex economic, political, social, and cultural needs of local communities. LAES projects have ranged from community housing construction with re-purposed shipping containers, to re-designing pedestrian neighborhood corridors, to the use of narrative-driven STEM education modules with underserved middle school students, to the design of immersive-reality explorations of artificial coral ecologies off the coast of California.

In this paper, we review what we have learned from our project work, with a focus on student learning assessment, leadership training, and teamwork management, demonstrating how those practical academic concerns interact with the instruction of our design principles. We conclude by offering practical recommendations for how other programs may use some of our design guidelines and project ideas within their own curriculums.

A Community-based Context Learning Approach to Promoting Social Justice in Teaching Engineering Communication

Wang, Hua

Cornell University, United States of America

Scholarship on community engagement learning mainly focuses on positive effects on students' academic learning, personal and professional development. However, Stoecker points out many students serve as volunteers and community engagement learning defaults to a charity form of service and involves little social justice work that directly implies social change. As the "service" can't target the causes of community issues and make social change, this research suggests a community-based context learning approach without service. This approach maintains social justice orientation with a focus on raising engineering students' awareness of association of issues of equity with their field and profession and help them promote social change.

This research is situated in the context that "engineering is never neutral" and there are "linkages between engineering artifacts, systems, and models and issues of equity". The approach engages students with marginalized cultural communities to investigate how technology design marginalizes the cultural communities and propose for a change. It facilitates a community-based context learning beyond the classroom to a social-tech level by getting students involved in engineering-related injustice existing in marginalized cultural communities and employing their expertise to enact engineering justice.

This research was conducted in an engineering course at Cornell University in 2022 Spring semester. This research focuses on a project that lasted 4 weeks. The final deliverables were a group poster presentation, a formal proposal, and an individual reflective essay. The proposal topics and the students' reflective essays were collected for data analysis. Through grounded theory/content analysis, some interesting findings have been identified.

ENHANCING QUALITY TEACHING THROUGH INFORMAL COMMUNITY LEARNING IN KNOWLEDGE CENTRES

Gomez-Puente, Sonia M.; Ventura Medina, Esther

Eindhoven University of Technology, Netherlands, The

Teaching and learning have always been at the heart of the missions of universities. The growing interest nowadays to pay attention to the quality of higher education teaching results in initiatives such as the establishment of Teaching and Learning Centres (TLCs). The Academy for Learning and Teaching (ALT) at XX University has recently been created with the purpose of promoting quality of teaching through engaging staff in interaction and in learning lessons from evidence-based educational practices and innovation in engineering education. Furthermore, ALT supports the professional development of faculty teaching staff through Learning Communities (LCs) as informal learning mechanisms that stimulate knowledge sharing about engineering education experiences across departments (and universities). LCs facilitate interaction with peers, discussions on educational practices, working in teams, and exposing academic and education support staff to have access to state-of-the-art research and information on educational issues. LCs are organized by themes, such as Digitalization, that cover topics relevant to innovative practices, e.g., Learning Analytics, Artificial Intelligence in education, or Digital Assessment. The purpose of this study is to present the ALT model as a knowledge centre in engineering education that stimulates the advancement of quality teaching. ALT may serve as an inspiring model for other engineering and technical higher education institutions and universities wishing to promote professional development of teachers.

Time to Rethink Engineering Outreach?

Clark, Robin; Andrews, Jane; Wang, Yiduo; Cooke, Gill; Makrinov, Ninna

University of Warwick, United Kingdom

Starting with the research question 'Does engineering outreach work?' this paper looks at the often 'sticky' subject of the validity of engineering outreach in UK High Schools. It examines how Engineering Outreach Activities are conceptualised by external bodies (RAEng., 2016) and critiques the complex range of practical experiential engineering educational interventions offered in school (Neon, 2023, STEM learning, 2023). Drawing upon the findings of, what is, a small single strand of a much larger multi-method, longitudinal analysis of Engineering Education Outreach Activities provided across the West Midlands region of the UK (LBEEP, 2023)], the paper provides a unique insight and descriptive analysis of engineering outreach in schools.

The findings section comprises a comparative analysis of the socio-economic background of schools before looking at the gender breakdown of outreach participants. The various engineering interventions provided are briefly discussed before consideration is given as to how sustainable current engineering outreach activities are. Finally, in questioning whether the UK's current approach of providing engineering education experiences in the form of what are often idiosyncratic, short-term episodic activities, the paper questions the financial, pedagogic and practical wisdom of confining engineering education to 'outreach'. The conclusion suggests that it's time for a sea-change in how we, as a society, teach children and young people about engineering and suggests that perhaps it is time to embed the subject into more established areas of study such as maths and science but also in history and social science.

Paper Session 2-07: Climate Change and Sustainability 3

Time: Tuesday, 12/Sept/2023: 9:00am - 10:00am · Location: EQ-208 Flat Room

Session Chair: Raffaella Manzini

SETTING UP AN ENGINEERING "PILOT STUDY PROGRAM" IN E-MOBILITY" FOR INTERNATIONAL STUDENTS: ISSUES AND SOLUTIONS

Herbert, Meike; Nasarow, Alexander; Kreis, Oliver

University Erlangen-Nuremberg FAU, Germany

This practice paper presents the issues and solutions in introducing a new international engineering study program at a German university that attracts especially non-European students. The master's program "E-mobility-ACES" with the four majors Artificial Intelligence and Autonomous Driving, Connectivity, E-Powertrain and Sustainable Mobility & Production Technology was newly introduced in the winter semester 2022/23. It combines the expertise of all engineering departments like mechanical engineering, electrical engineering, computer science and AI, materials science and chemical engineering to offer a very modern and attractive engineering education for sustainability in an ecologic and economic extremely important field.

The extremely high amount of applications with more than 1600 applicants per semester shows the high visibility and attraction of this study program. As the international Master program is offered in English language, especially students e.g. from India, Pakistan or Bangladesh who already have a bachelor's degree taught in English language are interested in this program. The selection of future students out of an extremely high number of applications is challenging, while this process has to be completed in a very short period of time. With this high number of international students, further issues occur regarding visa application, housing and other organizational aspects. Practical solutions are presented in this paper that lead to transferable recommendations for the future design of such large-scale study programs for other universities.

Addressing long-term challenges in energy for sustainable futures by applying Moonshot Thinking

Sumper, Andreas; Jené-Vinuesa, Marc; González-de-Miguel, Carlos; Marin-Macaya, Maria

Universitat Politècnica de Catalunya, Spain

The rapid and exponential changes in our society call for the education of engineers to help them generate solutions to future and long-term challenges such as climate change. Exploration and innovation methodologies such as Futures Thinking and Moonshot Thinking have the potential to provide engineering students with valuable tools and skills to build sustainable futures.

To this end, the InnoEnergy MSc Energy for Smart Cities program at BarcelonaTech (UPC) has developed a challenge-based learning (CBL) subject that applies Moonshot Thinking to tackle major energy problems. This paper presents the methodology refined over three years of conducting the CBL course with second-year Master's students in energy engineering.

The course begins by constructing a narrative working future using exploratory tools from the Futures Thinking methodology. Breakthrough technologies are introduced, and their disruptive potential is analysed. Students then define a long-term problem in sustainability and energy and apply various ideation methodologies to develop a solution. Using technologies such as 3D printing, Artificial Intelligence, and open-source electronic prototyping platforms, they build a Minimum Viable Product (MVP) and develop a business model. Finally, following an agile approach, students have to design future iterations and analyse the possible exploitation of their solution.

The evaluation results of the subject show that students are highly motivated to acquire the necessary skills to address complex energy and sustainability challenges, preparing them to apply their knowledge in practical, real-world settings.

Varieties of Project-Task Design in Interdisciplinary Engineering Education

MacLeod, Miles¹; Johnson, Coralie¹; van der Veen, Jan²

¹University of Twente, Netherlands, The; ²Eindhoven University of Technology, Netherlands

Experience in interdisciplinary problem-solving is considered crucial if engineers are to be equipped to handle modern complex environmental and sustainability challenges. Such challenges cross disciplinary boundaries. Project-based learning is currently a central paradigm for providing that experience. Teams from different disciplines are formed to work together on a specific scientific or engineering project-task (often a real-world inspired problem). Furthermore according to the paradigm projects should be open-structured to allow students to experience interdisciplinary problem-solving as it might occur in the real world. In this study we explore preliminary results of data collected on 5 project-based modules at a Dutch technical university. We find that despite the preference for open-structure advocated in educational research the modules differ in terms of how structured they are, with the majority structured in a substantial way. In these cases the instructors design their project tasks to meet both institutional objectives and also to afford interdisciplinary interaction between students. We examine the motivations behind the design features they employ, and also some of the drawbacks based on student feedback. This study points the way to further research but should help build awareness of different design options and their tradeoffs.

Between flexibility and relativism: how students deal with uncertainty in sustainability challenges

Bohm, Nina Lotte¹; Klaassen, Renate¹; Van Bueren, Ellen¹; Den Brok, Perry²

¹Delft University of Technology, The Netherlands; ²Wageningen University and Research, The Netherlands

Universities open their doors to society, inviting the complexity of the world to enter engineering education through challenge-based courses. While working on complex issues, engineering students learn to deal with different kinds of uncertainty: uncertainty about the dynamics of a real-world challenge, the knowledge gaps in the problem, or the conflicting perspectives amongst the people involved. Although we know from previous research that students are likely to encounter these uncertainties in sustainability challenges, which metacognitive strategies they use to deal with them is unclear.

We interviewed nine MSc students at the end of a challenge-based course at a Dutch university of technology. We asked the students how they dealt with uncertainty in collaboration with the commissioner, their student team, and the teachers. The interviews were analyzed through grounded, consensus-based coding by two researchers.

Preliminary results show students use three main strategies. First, the different perspectives from peers in their team inform the position of the student. Second, students find expectation management of the commissioner essential, yet students struggle with how to do this in a professional and timely way. Third, students frame the uncertainties they encounter as part of the learning process, which allows them to accept the possibility of failure.

This study provides first insights in metacognitive uncertainty strategies and suggests those strategies should become a more prominent topic in coaching students. When uncertainty becomes an explicit part of challenge-based education, students learn to deal with both the known and unknown in the transition to a sustainable society.

Paper Session 2-08: Engagement with Industry and Innovation 2

Time: Tuesday, 12/Sept/2023: 9:00am - 10:00am · Location: EQ-117 Tiered Room

Session Chair: Patrick Flynn

International Cooperation Framework for Next Generation Engineering Students

Kakko, Anneli

JAMK University of Applied Sciences, Finland

International Cooperation Framework for Next Generation Engineering Students (NextGEng) is an Erasmus+ Cooperation partnership in higher education project which started in the beginning of October 2022 and will end in the end of September 2025. In this project there are six full partners who are participating in all project's activities: Technical University of Cluj Napoca (main partner) and Robert Bosch SRL from Romania; Jamk University of Applied Sciences and Valmet Technologies Oyj from Finland; University of Jaen and Sensory Integration and Robotics from Spain. This project aims to develop an international cooperation framework that promotes international team-teaching aligned with the European Education Area 2025 and labour market needs, including actions to support collaborative, international and experiential learning in engineering. To achieve that end, NextGEng activities are based on three lines of action: a tailored training process for teachers, an international team-teaching pilot program and cases for experiential learning. The presentation describes the goals and major features of NextGEng, details of three lines of action and achieved results during the first project year.

Progression by imitation: Empirical evidence from the NTNU–CERN Screening Week

Thi-Thanh Do, Thuy; Aadland, Torgeir; Haneberg, Dag Håkon; Widding, Øystein

NTNU, Norway

Engineering students should work on authentic and 'wicked' challenges to be best prepared to develop technologies that address challenges in our complex world. This can be done with a learning-by-doing approach where students are positioned as entrepreneurs exploring market opportunities for novel technologies. During the NTNU–CERN Screening Week, students in an entrepreneurship program search for- and create opportunities based on technologies developed at CERN and that may have the potential to later become a start-up. However, the students have very limited domain knowledge in terms of the advanced technologies or industrial application of them. Also, the technology readiness level (TRL) of the presented CERN technologies is often far from being ready for market entry. Previous research has primarily considered how student-oriented programs for technology commercialization are organized. In the present paper, we ask how students proceed to successfully generate market insights for progressing in a technology commercialization process. We performed an empirical process study of five student-driven feasibility studies. Our data includes in-depth interviews, field notes and on-site observations. The data is systematically analyzed according to the Gioia-protocol for robustness and reliability. Our findings demonstrate how the students are translating an immature technology into a higher TRL and envision applications that do not exist in the real world, to be able to initiate conversations with potential customers and users. These insights contribute to the understanding of how students are becoming 'great pretenders' or 'breaking the norms' to engage stakeholders and enter the "Promoters Dilemma", also challenging existing norms.

The contribution has been withdrawn.

Innovating University-Industry Educational Collaboration: A Pilot Chinese Case

Zheng, Lina; Han, Yu; Wu, Ruilin; Zhang, Jianglong; Ye, Jinxin

Beihang University, People's Republic of China

The contribution has been withdrawn.

Determinants of the entrepreneurial self-efficacy of engineering students from a South African University of Technology

Ngonda, Tiyamike Nyozeni; Ngonda, Virginia Shahida

Cape Peninsula University of Technology, South Africa

Paper Session 2-09: Innovation in T&L 2 - Interdisciplinarity

Time: Tuesday, 12/Sept/2023: 9:00am - 10:00am · Location: EQ-118 Tiered Room

Session Chair: Siara Isaac

Do we unwittingly exclude students? A case study to evaluate an engineering test for inclusivity.

Crapa, Sofie; Cannaearts, Mieke; Langie, Greet

KU Leuven, Belgium

Engineering stereotypes are one of the factors that can hinder different groups to identify with and choose for engineering. The stereotypical image of engineers, often characterised as male, white and harsh technical oriented, can negatively impact students' perception of engineering as a field that they can belong to or fit in.

Recently, PREFER tests were designed to increase students' awareness of the different roles an engineer can take on and of the importance of professional competencies in engineering. Research indicated that the tests were gender sensitive, meaning that females had other role preferences than men. These results inspired us for a follow up project to investigate how the tests can be used as instruments to increase attractiveness and retention in engineering.

This paper reports on a study that was conducted to evaluate whether the PREFER Explore test was designed in an inclusive way. To validate the test with different student groups, a survey was distributed among 1173 first year engineering students (October 2022) and xxx final year secondary education pupils in science/math tracks (March 2023) in Belgium. After completion of the test, participants were asked seven additional questions about whether they could identify with the test cases, found the test difficult to complete, the cases interesting etc.

This study will compare the results between males and females, and between students with and without a migration background (data are currently being analysed). The results will be critically discussed, and the next steps presented. Recommendations for inclusive student material will be made.

Enhancing Professional Skills Among Engineering Students by Interdisciplinary International Collaboration

Meitoff, Thomas¹; Cripps, Helen²; Fong-Emmerson, Melissa²; Blöcker, Christopher¹

¹Umeå University, Sweden; ²Edith Cowan University, Australia

Providing necessary knowledge and skills for engineering students to become successful professionals is a tricky task. Besides disciplinary knowledge, e.g., communication skills, ability to work in teams, and international experience are often mentioned as important. Regarding internationalization, most engineering programs in Sweden rely on either student exchange or low-level internationalization-at-home, such as international literature and lecturers. This paper explores sustainable international experiences for students on their home turf provided through an international interdisciplinary collaboration where engineering students in Sweden and marketing students in Australia work together on a project. The setup simulates a consultancy firm with development and marketing offices in different countries that cooperate to launch an application for the Australian market. The paper is based on interviews and surveys with students and teachers participating in this, since 2017, ongoing project.

Findings reveal that students encountered several challenges that are hard to simulate in an ordinary university setting, e.g., language barriers, cultural differences, time differences, differences between disciplines, and varying work habits and values. The results also highlight opportunities such as learning from each other's perspectives and expertise, developing a more professional approach, presenting to people from other industry backgrounds, and gaining a better understanding of different cultures. The results show that the students gain professional experience that is of great value for their future profession. From a teacher's perspective, the paper discusses important issues when setting up an international inter-disciplinary collaboration, e.g., alignment of exercises, building a common ground, and the need for flexibility.

Teachers' reflections on their experiences teaching interdisciplinary project-based courses

Kjellberg, Malin¹; O'Connell, Michael¹; Bergman, Becky²; Stöhr, Christian¹; Larsson, Johanna¹

¹Engineering Education Research, Department of Communication and Learning in Science, Chalmers university of technology, Sweden;

²Language and Communication, Department of Communication and Learning in Science, Chalmers university of technology, Sweden

In project-based, interdisciplinary engineering courses, teachers face the challenge of not only imparting technical knowledge but also facilitating effective project- and teamwork. This requires teachers - who themselves often were taught in a traditional way - to learn how to facilitate students working in teams. This study responds to the need to understand what PBL teachers perceive as difficult and challenging in this process by investigating teachers' experiences of teaching interdisciplinary project-based courses. We conducted thematic qualitative analysis of 11 teachers' reflections about their experiences teaching an interdisciplinary project-based course at a Swedish technical university. Broader categories within this analysis include teaching approach, perceived benefits, challenges and need for support. Teachers reported varying forms of pedagogical training, most had earlier experiences of project-based teaching. However, this experience rarely included interdisciplinary courses. Teachers appreciated project-based teaching as a means to motivate students and to connect education with current research. One consistently reported challenge was handling differences in terms of knowledge level and discipline. However, some teachers described differences like cultural diversity as a strength of student groups. Most teachers did not describe a need for further training in project-based teaching. Interestingly, teachers who did identify such needs also seem to already make use of a wider range of strategies to support student learning in projects. We discuss the implication of our findings for practitioners and researchers interested in problem-based learning in interdisciplinary engineering courses.

To withdraw, investigate, negotiate or integrate? Students' coping strategies with disorienting dilemmas in interdisciplinary project courses

Feng, Xiaogqi; Sundman, Julia; Aarnio, Hanna; Taka, Maija; Keskinen, Marko; Varis, Olli

Aalto University

In today's rapidly changing and increasingly interconnected world, engineering education practitioners are implementing innovative pedagogical approaches where students with different disciplinary backgrounds co-create solutions to complex real-world problems. However, interdisciplinary and experiential learning may evoke situations where students question their past learnings and even existing values, beliefs or assumptions. Our study examines the emergence of "disorienting dilemmas", a central concept to transformative learning theory, and students' experiences in coping with them.

We conducted qualitative interviews with ten students from two interdisciplinary project courses in the engineering school of a Nordic university, and used thematic analysis to identify the types of disorienting dilemmas and the coping strategies that students employed. Our study found that students experienced disorienting dilemmas related to self-beliefs, approaches to real-world challenges, teamwork, and disciplinary differences. To cope with these dilemmas, we identified four strategies that reflected different levels of cognitive-behavioral responses: withdrawing, investigating, negotiating, and integrating.

Our study contributes to transformative learning theory by extending the understanding of disorienting dilemmas in the context of interdisciplinary project-based education. We also provide practical implications for engineering educators seeking to develop students' competencies to effectively address complex challenges in the working life. Effective interventions, such as critical reflection, open discussion, and resolving conflicting

perspectives, can help students navigate disorienting dilemmas and enhance their interdisciplinary and transformative learning. Future research can further explore the link between students' team characteristics and the emergence of dilemmas and coping strategies, as well as investigate the impact of different scaffolding strategies on students' learning outcomes.

2023 Draft Book of Abstracts

Parallel Workshops 2-10: Parallel Workshops 2-10

Time: Tuesday, 12/Sept/2023: 10:30am - 11:30am · Location: EQ-112 Flat Room

Help Them Grow – The ENG-IST Tool - Supporting students' personal development process to stimulate lifelong learning

Beagon, Una¹; Byrne, Aimee¹; dePaor, Caitriona¹; Van Den Broeck, Lynn²; Dujardin, Rani²; Craps, Sofie²; Naukkarinen, Johanna³

¹TU Dublin, Ireland; ²KU Leuven, Belgium; ³Lappeenranta-Lahti University of Technology LUT, Finland

EXTENDED ABSTRACT

1 Motivation and learning outcomes

Teaching staff often acknowledge the importance of Lifelong Learning (LLL) competencies but they do not necessarily feel adequately prepared to support students' personal development towards obtaining these important skills. TRAINeng-PDP is an Erasmus+ project which aims to prepare students for a life full of learning through a personal development process (PDP).

One outcome of the project is an Engineering Programme - Intervention Selection Tool (ENG-IST) to assist lecturers in choosing appropriate interventions for the engineering classroom which support the students' personal development process. Our motivation in this workshop is to showcase, test and enhance the ENG-IST tool so that once complete it is a highly relevant, broadly applicable and context specific resource for the engineering education community.

Specifically, participants of the workshop will be able to;

1. Recognize the variety of interventions that are available to support the PDP of students
2. Reflect on their own teaching to identify a module which would be suitable for an intervention
3. Co-create an intervention design appropriate to a specific context
4. Discuss the constraints associated with the implementation of a particular intervention

2 Background, rationale and relevance

The project team undertook a scoping review to identify which types of interventions have already been successfully implemented in higher education more generally (Van den Broeck et al. 2022). We used these findings and the contextual aspects of how they were implemented to create the ENG-IST tool to be appropriate to the engineering classroom. The ENG-IST tool is a flowchart which identifies the most appropriate intervention for a particular context, and the educator's aims, based on different criteria and preconditions. Some considerations include:

- Focus of the intervention (type of skill to be developed)
- Investment required from students,
- Class-time devoted to PDP,
- Type of feedback,
- Other developed skills,
- Preparation time for lecturers,
- Follow-up time for lecturers.

Educators can use the flowchart to select an appropriate intervention for a particular context. As a further resource for educators, we have also drafted instructional "How To" guides for each type of intervention. We wish to improve the quality of the ENG-IST tool and the intervention guides in this workshop by testing, co-creating and enhancing the tool and instructional guides for specific interventions.

3 Workshop design

- 0-10 mins - Short introduction to the workshop, explanation of interventions identified in the literature as part of the scoping review (Van den Broeck et al. 2022). (LO 1)
- 10-15 mins- Individually, participants reflect on their own teaching and choose a module that would be suitable to introduce an intervention. Using a Context Template, they record the constraints and contextual considerations associated with this module. (LO2 and 4)
- 15-20mins- The ENG-IST flowchart is circulated, and participants use it to choose an appropriate intervention based on their context.
- 20-45 mins- Participants now move to a table specific to that intervention.
- Facilitators and participants co-create an Intervention How to Guide (with some sections pre-filled) gathering best practice and views from participants including any constraints. (LO 2,3 and 4)
- 45- 55mins- Each Group reports back (2 mins each) (LO 4)
- 55-60 mins - Wrap Up. Participants leave with the ENG-IST flowchart and list of interventions.

4 Workshop After Work

The extended abstract will be supplemented with the key findings of the workshop as part of the proceedings. Participants will also be invited to provide contact details so that the team can send them an interactive copy of the ENG-IST tool (the interactive version is currently under construction), and the finalised Intervention Guides.

The next step of the project is to trial interventions with student groups which will use the Intervention Guides created in this workshop. We hope that the participants will also be motivated to trial interventions in their own context.

5 Significance for engineering education and attractiveness of the workshop topic

Engineering employees need to continuously update and up-skill their competencies, to keep pace with changing technology and shifting requirements of the labour market (European Commission 2019; OECD 2019) hence Lifelong Learning skills (LLL) are a key component to maintain and improve employability (Employer's Statement 2019). Thus it is essential that students are facilitated in their personal development and this ENG-IST tool and accompanying guides provide a useful resource for educators.

This workshop is attractive as it is an engaging interactive session which will allow educators to become aware of the key LLL competencies students require and the appropriate interventions needed. Furthermore, educators will have some space to reflect on a module in which they could implement an intervention and to assist in co-creating an intervention guide. We hope this workshop will both motivate and support educators in implementing an intervention which we would love to hear about at SEFI 2024.

6 Target audience, participant knowledge required, target numbers of participants and restrictions on size if appropriate.

Our target audience includes engineering educators who are interested in helping students with their personal development and who are open to undertaking an intervention. No participant knowledge is required, but it would be helpful if the participants are active educators so they can consider a specific module in which to undertake the intervention. Target number is 25, max 40.

7 Enhancement of knowledge and dialogue on the workshop topic.

Participants will leave not only with a useful tool for selecting appropriate interventions but also with an awareness of the different types of interventions available. The following interventions were chosen as result of our scoping review (Van den Broeck et al. 2022) which investigated appropriate interventions in many different disciplines.

These include;

- E-portfolios, Reflective essays, Digital storytelling, Mentor guidance, Role-playing, Online resources, Sessions/lectures, Journals/logs, Student-centred teaching methods, Peer or self-assessment.

The workshop will also enable us to meet like-minded educators who are interested in LLL so that we can further develop projects such as this and increase the impact of our work and further research funding applications on a wider scale.

ACKNOWLEDGEMENTS

We would like to acknowledge the EU Erasmus+ funding body and all partners and associated partners in the TRAINeng-PDP project (grant number: 2021-1-BE02-KA220-HED-000023151) for their help in this activity and report.

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Parallel Workshops 2-11: Parallel Workshops 2-11

Time: Tuesday, 12/Sept/2023: 10:30am - 11:30am · Location: EQ-116 Flat Room

Application-based learning of signal analysis methods with the help of a graphical open-source software

Hetkämper, Tim; Koch, Kevin; Webersen, Manuel; Claes, Leander

Measurement Engineering Group, Paderborn University, Germany

Signal analysis is a central component in engineering education. While the theoretical foundation is taught in detail in many courses like e.g. signal theory, the curricula often offer only few application-based learning opportunities. The reason for this is that physical implementation of signal processing requires expensive experimental equipment. Alternatively, students can experiment with digital signal processing, but this requires specific programming skills. Another problem is that typically, despite several signal analysis methods are taught, problem solving strategies are not. This becomes evident when students are confronted with real-world problems. They often possess the necessary knowledge and they can explain specific methods, but they do not know what to apply to a given problem.

In order to provide students with experimental learning opportunities with a focus on problem solving at the undergraduate level, an easy-to-use signal processing software, the 'Multi Channel Analyser' (MCA), is in development at our group. The MCA, which is an open source project, enables virtual signal processing by connecting processing blocks graphically, thus requiring no programming skills. It can be used in courses such as about measurement, instrumentation, and signal analysis, or in laboratory courses. For example, the function of circuits to be designed in a laboratory course can be examined virtually on a block-level to aid in choosing a fitting circuit implementation. The MCA is written in Python and also provides an easy-to-use, well-documented API to implement new signal processing blocks.

In this workshop, the attendees will first be shown how an application-oriented task can be designed using the MCA. Attendees are asked to bring their own laptop to be able to test the MCA in their preferred operating system. After the introduction, the attendees will take the role of a student and try to solve an exemplary task themselves. Based on the experiences in this practical part, the following questions will be discussed:

- Do the attendees use any similar software/methods in their daily teaching?
- How was the user experience in solving the given task and were there problems in using the MCA?
- Could the attendees imagine to use our software and are there suggestions for improvement?

If feasible, we will implement the discussed improvements in our software and publish them for everyone to use.

We will also elaborate on our first experiences in teaching with the MCA. However, as the software development is still ongoing, broad usage in our lectures still has to be established and the influence on the learning outcome has to be examined. In the future, it should also be investigated to what extent an automated evaluation of the user interaction with the MCA is possible.

Parallel Workshops 2-12: Parallel Workshops 2-12

Time: Tuesday, 12/Sept/2023: 10:30am - 11:30am · Location: EQ-203 Flat Room

Promoting awareness of, and sharing good practices on, supporting engineering students with disabilities

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¹UCL, United Kingdom; ²Delft University of Technology, Netherlands; ³Northumbria University, United Kingdom

The amount of literature that focuses on diversity and inclusion within engineering education continues to grow. However, research traditionally focuses on gender, and despite the United Nations Convention for the Rights of Persons with Disabilities (CRPD) being passed in 2016, there is still a lack of work which describes the experience of students with disabilities.

This is particularly pertinent given the increasing number of engineering students with non-visible disabilities (NVDs) such as ADHD and ASD, as well as mental health conditions. These students face many barriers, for example: bias around decisions regarding accommodations [1]; dependence of grades on suitability of reasonable adjustments [2]; stigma over disclosure of disability [3]; and a disability employment, retention, and progression gap [3]. There is also insufficient academic training and understanding of how disabilities affect learning and academic performance, and staff attitudes toward disability support have been shown to have a direct impact on academic success [3].

This lack of understanding is compounded by the varied nature of disabilities (both visible and non-visible) and thus student needs, as well as whether individuals chose to disclose their disability. The way in which disability is treated is also likely to vary in different geographical locations.

These issues are compounded by the learning experience within HE, which varies substantially from that within schools in which learning is often highly structured. At the same time there is shift in pedagogical approaches used within engineering education [4] and a higher degree of unstructured time and informal instruction. In comparison, existing accommodations have been developed for traditional learning environments and it is unclear whether reasonable adjustments allow students to develop the professional skills (e.g., flexibility, executive functioning) increasingly required by engineering employers. This alongside, the non-academic factors which may affect disabled students, may result in lower levels of self-efficacy and reduced outcomes, particularly with respect to employability, this reducing the potential for the profession to benefit from their abilities which include strong divergent thinking, creativity, innovation and risk-taking [5].

Although the use of labels can help us understand ourselves and others, and often allow access to support and resources, they can also be problematic. For example, they can only tell you so much about a group rather than an individual and thus do not encourage the use of student-centred approaches.

The workshop welcomes participants who are interested in the topic and eager to learn and discuss more; no prior knowledge of the topic is required.

Our objectives include amplifying practices that foster inclusion of disabled engineering students and creating opportunities to share insights and practice. Focus will be given to emerging pedagogical processes. For example, we will discuss: creation of transparency and structure; treatment of spontaneous work and feedback; use of alternative work spaces; scaffolding team agreements; and self-advocacy within groups. We will make use of The UDL Guidelines [6] as a tool for the implementation of Universal Design for Learning. **The framework offers a set of concrete suggestions that can be applied to any discipline (including engineering) to ensure all learners can access and participate in meaningful learning opportunities.**

By the end of the workshop, participants will have an increased awareness of the different contextual uses of the term 'disability' as well as ideas about how to enhance the experience of students with disabilities in their own institutions. This session aims to form the basis for the formation of community of engineering educators interested in supporting the education of students with disabilities. It is envisaged that outcomes will include equipping participants with the skills to contribute towards development of a toolkit to support students with disabilities in classroom and laboratory environments.

Workshop structure

- 1.) Plenary: introduction to the current situation
- 2.) Group activity: Participants work in international break out groups to discuss variations in the definitions of disability and requirements for support and reasonable adjustments within different contexts.
- 3.) Plenary: Report back from groups.
- 4.) Group activity: Current policies and practice including: support for transition to university; examples of practices and teaching interventions that support disabled students with discussion primarily focused on group work, presentations and PBL; alternative assessment; skills development and employability support.
- 5.) Wrap up including discussion about next steps and production of tool-kit.

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Parallel Workshops 2-13: Parallel Workshops 2-13

Time: Tuesday, 12/Sept/2023: 10:30am - 11:30am · Location: EQ-207 Technology Room

Planning Interdisciplinary Artificial Intelligence Courses for Engineering Students

Schleiss, Johannes; Stober, Sebastian

Otto von Guericke University Magdeburg, Germany

As Artificial Intelligence (AI) becomes increasingly important in engineering, instructors need to incorporate AI concepts into their subject-specific courses. However, many teachers may lack the expertise to do so effectively or don't know where to start. To address this challenge, we have developed the AI course design tool to help instructors structure their teaching of domain-specific AI skills.

This workshop aims to equip participants with an understanding of the framework and its application to their courses. The workshop is designed for instructors in engineering education who are interested in interdisciplinary teaching and teaching about AI in the context of their domain. A basic understanding of AI is sufficient to attend the workshop. By the end of the workshop, participants should be able to (1) distinguish between AI literacy and more advanced AI competencies, (2) understand important categories and leading questions for developing domain-specific AI courses using the AI course design tool, and (3) apply the AI course design tool for their own course and discipline context. Throughout the workshop, participants will work hands-on in groups with the AI course design tool and apply it to their intended courses. Moreover, they will reflect on its potential strengths and weaknesses. In the end, the experiences and findings are brought together in a collaborative summary. Overall, this workshop provides instructors with the tools to develop domain-specific AI courses and familiarize themselves with possible AI competencies in their respective domains. It is an opportunity for instructors to learn how to effectively integrate AI into their teaching practice and contribute to the advancement of AI education in engineering.

Parallel Workshops 2-14: Parallel Workshops 2-14

Time: Tuesday, 12/Sept/2023: 10:30am - 11:30am · Location: EQ-208 Flat Room

How to Use New Tools to Integrate Sustainability into Engineering Teaching

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¹NMITE, United Kingdom; ²Engineers Without Borders - UK; ³Lemelson Foundation, United States

Have you wanted to embed sustainability in your engineering modules but are unsure how? Do you want to gain confidence in equipping and motivating your graduates to tackle the serious sustainability challenges facing the environment and society? This workshop will introduce new tools designed to help engineering educators more easily and effectively integrate the sustainability knowledge, skills, and mindsets that both students and employers are demanding and that are essential to the globally responsible practices society needs today.

Recently, two projects have addressed the challenge that while many excellent resources on sustainability education exist, there aren't many that explicitly guide engineering educators to integrate these into their teaching, or indeed that are intended to upskill engineering academics to be able to deliver this teaching: the Reimagined Degree Map project undertaken by Engineers Without Borders UK (sponsored by the Royal Academy of Engineering) and the Sustainability Toolkit project undertaken by the UK's Engineering Professors' Council (sponsored by Siemens and the Royal Academy of Engineering). Both aim to build the capacity of educators to embed knowledge, skills and mindsets in their modules, courses or curriculum that will enable students to become competent in sustainable and globally responsible engineering practice. In cooperation with academic, industry, and advocacy group leaders, these two projects have resulted in the development of several educational tools.

This interactive workshop will introduce these new resources, giving attendees a chance to learn about them as well as to plan how they could be implemented in their own educational contexts. First, workshop participants will discuss the current context of sustainability in engineering education, at the programme, institution, national, and global scales. This discussion will also address inputs from students (via outcomes from the Siemens Skills for Sustainability Student Survey) and industry (via engagement with professional engineering institutions and companies conducted by Engineers Without Borders UK). Second, we will introduce the Reimagined Engineering Degree Map, which is a key action-orientated tool for considering the broader purpose of education, mapping learning journeys effectively, designing relevant learning, and assessing its effectiveness. Next, attendees will be guided through applying the Map to their own module or programme. Finally, we will reflect together on existing good practice and where gaps remain in implementation. This reflection process will in turn inform other resources under development for the Sustainability Toolkit.

Another outcome for the workshop will be to discuss opportunities for establishing an international community of practice dedicated to implementing and continually iterating on these educational tools.

Parallel Workshops 2-15: Parallel Workshops 2-15

Time: Tuesday, 12/Sept/2023: 10:30am - 11:30am · Location: EQ-211 Flat Room

Reflection on your personal perspective through other perspectives. A step in dealing with wicked problems

Hermesen, Pleun; Van Dommelen, Sjoerd; Hueso Espinosa, Paula

Delft University of technology, Netherlands, The

Don't we all sometimes seek the perspective of someone unrelated to our work, to get unstuck, or when we seek creativity? Engineers, educators, and students put their trust into science, protocols, procedures and models. Rightfully so, from the perspective of the laws of engineering this makes sense. This also explains why when people deal with challenges, they often tackle them (consciously or unconsciously) with their preferred strategies (Hayashi 2018) (Mezirow 2000). However, these preferred strategies might offer a false sense of security because they oversimplify the complicated nature of the challenge. People might focus on the part of a problem which is easy to solve rather than addressing a bigger networked problem (Kahneman 2013).

In dealing with complex problems, it is helpful for engineers to become aware of habits and open their eyes to other ways of seeing and doing, as solving (today's) multidisciplinary wicked problems often require that. (Braun 2021; Braun and Kramer 2015; Kramer and Braun 2018; Seniuk Cicek et al. 2021; Veltman, Van Keulen, and Voogt 2019). For example, if we consider a complex societal issue such as the energy crisis, engineers should recognize that the solution may not solely lie in developing new energy harvesting technologies. Instead, they should also consider the systemic context that may need innovation, such as political structures, unequal access to resources, or ways of promoting sustainable policies and practices in their context. By recognizing the interconnectedness of various factors, engineers can contribute to more holistic and impactful solutions to wicked problems. Recognizing one's own perspective is the first step towards valuing other perspectives or approaches to a problem. By understanding 'our own eyes', we can connect with and value other perspectives and alternate ways of doing something.

This workshop introduces reflection through third person perspectives, to help participants recognize the habits that are embedded in their own perspectives. Participants can later apply the method and material used in the workshop in their own educational context. It is suitable for students, researchers, and teachers.

Parallel Workshops 2-16: Parallel Workshops 2-16

Time: Tuesday, 12/Sept/2023: 10:30am - 11:30am · Location: EQ-212a-d (All)

Using a spiral approach to facilitating engineering research and education in real industry settings

Pereira Pessôa, Marcus Vinicius; Nizamis, Kostas

University of Twente, Netherlands, The

Engineering research and education is often done in cooperation with industry. This is because the practical effectiveness of engineering methods and techniques in industry can only be evaluated in such settings. Unfortunately, research findings in this context often fail to be adopted by industry, despite using a thorough and rigorous research methodology like the Design Research Methodology and the Design Science Methodology.

With this motivation, this workshop has the objective of discussing best practices when conducting engineering education and research in collaboration with industry. At the end of the workshop, participants are expected to:

1. Reflect on their work approach in collaboration with the industry.
2. Share concrete actions and examples from their own experience.
3. Learn from concrete actions and examples from the presenters' and the other participants' experience.
4. Contribute to all participants' common understanding of opportunities and challenges of Industry as Laboratory (IaL), Challenge-Based Learning (CBL) and the use of the Spiral Approach for Systems Engineering Research (SASER) when conducting engineering education and research in collaboration with industry.

Background and relevance

Industry as Laboratory (IaL), and Challenge-Based Learning (CBL) are prime examples where academia meets the industry both in terms of research and education. IaL is a research approach that improves relevance for industry by embedding parts of the research in real industry settings. CBL brings industry challenges to the classroom and also to research. However, both IaL and CBL face the challenge of aligning traditional academic work with fast-paced industrial processes (e.g., extensive and time consuming analysis, may lead to lost interest by the company). This often reduces the industry interest, creates tension between academia and industry, and weakens the will for collaboration.

SASER is an empirical approach that addresses the aforementioned problems. SASER explicitly embraces the reality where research questions are not self-contained and that the work is rather cyclical and not linear. During each spiral intermediate results are created, which deliver value to the industry partners and bring good feedback to the researcher. Finally, SASER is not limited to systems engineering but can be applied during any engineering research or project that face similar challenges.

This workshop's relevance to the Engineering Education community lies on assisting to devise techniques to resolve industry-academia tensions related to supervision of research and education. By using a spiral approach like SASER, either independently or in combination with CBL, a closer fit between academia and the industry needs can be achieved.

Workshop activities

To achieve the planned learning outcomes, the workshop activities will follow a cycle of learn=>apply=>reflect:

Learn: The motivation and justification behind SASER is briefly presented, the workshop structure is explained, and the approach is described through an example.

Apply: The workshop attendees are divided into groups and receive a hands-on task, where they work in a case to define possible strategies to execute a class project or a research in collaboration with industry. Although SASER is one alternative, the attendees are also expected to discuss other possibilities. Although sample cases are provided by the workshop organization, the attendees can make use of cases from their own experience. Regardless the choice, the case must include the needs from the industrial partner and the proposed research questions or learning objectives. Depending on the number of attendees, the plan is to have at least three groups, each working on a different case at the under-graduate, post-graduate or research levels..

Reflect: The groups will share their experience from comparing SASER with other strategies for collaborating with the industry, and highlight their observed strengths and weaknesses. The results of this reflection will be organized and made available to the attendees.

Target audience and intended benefits

This workshop's does not require any previous knowledge and its target audience includes educators that have interest in working in collaboration with industry, either during education or research.

In the context of engineering research, the expected benefit is enhancing the educators' competence on supervising research and on defining a research methodology in the case of industry-based research. In the context of engineering education, the expected benefit is enhancing the educators' competence on creating a challenge solving dynamic, which enhances the mutual gains from the interaction between academia and industry. By increasing such competences, the educators can augment the supervised students' confidence, avoid being trapped into the analysis phase, guarantee that the work delivers value to industry, and strengthen the relationship with the industry partners.

Parallel Workshops 2-17: Parallel Workshops 2-17

Time: Tuesday, 12/Sept/2023: 10:30am - 11:30am · Location: EQ-315 Flat Room GD

Integrating Learning Analytics into Engineering Education: Design Strategies for Teachers

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Technical University of Eindhoven, Netherlands, The

Background, Rationale and Motivation

While reflecting on the role of engineering education for a sustainable world, one must consider one of the most important gamechangers in education of this century: the use of big data, and within it, Learning Analytics (LA).

LA is defined as "the measurement, collection, analysis and reporting of data about learners and their contexts, for purposes of understanding and optimizing learning and the environments in which it occurs" (Gasevic *et al.*, 2019; Long *et al.*, 2011). LA generally comprises three major themes: indicators and predictors, visualizations, and interventions (Gasevic *et al.* 2019; Brown, 2012) which are interconnected. For instance, specific Learning Analytics indicators can be developed and subsequently used to visualize critical areas of the learning experience to provide the basis for the design of class interventions. Some examples may include: basic summary indicators such as total learning time online and total number of learning sessions (Conijn *et al.*, 2017), study irregularity indicators such as irregularity of learning time and entropy (Jovanovic *et al.*, 2019), and indicators of resource accessing such as number of file downloads and number of forum posts (Park *et al.*, 2016). Indicators have been found to be predictive of students' learning outcomes (Conijn *et al.*, 2017), beneficial forms of learning (Liz-Dominguez *et al.*, 2022) or student well-being (Sher *et al.*, 2022).

One important aspect of learning behavior often explored is student engagement, that has always been considered essential for successful learning, which modern LA methods have allowed us to get a deeper understanding of this process (Saqr & Lopez-Pernas, 2021). Student engagement is a fluid and dynamic process, and can change over the duration of the course, year, or even the whole study program (Saqr & Lopez-Pernas, 2021). Such trajectories are difficult and costly to measure with more traditional methods (such as surveys or interviews) (Panadero, 2016).

Educational professionals can utilize these insights to identify students' needs and design educational interventions that can help students improve (Charleer *et al.*, 2016). Big data from individual students can be used to create personalized learning approaches and targeted interventions that account for particular needs and goals (Zhang *et al.*, 2020). Interventions would need to be done early enough during a course so that students can adjust their learning behavior over time. Also, teachers would need to design their course and interventions so that students' online learning behavior generates data required by the indicators.

Workshop objectives and outcomes

This workshop provides an opportunity for engineering educators to learn about LA, how it can be incorporated in their course design and what LA literacy do teachers and students need to take advantage of this approach. This will in turn improve student learning outcomes, address student behaviour with respect to performance and improve personalized learning (Akhila *et al.*, 2020).

One aspect that we will cover throughout is the ethical usage of big data in education. Using technology that can store and identify the trace data of individual students leads to the possibility of tracking learners (Pardo & Siemens, 2014) and hence give rise to ethical and privacy issues that require understanding and active effort from educators, researchers, and policy makers to solve. We will present some of the frameworks and models that have been created for this (Kitto & Knight, 2019).

At the end of the workshop participants would be able to a) list different indicators (e.g. to support student's achievement of learning outcomes and or student well-being), b) grasp the basis of course design to generate useful data for different types of indicators in an ethical, transparent and responsible manner and c) identify tools that can support the interpretation of data that supports their decisions on course design in engineering education.

Workshop

We will initially present the background of LA and set the scene on type of indicators and tools for data visualisation. We will use the workshop design of Hrastinski (2021) so that participants consider their own courses and work in small groups. The groups will be based on type of indicator (to support student learning outcomes/student wellbeing/personalized learning and student engagement).

activities

In this way each participant can get useful information for its own course from this workshop. The following points will be considered within the groups:

1. Background – Share your own module, e.g. name, purpose, level, scope/credits, approximate number of participants
2. Design -Describe and motivate the indicators incorporated in the course design
3. Evaluate - How should the indicators be visualized and interpreted to make informed decisions?
4. What potential ethical challenges may arise, and how can they be effectively addressed?
5. Share - How can lessons learned be shared with colleagues?

We will use posters in each 'round table' to record the outputs of the idea generation. Finally, we will bring all the ideas together in a plenary discussion where all participants can share lessons and challenges they might face.

Conclusions

The workshop aims to discuss broadly opportunities provided by LA and as such it will be of interest to educators and practitioners looking to improve students learning in engineering education through the use of educational data. There is no prior knowledge on LA required and no maximum number of participants.

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Parallel Workshops 2-18: Parallel Workshops 2-18

Time: Tuesday, 12/Sept/2023: 10:30am - 11:30am · Location: EQ-113 Flat Room

Enhancing Retention and Transfer of Mathematics in Engineering Education

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Introduction

Mathematics is at the heart of the engineering curricula and is instrumental in the engineering profession. However, one of the significant problems of engineering education is the dropout rate. Arguably, difficulties in higher education start in secondary school, where mathematical competencies are less developed than needed for tertiary education. Additional stumbling blocks are instigated by the many foundational mathematics courses at the start of the bachelor programme. Treacy (2016) found that these BSc mathematics courses cause as high a dropout rate as one-third of the student population entering STEM education. High shortages in STEM graduates ask for mitigating these effects worldwide as UNESCO shows mounting shortages. Creating Service Mathematics Education (SME) with the highest possible passing rate is of the utmost importance to keep, sustain and retain as many students as possible to continue and successfully finish their engineering education.

PRIME Mathematics Education

At TU Delft, a large-scale programme of innovation in SME (PRIME) has been focused on this idea for the past few years by introducing a blended learning programme in which Prepare, Participate, and Practice is at heart of the didactical model, activating students as much as possible towards satisfactory learning results. However, more than PRIME is needed to realise the wished-for success rate in engineering. To mitigate the low retention and looming shortages, TU Delft intends to set up an alternative support structure focused on the following:

- Programmatic assessment (Baartman et al., 2020), making regular and formative assessment central to signalling failure and timely feedback and support to reduce dropout.
- Micro-credential support programme; embedding online in offline education.
- Increased autonomy for students allows for greater satisfaction and self-directedness in responsible learning.
- Using Mathematical Competencies to bridge the gap between SME and engineering.

We are investigating the typical problems and issues in SMEs, the causes for low retention, and what typical shortages create barriers that limit the transfer from Mathematics to Engineering.

Workshop

In this workshop, participants will interactively create a mind map in which these problems/barriers become visible to the mathematics community and may engender more systemic change. The workshop will briefly introduce the theoretical foundations of mathematical learning problems in higher engineering education. Successively, we will tap into the tacit knowledge of engineering and mathematician teachers and researchers that will attend the workshop. Jointly, the participants will create one mind map visualising the within mathematics problems and one mind map visualising the transfer of mathematics to engineering problems. Followed up by a general discussion of our intended solutions and audience-proposed solutions.

- Introduction (15 minutes)
- Mapping Mathematics Problems/Transfer of Mathematics to Engineering (25 min)
- Walk-around discussion (5 min)
- Plenary discussion (15 min)

The mind maps and discussion results will be shared with the entire audience after the workshop.

References

Baartman, L, van Schilt- Mol, T., Vander Vleuten, C. (2020), Programmatisch toetsen: voorbeelden en ervaringen uit de praktijk, HvU

Cristea, T.S., Snijders, C., Conijn, R., Matzat, U., Kleingeld, A. (2021), The Relation between Autonomy and Well-Being in Higher Education Students During the COVID-19 Pandemic

Plenary 2: Plenary Panel Session - Which Engineering is Needed for AI?

Time: Tuesday, 12/Sept/2023: 11:30am - 1:00pm · Location: EQ-010 Performance Hall & EQ-002 Lecture Hall

Which Engineering is Needed for AI?

Tarchini, Alex

Mathlab Central

Convened by Mr Alex Tarchini and Moderated by members of the **Board of European Students of Technology (BEST) and European Students of Industrial Engineering and Management (ESTIEM)** with Panel Invitees; **Xavier Fouger** (Dassault Systèmes), **Susannah Cooke** (ANSYS), **Marco Rossi** (MathWork), **Martin Koczmann** (Siemens) and **Susie Ye** (Bentley)

Which Engineering is Needed for AI?

Artificial Intelligence (AI) has become one of the biggest drivers of technological change, impacting industries and creating entirely new opportunities.

There is a massive demand in the industry for individuals who possess the skills required to deploy scalable AI applications. Companies of all sizes (from small start-ups to large organizations) hire AI engineers to build machine learning products. Although you do not need to be an expert or practitioner of AI to develop an AI vision and strategy, understanding AI and related subject matter areas is critical to making informed decisions.

We are asking panelists, to elaborate and share with the audience about their company position and:

- to outline **how AI is transforming** the industries served by their companies;
- to report about the “**AI needs**” that their industrial customers are expressing: what skills (technical and soft) are requested to embed AI in engineering design?
- To offer **ways engineering universities could match these needs** (Dual Learning, Micro Certificates, PBL, ...)

Xavier Fouger is an Industrial Engineer, former Science Attaché for the French embassy in Vienna, Xavier joined Dassault Systemes in 1990 to develop innovation processes for automotive manufacturers in Germany and Korea.

He founded the corporate organization in charge of academia, designed learning initiatives for secondary and vocational education in the USA, Malaysia, Canada and France and deployed learning centres in universities in India, China, Brazil, Mexico, South Africa, Kenya, Ivory Coast, Vietnam and Argentina. He created Dassault Systemes' Learning Lab to collaborate with university in educational innovation within projects funded by US and European agencies, focusing on practices enabled by digital technologies: social innovation, precision agriculture, Internet of Things, Virtual Twins, Additive Manufacturing, Collaborative Robotics, Smart Farm/Factory/City/Building and Model Based Systems Engineering. He currently works on industry-inspired learning centres, educational government programs and collaboration with engineering education societies.

- IFEES & GEDC Founding Member
- CTI expert, ASEE fellow, SEFI fellow
- Member of the Consultative Board of the UNESCO Aalborg Centre for Problem Based Learning
- “Peter the First medal” of the Association for Engineering Education of Russia (AEER)
- “Nikola Tesla chain” of the International Society for Engineering Education (IGIP)

Susannah Cooke is a Senior Product Manager at Ansys, managing Ansys Academic software.

She works with universities to ensure that Ansys tools can be deployed to best effect in teaching and research. She holds an MEng and DPhil in Mechanical Engineering from the University of Oxford, where her doctoral thesis focused on fluid flow around tidal turbine arrays. She has also previously worked for the UK's research funding agency, UKRI, and she began her engineering career in railway maintenance.”

Martin Koczmann is the Academic Project Manager for the EMEA (Europe, Middle East, and Africa) region at Siemens PLM Software. In this role, he manages academic relations in the EMEA Zone and helps develop and support Siemens PLM Software's academic partner community.

Engagement in dialogues on industry trends, academic best practices, and digital transformation is an integral part of this role. These discussions take place with educators and other professionals, creating a rich exchange of ideas and experiences. There's a significant focus on preparing the next generation of digital talent, with a particular emphasis on the contexts of emerging technologies such as Industry 4.0 and Artificial Intelligence. The goal is to ensure that the future workforce is not only proficient in these technologies but also skilled at integrating them into practical applications that drive industry growth and innovation, while also considering sustainability.

Susie Ye is an Education Program Manager from Bentley Systems, an infrastructure engineering software company. Being a technology enthusiast in the engineering industry, Susie loves discovering emerging engineering technologies and how they can contribute to solving real-world problems.

Being an Education Program Manager, her goal is to support young professionals upskill and unlock new career opportunities by providing industry engineering software and expertise to education institutions and engineering students. Having been working in manufacturing, tech and AEC industry, Susie finds herself constantly learning new technologies & innovations and privileged to have benefited from many industry mentors' help. During the learning process, Susie understood the need to develop new talents for the engineering industry in order to build a better world, as well as unlock the power of engineering education that enables talent development.

Marco Rossi is member of the MathWorks Academia Team and supports lecturers and researchers in the use of MATLAB and Simulink for teaching and research.

Since 2020, Marco runs curriculum development projects in Hungary, Croatia, Czech Republic, Turkey, South Africa, and many other Universities. Marco graduated in Aeronautical Engineering from La Sapienza in Rome. Since 2015 he worked as Assistant Researcher at TU Dresden in Germany, where in 2019 he obtained a PhD in Mechanical Engineering due to his work on modeling and simulation of soft materials. Marco taught several courses during his academic experience including statics and intelligent materials.

Paper Session 2-10: Learning Supports for Students

Time: Tuesday, 12/Sept/2023: 2:30pm - 3:30pm · Location: EQ-002 Lecture Hall
Session Chair: Deolinda Maria L. Dias Rasteiro

Engagement and Solidarity while Learning

L. Dias Rasteiro, Deolinda Maria¹; R. Caridade, Cristina M.¹; Hernandez Encinas, Ascensión²; Queiruga-Dios, Araceli²; Mierlus, Ion³

¹IPC/ISEC, Portugal; ²University of Salamanca; ³Technical University of Civil Engineering Bucharest

2020 and 2021 were difficult years for students attending higher education and secondary education especially if they were preparing to enter higher education. Teaching was adapted, and assessments were the possible ones according to what we lived and experienced. Thus, students need innovative and stimulating teaching and learning practices that motivate and involve them in the teaching/learning processes. ICT and digital platforms have seen their indiscriminate use, not without sometimes, teachers and students questioning whether they were being used in the best possible way or they were being taken full advantage of. Face-to-face group work and involvement with the needs of colleagues lost some space for achievement and effectiveness. The preference for individual work and the visible reduction in solidarity among colleagues was an issue/question posed at the beginning of this study. An activity was proposed over a semester to students of Statistical Methods from Informatics Engineering. This curricular unit enrolls 534 students, 85 on an after-work basis. The objective of this proposal was to create a collaborative learning platform where students could interact with each other within the scope of the curricular unit. Cumulatively, it was an objective that students deepen the topics taught in class, including references provided, and reviewing exercises carried out by their colleagues. Regularly professors corrected the materials proposed by the students. All students who participated had access to all the work developed. The evaluation of students' involvement, collaboration, and solidarity in addition to the results will be discussed and presented.

Using Padlet on math collaborative learning in an engineering course

R.Caridade, Cristina M.; L. Dias Rasteiro, Deolinda Maria

IPC/ISEC, Portugal

This paper describes a study, with the objective of evaluating the possibilities of knowledge construction through collaborative learning (CL) in the innovative Padlet environment. During the practical classes of a math curricular unit of an engineering course, activities and assessments were carried out using Padlet. Program themes are organized by columns as a wall. Each student's group accesses a problem proposal using a QR-Code. In the first part of the class, the group must solve the problem correctly, using all the materials and technologies they deem necessary. In the second part, each group will correct another group's problem. The teacher provides the necessary support with the role of advisor in carrying out the proposed problems. Through direct observation of the teacher during the classes, the experiences of the authors, and the evaluation of the students in these contents, it will be possible to collect information that will allow demonstrating that CL using Padlet was efficient. Students' opinions gathered through interviews and two questionnaires (initial and final) will also be very important data to be presented regarding their interest in this collaborative activity.

In conclusion, this paper will describe, analyze, and discuss the interest in using a CL environment for the development of knowledge and student motivation in teaching/learning math for engineers. Students' perspectives will be observed regarding their motivation and interest, allowing teachers to expand the range of perspectives on the contents covered and enriching the necessary discussions for future activities development.

Mentoring programs for engineering students as a way to improve their skills and competencies

García-Cardo, Susana¹; Murillo Ruiz, Rebeca Jackeline²; Díaz-López, María José¹; Queiruga-Dios, Marián¹

¹Universidad Francisco de Vitoria; ²Universidad Vasco de Quiroga

Universidad Francisco de Vitoria (UFV) in Madrid (Spain) and Universidad Vasco de Quiroga (UVAQ) in Morelia (Mexico) seek the comprehensive academic training of students: not the mere development of technical skills, but also the personal and soft skills that enable them to face their professional reality.

Educational Missions in both institutions aim for sustainable development oriented towards people and the societies in which they are immersed. Their substantial actions have been designed, in a way that active methodologies and innovative proposals are included. Among them, it is worth highlighting the provision of a personalized support system for students, in which, through a competence itinerary with their tutors, issues are addressed to help them to full development.

An added value has been identified by applying this mentoring system in engineering careers (mainly based on hard skills), when supporting students in the development of other skills.

A comparative study was carried out on the differences and similarities between the programs of both universities, from the point of view of the people who mentor and guide students. Thanks to those contributions, we have information that will allow us to adapt the processes and thus respond more adequately to the needs of engineering students in their first undergraduate degree courses. The focus group technique was used in the process.

Improving motivation and continuous assessment in engineering classrooms through Student Response Systems

Merchán Moreno, María Dolores¹; Pascual Corral, Elena²; Prieto Calvo, Cristina³; Miguel Hernández, Mario⁴; Santos Sánchez, María Jesús⁵

¹Dpt. Physical Chemistry, University of Salamanca; ²Dpt. Applied Physics, University of Salamanca; ³Dpt. Fundamental Physics, University of Salamanca; ⁴School of Maristas Champagnat, Salamanca; ⁵Dpt. Applied Physics. Institute of Fundamental Physics and Mathematics, IUFFyM, University of Salamanca

The use of Student Response Systems (SRS) is highly recommended to encourage the active and meaningful learning of students in each lecture. SRS promotes the motivation of students and improves the system of continuous assessment [1-4]. This resource is very useful for face-to-face classes, but even more in online classes where it is easier for students to lose the thread of the class due to possible external distractions or tasks.

One of the most popular applications designed for SRS is Socrative [5], which can be used from a computer or mobile device, and being easy to handle. The use of Socrative in classrooms gives an authentic sense to continuous assessment, as the teacher has an easily manageable record (spreadsheet) of the learning evolution of their students. The use of quizzes in Socrative will help the teacher to program both formative and summative assessments. As the application generates a detailed record of each student's responses it allows the detection of topics that each student may not have understood and even determines the percentage of the entire class with the same difficulty.

In this work, we will focus on the use of Socrative in various bachelor engineering degrees (Chemical Engineering, Mechanical Engineering, and Materials Engineering), in which the track of the daily learning and accompaniment of the student is necessary to verify if they are developing the required competencies. It allows the teacher to perform a true continuous assessment of each student's learning process, and provide real-time explanations to solve possible deficiencies.

Paper Session 2-11: Engineering Ethics Education 2

Time: Tuesday, 12/Sept/2023: 2:30pm - 3:30pm · Location: EQ-116 Flat Room
Session Chair: Fiona Truscott

Digital Ethics Canvas: a Guide for Ethical Risk Assessment and Mitigation in the Digital Domain

Hardebolle, Cécile¹; Macko, Vladimir²; Ramachandran, Vivek¹; Holzer, Adrian²; Jermann, Patrick¹

¹Ecole Polytechnique Fédérale de Lausanne (EPFL), Lausanne, Switzerland; ²Université de Neuchâtel (UniNE), Neuchâtel, Switzerland

Ethical concerns in the digital domain are growing with the extremely fast evolution of technology and the increasing scale at which software is deployed, potentially affecting our societies globally. It is crucial that engineers evaluate more systematically the impacts their solutions can have on individuals, groups, societies and the environment. Ethical risk analysis is one of the approaches that can help reduce "ethical debt", the unpaid cost generated by ethically problematic technical solutions. However, previous research has identified that novices struggle with the identification of risks and their mitigation. Our contribution is a visual tool, the Digital Ethics Canvas, specifically designed to help engineers scan digital solutions for a range of ethical risks with six "lenses": beneficence, non-maleficence, privacy, fairness, sustainability and empowerment. In this paper, we present the literature background behind the design of this tool. We also report on preliminary evaluations of the canvas with novices (N=26) and experts (N=16) showing that the tool is perceived as practical and useful, with positive utility judgements from participants.

Instructors' expectations and objectives for integrating sustainable development and ethical issues into the curriculum

Tepsa, Tauno Aki; Mielikäinen, Maisa Tuulikki; Angelva, Juhani

Lapland University of Applied Sciences, Finland

The integration of sustainable development and ethical issues into the curriculum is increasingly important in higher education. The study surveyed 17 instructors in ICT engineering education at the <university, region> involved in curriculum development to explore their expectations and objectives in integrating sustainable development and ethical issues into their courses. Although most instructors had a good understanding of sustainable development and ethical issues, not all saw them as relevant to their courses. Those who did incorporate these themes focused on topics such as energy conservation, social sustainability, and sustainability and ethics in solutions. However, almost half of the instructors did not plan to incorporate ethical issues into their courses, and those who did focus on copyright, artificial intelligence, and source criticism. Instructors expressed the need for themed discussion sessions and expert lectures to enhance their knowledge and skills. The study's results suggest the need for more effective strategies to incorporate sustainable development and ethical issues into ICT education. The findings of this study could support academics in their ongoing efforts to incorporate ethical and sustainable development concerns into their curricula.

Effect of engineering education on students' ethical attitudes

Virta, Ulla-Talvikki Anniina; Järvinen, Hannu-Matti

Tampere University, Finland

Integrating teaching about ethics in engineering degree has challenges: Teachers focused on the degree core topics may lack the expertise to handle the ethics, and teachers with ethics background may struggle to connect the ethics teaching to the field specific issues. In addition, a portion of the students themselves may consider the non-core topic to be unnecessary or unmotivating, which poses further challenges for the teaching. In the paper, we explore the ethical attitudes of students based on a survey conducted to information technology, electrical engineering and computer sciences students at our university.

The survey received 224 responses. We compare the attitudes of students depending on their progress of the studies and whether they have had any ethics teaching included in their studies. In addition, discuss the students' attitudes compared to ethical attitudes of the graduated engineers from survey to members of a national engineering association.

As the goal is to understand how to better integrate the ethics teaching to the education, we also discuss the students' views how the teaching should be integrated and if students' previous encounters with ethics teaching affect their opinion on the matter.

Drawing from SEFI ethics knowledge to support eco-ethics education within the European University of Technology

O'Sullivan, Jye Benjamin; Chance, Shannon

TUDublin, Ireland

We are leading a project called Ethico that is part of the European University of Technology (EUT). Ethico aims to design and promote the uptake of innovative, ecological ethics for technological education.

The proposed paper will briefly summarize the aims and structure of the Ethico project, and then focus on the work completed as part of the teacher training module developed in Cluj, from the 7th to the 9th of March 2023. The work drew its conceptual framework from the short abstracts currently available in the *Engineering Ethics Education Handbook*. The handbook is under development by SEFI's Ethics special interest group, who shared the content with us. We drew particularly from Theme 3, covering Teaching Methods for Engineering Ethics Education, for the work session in Cluj.

From these abstracts, we designed and piloted tested a teaching training course with flexibility to apply to diverse cultural and administrative conditions. We explored how we could apply the literature review and dialogical/reflective chapters of the EEE Handbook, as well as of three of the Student-Centred Learning approaches (case studies, challenge- and problem-based learning, and Virtues Practice Design), with very promising results.

This paper will examine the ethical models engaged with and the teaching models developed. It will discuss the data collected as an evaluation of the intensive study period. Then, it will outline and problematise our proposed module for eco-ethics in technological education, highlighting the key tensions for implementation in cross-cultural and interdisciplinary contexts.

Paper Session 2-12: EDI 4 - Inclusivity and Design

Time: Tuesday, 12/Sept/2023: 2:30pm - 3:30pm · Location: EQ-211 Flat Room
Session Chair: Helena Kovacs

Inclusive Design in action – A case study describing the design of social area seating in a University

Nolan, Mary; Murphy, Eva; Carden, Mary

ATU Sligo, Ireland

This practice paper outlines the inclusive design process used in the redesign of communal/social seating in an Engineering faculty in a University in Ireland. The old seating was not being utilised by the students. Engineering courses often present challenging assignments to students; literature shows that access to information, knowledge exchanges and opportunities for learning through social interaction can be crucial to student success.

Equality, Diversity, and Inclusion (EDI) has grown as an important agenda item across society. Therefore, the methodology used in this redesign was inclusive design. Inclusive design is a design framework that takes into account the diversity of the human race and embraces co-design to ensure no one is excluded. It is "...not designing one product for all people; instead, it's designing a diversity of ways to participate so that everyone has a sense of belonging" (Holmes 2018).

The design team on this project was composed of a voluntary, diverse group of students and staff. The data collection methods employed was a design walk through of the University, a faculty-wide survey, and a design hackathon.

The inclusive design process resulted in various social seating designs that addressed the needs of a broad range of users, including those with physical disabilities and sensory impairments. The final designs are available for perusal in Appendix 2, that show a more inclusive space for students and staff to interact and collaborate.

The findings of this study highlight the importance of using an inclusive design process when designing academic environments. By involving a diverse group of stakeholders in the design process, the resulting spaces can better cater to the needs of all users. The recommendation is for other higher education institutions to consider implementing inclusive design principles in their design processes to ensure all members of their community are catered for, leading to a more inclusive and accessible academic environment for all.

Inclusive engineering classrooms: student teaching assistants' perspectives

de Lima, Joelyn; Isaac, Siara; Kovacs, Helena

EPFL, Switzerland

Inclusive teaching is the intentional practice of recognising biases, working to mitigate their impact, and ensuring that students have equitable learning opportunities. In addition to improving students' sense of belonging and self-efficacy, inclusive teaching improves retention, improves academic performance, and reduces achievement gaps. In many large enrolment introductory classrooms, student teaching assistants (TAs) contribute to the classroom climate in addition to the teachers and the students.

In this qualitative study, 262 TAs were asked about their teaching strengths, areas that need improvement, obstacles, and ideas about their role in reducing incidents of discrimination or harassment. We coded their open-ended responses using a framework proposed by Dewsbury (2020), to map ideas about inclusive practices that these TAs are bringing into the classrooms.

Our analysis suggests that TAs can be powerful forces in building inclusive classrooms, given the coherency with Dewsbury's inclusive teaching competencies. Following training, the importance accorded to content knowledge decreased and active learning increased, coherent with increased focus on supporting students' learning. Positive classroom climate dominated TAs' ideas about decreasing discrimination in the classroom, however this did not feature among the teaching strengths they listed and many TAs cited a need to improve their skills in this area. However, empathising with students was also cited less often in the post survey, suggesting unintentional impact of the training that is counter to inclusive teaching. This suggests that TA training needs to be explicit about how to do inclusive teaching to fully exploit potential for TAs to foster inclusive classrooms.

Fostering a Sustainable Future through Inclusive Design

Omar, Samara; Youmans, Kate; Wigner, Aubrey; Archer, Henry; McClelland, Carrie

Colorado School of Mines, United States of America

Fostering a sustainable future requires a balance between human necessities, societal institutions, and environmental systems; and this delicate equilibrium is best attained through strategic and innovative design. With this, and the growing diversity of our communities, it is imperative to equip engineering students with inclusive perspectives that allow them to critically assess the socio-technical elements of sustainable design. Recent research within engineering education has elevated the importance of empathy as a design practice and inclusivity as a design principle; exploring topics of bias and exclusion are essential to this work. As part of a first-year design course, we introduced these topics in a five-part instructional series, called Leading through Inclusive Design.

This series first focused on identifying exclusions in our designed world and exploring the intentionality of design. Second, students reflected on their identities and considered how biases might influence design work. Next, in the context of a re-design project, students evaluated the exclusivity of an object and implemented learned strategies toward an inclusive re-design. Finally, by applying inclusive design principles and leadership mindsets, students were asked to develop an 'ecology' of solutions for a Grand Challenge' as defined by the National Academy of Engineering. Solving these multiplex problems around themes of sustainability, health, security, and joy of living required cultural, ethical and economic awareness beyond traditional engineering proficiencies. We describe the implementation of this series and summarize the unique outcomes of our approach for a class of predominant white, male engineering students with diverse majors and passions.

Inclusion in Computing via the Early Research Scholars Program at UIC

Revelo Alonso, Renata Alejandra¹; Diaz Herrera, Diana¹; Rozhkova, Anastasiia¹; Hummel, Joseph²

¹University of Illinois, Chicago, United States of America; ²Northwestern University

For a sustainable world, all people who aspire to be engineers should have an equitable opportunity to achieve their engineering education. In the United States, groups of individuals continue to be minoritized in engineering and computing specifically. This practice paper addresses inclusion and diversity efforts in the computing field, within two departments of a college of engineering, to 1) increase the number of minoritized students in computing, 2) introduce research as a career path to undergraduates early on in their education, and 3) nurture a sense of community (within the department and the computing field) for students. These efforts are being furthered through the Early Research Scholars Program, which is a program to engage students with research within their first 3-4 semesters in their undergraduate careers. In this paper, we will review aspects of this program that make it inclusive and harness diversity, share preliminary results from the last two years on community building within the program, and provide implications for other institutions to implement inclusive and community-building practices in their curricula or programming.

Paper Session 2-13: Virtual and Remote Education Post Covid 4

Time: Tuesday, 12/Sept/2023: 2:30pm - 3:30pm · Location: EQ-203 Flat Room
Session Chair: Eugene Coyle

Problem solving skills deconstructed and implemented in an adaptive learning tool

Duyver, Arne¹; De Keyzer, Jozefien¹; Wieers, Els²; Henriouille, Kris¹; Aerts, Kris¹

¹KU Leuven campus, Faculty of Engineering Technology, Diepenbeek campus, Belgium; ²UHasselt, Faculty of Engineering Technology, Belgium

The development of problem-solving skills is an important subject in engineering curricula. Helping novice students develop such skills can be challenging because problem solving is a complex skill in the sense that it is accompanied with an internal thinking process that many experts are even unaware of doing. From a combination of literature and a thinking-aloud exercise with the entire teaching team, a scheme with building blocks and strategies that are commonly used by engineers was constructed. In addition to commonly named steps such as Identify/Define, Plan/Choose, Carry Out/Do and Look back/Inspect the scheme refines the first step into multiple interdependent building blocks, emphasizes the need for critical reflection at each point as well as the possible need to return to previous steps at any time. Moreover, multiple correct solution paths can be followed in solving a problem. To address this and to empower the students in their divergent thinking processes when solving a problem, an innovative intra-exercise adaptive e-learning tool was created. The anywhere-anytime availability enables for virtual and remote learning in the post-COVID world. In the learning tool students can choose between different solution paths, after firstly identifying the correct context, parameters etc. This paper describes the process of defining the building blocks, resulting strategy scheme and implementation of the building blocks in the adaptive e-learning tool. Initial findings indicate that the strategy scheme consisting of building blocks and the adaptive e-learning tool help students in developing their problem-solving skills.

A framework for a scoping review of digital transformation of engineering education

Lyngdorf, Niels Erik Ruan; Leegaard, Jacob Højholt

Aalborg University, Denmark

The digitalization of engineering education has made significant progress in recent years due to societal circumstances such as corona but also thanks to technological development and progress and digital transformation of engineering education seems more imminent than ever. This paper presents the process and development of a framework for an ongoing scoping review regarding frameworks for digital transformation of engineering education. Empirical studies on digital innovations in specific small-scale contexts are numerous and the literature is rich. This study, however, aims to identify more systematic and holistic approaches to digital transformation. At this stage the review work has resulted in 38 research papers for full-text screening from 4 databases, SCOPUS, ProQuest, Web of Science, and Engineering Village. The proposed framework facilitate analysis of how frameworks for digital transformation of engineering education are informed and conceptualized ideologically in the sense of what digitalization should do for engineering education and how they guide and facilitate digital transformation. The framework builds on and combines theory from educational and digital transformation research and enables elicitation of essential elements of digital transformation in an educational context, including ideologies, models, dimensions, actors, elements, and levels of digitalization.

EXPERT-NOVICE DIFFERENCES IN ELECTRICAL CIRCUIT ANALYSIS BASED ON THE ORDER OF ATTENTION ON ELEMENTS USING A CONCURRENT THINK-ALOUD PROTOCOL

Paikrao, Amit Mahendra; Mitra, Ritayan

Indian Institute of Technology Bombay, India

The difference between experts and novices during problem-solving has been established in several domains. However, in electrical engineering, studies are sparse. This study compares experts and novices in an introductory electrical engineering course. Four novices (students) and three experts (teachers) were made to solve eight circuit problems with a concurrent think-aloud protocol conducted remotely due to COVID restrictions in India at the time of the study. Experts predominantly followed the direction of the current showing a working-forward strategy. Conversely, Novices displayed a means-end approach by jumping to mathematical calculations more than anything else. In addition, the arrangement of complex circuits confused them as they tried to solve the circuits based on a superficial understanding of the problems. We discuss the results in the context of what is already known about expert-novice differences.

Emerging trends, approaches and challenges in engineering education in the UK

Fowler, Stella^{2,1}; Direito, Ines¹; Bellingham, Kate¹; Mitchell, John¹

¹UCL Centre for Engineering Education; ²Engineering Professors' Council, United Kingdom

Worldwide, engineering educators are searching for approaches, pedagogies and change strategies to develop programmes that will equip their graduates to be successful engineers, effective engineering leaders and catalysts for social development. In the UK, focus largely rests on new pathway initiatives and new HE institutions. There is little shared understanding of the established sector's evolution from a maths and science heavy curricula to the innovative and world-leading models of engineering education found in the UK HE sector today.

This research paper looks at examples of trends that are emerging in engineering education provision in the UK and highlights case-studies of innovative provision and new models in the sector. A mixed-mode approach of desk research, structured survey and case studies were used to collect data. Data analyses show that across the UK there is a complete spectrum of engineering higher education, with the reality of the provision being complex with a broad diversity of educational models on offer. The research reviews current teaching and learning approaches and highlights evidence of innovations in laboratory practical teaching; use of projects; dissertation projects; project-based learning, project-based initiatives and frameworks; and examples of new buildings driving curriculum innovation.

In particular, the paper presents and discusses data concerning current teaching and learning approaches (including barriers and impact of the coronavirus on learning approaches and provision of engineering education in the UK), information on innovative elements, COVID mitigation and engagement with new methods of delivery, and coverage of sustainability in the curriculum.

Paper Session 2-14: Climate Change and Sustainability 4

Time: Tuesday, 12/Sept/2023: 2:30pm - 3:30pm · Location: EQ-204 Flat Room
Session Chair: Domhnall Ó Sioradáin

Embedding sustainability in the engineering curriculum: Meeting the requirements of professional accreditation

Carthy, Darren¹; Manton, Richard¹; O' Gorman, Louise²

¹Engineers Ireland, Ireland; ²Atlantic Technological University Sligo, Ireland

Professional accreditation agencies are increasing requirements on sustainability in engineering education as a response to ethical obligations, industry needs and emerging academic best practice. In 2021, Engineers Ireland increased sustainability requirements in new accreditation criteria. This paper reports on a thematic analysis carried out by Engineers Ireland on the self-assessment and achievement of these new accreditation criteria on sustainability. The analysis was conducted on the self-assessment reports from a large Irish University, referred to as University A hereafter. The results indicate that, for the purpose of meeting accreditation requirements, University A has interpreted sustainability in their programmes as either meeting the UN Sustainability Goals (SDG's) by mapping modules to the SDG's, or by aligning Programme Area (PA) 7 *Sustainability* of the Engineers Ireland accreditation criteria with the Engineers Ireland Programme Outcomes (PO's). The paper outlines the main themes and approaches identified across 17 engineering programmes and presents 2 case studies of how sustainability is embedded in engineering curricula in Ireland.

Preparing Structural Engineering Graduate to Increase their Positive Impact

Lynch, Louise^{1,2}; Norman, James²

¹Technological University Dublin, Ireland; ²University of Bristol, UK

Traditionally the role of a structural engineer was to design structures that were safe for use by society and that enabled society to develop and evolve. However, with the climate emergency structural engineers need to be more conscious of the choices that are made on their projects that lead to overuse of material, and work to reduce the embodied carbon in their structures. This cannot be achieved in isolation, it's a systemic issue, where decisions made throughout a project, from concept to construction, can impact the embodied carbon. The structural engineer needs to be mindful of these decisions to have a greater positive impact on construction projects. It may be due to how the project is specified, how it is designed or how it is constructed but the result is the same, the structure exceeds its functional need, it is overdesigned.

This research investigates, through 14 interviews, why overuse of material occurs on construction projects, specifically buildings, and what the first steps to change could be. This research outlines how some of these first steps include the knowledge and attitudes that are first developed in students within their early years of engineering education. This research aims not only to identify the messages we are giving to students but also to aid educators in recognising the other challenges that young graduates will be faced with. By developing educational programmes to equip individuals with the necessary skillset and knowledge, they can actively challenge traditional attitudes and become vital advocates for change.

Conceptual modelling as an overarching research skill in engineering education

Boon, Mieke

University of Twente, Netherlands, The

Today's society is impacted by complex, fast and continuously changing problems. These need to be tackled inter-, multi and transdisciplinary. At the University of Twente, we have developed a new CBL minor *Intelligence, creativity, and responsible technological innovation in societal transformations*, (ICR&TIST), which focuses on research skills in complex socio-technological problem-solving contexts. The design of this minor has been guided by new insights from long-running research aimed at developing a *Philosophy of Science for the Engineering Sciences* and extensive experiences with engineering education in project-based learning (PjBL).

Education in scientific research tends to focus on academic contexts, while scientific research in real-world problem-contexts (e.g., sustainability) requires the ability to effectively and responsibly construct relevant, reliable and intelligible knowledge for the benefit of the concrete, local problem and possible solutions, using everything science has to offer (knowledge, methods, instruments, mathematical tools). This type of scientific research calls for a *new paradigm*, called an *engineering paradigm of science*. *Conceptual modelling* (rather than hypothesis testing) fits better the core activity of this type of scientific research and should therefore be seen as an overarching skill.

The educational design of the minor has adopted conceptual modelling as the overarching learning objective. This new concept, how to work with the accompanying conceptual modelling methodology (B&K method) and understand the underlying philosophical insights appears exciting and challenging for the multi-disciplinary educational-design team. This paper will elaborate on the educational design process, the resulting design of the minor, and preliminary findings in the pilot-phase.

A Scoping Review: Examples of Mission-Driven and Mission-Oriented Innovation in Engineering Education Research

Christiansen, Svend Haukekrog; Markman, Anna Overgaard; Guerra, Aida; Du, Xiangyun

Aalborg University, Denmark

Engineers of the future are being requested to become part of solutions for dealing with complexities in the world, exemplified by the adaptation of the 17 United Nations sustainable development goals (SDGs). Ensuring that engineering students are introduced to these is of the utmost importance if sustainable solutions to grand challenges shall be developed, whether being of technological, social and cultural, and/or economic character. This paper entails a scoping review of the concept of mission-driven or mission-oriented innovation, as defined by the European Commission (EC) and the Organization for Economic Co-operation and Development (OECD), in engineering education research (EER). Seven papers were identified as relevant out of 50 papers derived from five databases, which were then reviewed by the two authors, indicating a substantial gap within engineering education research of mission-driven initiatives in education and research. It further reveals significant overlapping understandings, as the papers included often align their focuses with the SDGs without relating them to mission-driven or mission-oriented conceptual understandings. Outcomes of this scoping review propose that the field of EER acknowledges possible affordances, albeit challenges are still present, for engineering students in applying missions as a binding component for framing projects, cross-disciplinary collaboration, and partnerships with companies, authorities, or other stakeholders. Finally, future research directions are suggested in the field of EER concerning mission-driven or mission-oriented innovation for grasping practical circumstances for staff and students involved in the works of dealing with complexities through missions.

Paper Session 2-15: Engineering Graduate Attributes 1 - Transversal Skills

Time: Tuesday, 12/Sept/2023: 2:30pm - 3:30pm · Location: EQ-112 Flat Room
Session Chair: Kevin Gaughan

Work performance evaluation as a motivational approach for early-career self-management

Torres, Francesc; Silvestre, Santiago; Llorens, Ariadna; Elias, Antoni

Universitat Politècnica de Catalunya (UPC), Spain

This article presents the main features of an academic approach dedicated to facilitating a smooth transition to the technological job market for STEM graduates by motivating them to acquire relevant early-career professional skills and towards self-management of their careers. The results of a satisfaction survey after a pilot experience undertaken by 40 students at UPC, within the framework of the Engine4STEMers project [1], is also presented. This exercise is related to the concept of service and the rapid change in attitude and work methodology that a STEM graduate must undertake to evolve from a user culture (student) to a service provider culture (employee or entrepreneur).

Since students are very familiar with work performance evaluation in the academic environment, they are challenged to envisage and discuss what the main differences are when they sign up for their first jobs. That is, how is job performance evaluated in the workplace? However, this approach is not related to formal assessment tools. Instead, the concept of professional reputation is presented as an informal assessment of job performance that evolves along with career progression. The key importance of this public perception of job performance in career advancement is emphasized to present the need to cultivate soft skills. These are presented as personal and professional development tools (PPDT) that act as experience accelerators. The impact of instrumental skills on short-term progress compared to long-term personal and professional growth based on values and principles is also discussed.

EUniWell: Maximising academic and social outcomes in engineering education

Cooke, Neil¹; Forss, Jörgen²; Caporali, Enrica³; Charge, Pascal⁴; Chung, Sarah¹; Cottle, Daniel¹; Hawwash, Kamel¹; Andersson, Jesper²; Gianni, Bartoli²

¹University of Birmingham, United Kingdom; ²Linnaeus University, Sweden; ³University of Florence, Italy; ⁴University of Nantes, France

The ERASMUS+ European University for Well-Being (EUniWell) alliance's mission aims to resolve the paradox of Europeans' relative prosperity against the global security and sustainability challenge. "Maximising Academic and Social Outcomes in Engineering Education" is a project which interprets this contradiction for engineering educators; how to best teach non-technical skills to ensure engineers make the utmost contribution to societal wellbeing? Appreciably, the social outcome for the person who becomes an engineer is positive because the profession is relatively well-paid. Therefore, engineering education is good for social mobility providing the learning environment narrows attainment gaps between disadvantaged and mainstream cohorts. Accordingly, our strategy is to bring together the expertise of the British, French, Italian and Swedish faculties to transfer best practice for professional, business and sustainability skill teaching, while contrasting how their disadvantaged cohorts present. The project has two primary objectives: To understand how partners differ in terms of skill teaching, and how students from disadvantaged backgrounds are accommodated. The paper describes the background and rationale of the project, and its research design and methodology. Although the project is still in progress and data collection is still underway, this paper provides insights and perspectives for engineering educators looking to design similar collaborations to share best practice, while considering engineering identities and their underlying competencies.

The Need for Interdisciplinarity: A Case on Employees' Perspectives

Friedrichsen, Dennis; Winther, Maiken; Kolmos, Anette

Aalborg University, Denmark

The issue of interdisciplinarity contains disparate nodes of knowledge and practices, including a wealth of information concerning the potential and value of interdisciplinary work. In the context of companies that handle large-scale and complex tasks, interdisciplinarity takes on a real-life role since its presence and importance is readily observable and, as this paper shows, a conscious, deliberate, and highly valued aspect of innovation in companies. Academic literature on the issue of interdisciplinarity asserts that engineers in the future need a wealth of competences, including ability to collaborate in interdisciplinary teams. Aalborg University in Denmark has experimented with interdisciplinarity in various PBL contexts; the guiding research problem of this paper concerns how work practices call for interdisciplinary competence development. Through this perspective, we gain insight into how interdisciplinary competences are relevant for students at AAU as a competence that must be proactively developed.

The data set consists of nine interviews collected from a large Danish company. The interviews have been transcribed using Nvivo and coded according to the research problem. As the results of the qualitative data indicates, interdisciplinarity is not just an important competence for employees, but also a prerequisite for problem solving. Results indicate that interdisciplinarity is a competence that students must develop because interdisciplinarity is actively used for problem-solving in the types of jobs that engineering graduates will get in the future.

Students' and lecturers' perceptions on the importance, training, and assessment of engineering and lifelong learning competencies

Van Den Broeck, Lynn¹; Dujardin, Rani¹; Craps, Sofie¹; Beagon, Una²; Depaor, Caitriona²; Byrne, Aimee²; Naukkarinen, Johanna³

¹KU Leuven, LESEC, ETHER, Belgium; ²TU Dublin, Ireland; ³LUT University, Finland

Professional competencies and lifelong learning (LLL) are essential components for success in the engineering profession. Whilst engineering education has primarily focused on providing students with the required technical engineering competencies, new visions emphasise the importance of LLL and point towards the need for acquiring the necessary competencies for LLL during their study programme. The importance of professional and LLL competencies is clear, but what are the views of the engineering students and lecturers? In this study, a comparison is made between students' and lecturers' perceptions on professional and LLL competencies. The survey focuses on three aspects: (1) how important are the different competencies in engineering practice, (2) to what extent are they taught within the curriculum, and (3) to what extent are they assessed? In addition, lecturers were also asked to declare to what extent they possess the different professional and LLL competencies themselves. When looking at the top five competencies regarding perceived importance, extent of teaching, and extent of assessment, there are great similarities between students and lecturers. However, clear significant differences do emerge when comparing perceived importance, extent of teaching, and extent of assessment. These findings may be of interest to engineering programmes when evaluating, adapting or completely re-inventing the curriculum.

Paper Session 2-16: Mathematics and Sciences 1

Time: Tuesday, 12/Sept/2023: 2:30pm - 3:30pm · Location: EQ-208 Flat Room
Session Chair: Ann Marie F McKeon

Exploring Strategies to Promote Engagement and Active Learning through Digital Course Design in Engineering Mathematics

Kula, Fulya; Horstman, Erik M.; Lanting, Lavinia S.; ten Klooster, Linda R.
University of Twente

This research explores the strategies and techniques used to foster and promote the engagement and active learning of engineering students within a digital course. The digital course has been developed to address the varying levels of understanding of fundamental mathematics among first-year engineering students, who often have disparate levels of prior knowledge at the high school level. We observe an increasing need to bridge the widening gap between high school and university mathematics in order to prevent engineering students from being hindered in their academic successes due to a lack of prior mathematical understanding. With a team of engineers and mathematicians, both researchers and educators, we are developing a mathematics *Bridging Course* including the use of digital tools, such as videos, online interactions and technology-based assessments. These sources will be created, investigated and/or modified in order to develop an engaging learning environment in which students are made aware of and guided through misconceptions and mistakes in their understanding of fundamental mathematics. In the development of this *Bridging Course*, we consider the importance of interactive learning and timely feedback for student learning. We investigate the impact of digital course design on students' performance and learning outcomes using a qualitative approach. The outcomes of this research will provide valuable recommendations for engineering educators on ways of activating students' prior knowledge and promoting student engagement through interactive digital courseware.

Problem-Based Learning of Heuristic Methods for Decision Problems in Mathematics, Computer Science and Industrial Engineering

Engelhardt, Felix; Büsing, Christina; Schmitz, Sabrina
RWTH Aachen University, Germany

In a digitalized world, most processes can be formalised, measured and described mathematically. The use of analytical methods to optimise such models and decisions constitutes operational research (OR), developing new methods for a specific problem and analysing them are part of discrete optimisation (DO). However, there is limited research on OR and application driven DO in higher education. Furthermore, neither is well integrated into engineering education research.

In this work, we present a case study of an interdisciplinary Master's course on heuristic methods in the context of OR and DO. We discuss to what extent well-established approaches from engineering education practice, such as Problem-Based Learning, are applicable. Furthermore, we introduce two practical cases and argue that due to its application-oriented nature, OR and DO specifically stimulate independent student work.

Results from evaluations, minute papers and student coursework indicate that the teaching approach successfully contributed to students' achievement of the intended learning outcomes.

To further foster discussion, we not only provide the lecture notes publicly, but also all tutorial and project case data to instructors upon request under a CC BY-NC license.

Unlocking complex Vector Calculus concepts for engineering students using GeoGebra

Padayachee, Pragashni; Khemane, Thabiso
University of Cape Town

There is an increasing drive to exploit the power of technology to improve students mathematical conceptual understanding. This work is motivated by the authors research presented at the SEFI 2022 conference which reported on students experienced difficulties with the double integral, a concept central to vector calculus. Some of the difficulties included visualising and sketching three dimensional surfaces and regions of integration and changing coordinate systems from rectangular to polar. Vector calculus is a crucial subject for engineering students, but its abstract concepts can be challenging to grasp. This curriculum proposal is a response to improve the visualisation and the conceptual understanding and is a larger project to develop an innovative, engaging and effective way for undergraduate engineering students at the University of Cape Town to learn vector calculus concepts supported by GeoGebra. The choice was made in favour of the easy to use, freely downloadable mathematical software, GeoGebra which presents a creative, visual and integrative way to experience and understand mathematical concepts.

Informing this curriculum development initiative is Vygotsky's social constructivist perspectives with an emphasis on inclusivity, diversity and participant interactions. In this paper we discuss the above theoretical underpinnings with case studies on how to teach the double integral concept in GeoGebra for conceptual understanding. Additionally the benefits of using GeoGebra including its ability to engage students, promote critical thinking, and increase motivation will be discussed. This research will be of interest to those intending to use GeoGebra to improve the teaching and learning of vector calculus concepts.

Changes in first-year engineering students' performance in mathematics and engineering subjects at different stages of distance learning

Berezvai, Szabolcs¹; Köpeczi-Bócz, Ákos¹; Sipos, Bence^{1,3}; Szilágyi, Brigitta^{1,2,3}

¹Budapest University of Technology and Economics, Hungary; ²Corvinus University of Budapest Budapest, Hungary; ³MTA-ELTE Theory of Learning Mathematics Research Group

Covid pandemic was unprecedented in modern education but is not expected to be unique, therefore increased attention should be paid to accurately analyse its effects on education. Calculus is an important undergraduate mathematics course in engineering programmes, which gives the foundation for engineering subjects like mechanics or electronics. Unfortunately, recent experiences show that the performance of students admitting after the pandemic has deteriorated dramatically in recent years.

This research aims to analyse the changes in performance and attitudes of first-year students in the aftermath of the pandemic. In our research, we investigated the performance and learning habits of three groups of first-year mechatronics and energy engineering students during Calculus-1 and the related Mechanics subject.

The "2018 group" studied maths traditionally, whereas the "2020 group" took online education in the last months of high school and the first year of university. The "2022 group" spent two years of high school at home in remote learning (the significant 10-11th grades, for maths competence), but received in-person education at the university. Learning habit and performance of the students were monitored using EduBase online educational platform.

The results of both the qualitative and quantitative analysis have revealed that online education during the pandemic changed the learning habits of the group in 2020 and had only slight effects on their performance in Calculus and Statics. However, for group 2022, where the pandemic affected high-school maths studies, the performance at the university has fallen dramatically resulting in an increased drop-out rate after the first semester.

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Paper Session 2-17: Innovation in T&L 3 - Sustainability

Time: Tuesday, 12/Sept/2023: 2:30pm - 3:30pm · Location: EQ-117 Tiered Room

Session Chair: Uchenna Sampson Igwe

Certificate-Based Good Practice to Motivate Engineering Students to Learn Sustainability Skills

Barna, Orsolya; Szalmáné Csete, Mária

Budapest University of Technology and Economics Faculty of Economics and Social Sciences, Hungary

Engineering plays a crucial role in addressing sustainability challenges and helping achieve the sustainability transition. However, tackling the complex problems of sustainability needs a broader understanding of these issues from non-engineering perspectives as well. The Department of Environmental Economics and Sustainable Development of the Budapest University of Technology and Economics (BME), Faculty of Economics and Social Sciences (GTK), has developed a unique method for a uniform certification of studies in the fields of sustainability, environmental economics, and environmental management for engineering students. The so-called green certificate is provided after the successful completion of at least five elective courses such as sustainable business models, green economic development, smart and sustainable digitalisation-related solutions, sustainable rural or urban development, sustainable energy management or climate change-oriented courses, etc. The certificate can be obtained either in the framework of a bachelor's or master's degree programme, and it is available both in Hungarian and English, even for incoming mobility students. By achieving the green certificate, the engineering students gain a complex vision, a sustainability mindset and a truly green attitude. Our study quantitatively analyses the green certificates' data, focusing on the engineering students' profiles and the most frequently chosen courses. Our results can help further refine our methods to reach even more engineering students, and it can serve as a good practice to follow for other universities.

Discovering Sustainability Practices in Research and Innovation Sites

Downey, Robin Ann

Bilkent University, Turkiye

This proposed Practice Paper will focus on an experience with a sustainable development learning project for a Science, Technology and Society (STS) course. The class is a requirement for all engineering students at Bilkent University. The students participated in the 'STS Sustainability Awards' competition for two semesters in one academic year. For the project, the students found a company or laboratory, consulted them on their innovation practices and asked questions that were grounded in Responsible Research and Innovation (RRI) approaches. RRI approaches provide an opening for students to explore how various values are considered in innovation practices. The values by design approach can help engineering students to see that innovators consider both instrumental and qualitative values during the innovation process (van de Poel, 2015). The social values may include gender inclusion, stakeholder interests, user experience, privacy dimensions and environmental aspects. Although the project has been used in other years, the sustainability awards motivated students to explore how innovators respond to concerns around a range of sustainability issues. The jury for the events included specialists with an interest in sustainability from urban design, industrial engineering, education and electrical engineering. The award recipients produced projects on smart homes, nanotechnology-based solar panels, clean meat, industry 4.0, geothermal energy, air cars and MRIs and gave presentations in events hosted by the Faculty of Engineering administrators.

Going Beyond Intentions: A Methodology for Assessing Entrepreneurial Activity Among Engineering Education Alumni

Garcia Huertes, Saul; Bragós Bardia, Ramon

Universitat Politècnica de Catalunya, Spain

This research paper proposes a novel methodology for evaluating entrepreneurial activity among engineering education alumni using their public CVs as our main source of information. The objective is to go beyond measuring entrepreneurship intentions or mindset through surveys, and instead analyse actual career data to assess the impact of entrepreneurship education. The study utilises shared user data and employs GPT (Generative Pretrained Transformer) models to infer entrepreneurial activity that extends beyond job titles, delving into the specific responsibilities and achievements associated with each position.

The analysis shows that the proposed methodology, which uses context enriching to enhance model accuracy, effectively identifies instances of entrepreneurial activity among CVs profiles data. This approach provides a way to evaluate the effectiveness of entrepreneurship and innovation courses. Combining the insights gained through the proposed method with internal data sources would enable institutions to conduct a comprehensive evaluation of program impact on alumni career paths.

The study underscores the potential of AI models to facilitate the collection and analysis of data that has traditionally been challenging to access. Moreover, the research highlights the importance of evaluating the long-term impact of entrepreneurship education on alumni career trajectories, a key factor in addressing the growing field of engineering education. Ultimately, this study contributes to the academic discourse on entrepreneurship education by offering a novel approach for assessing the impact of such programs on alumni outcomes, thus enabling institutions to make data-driven decisions to improve program offerings.

Tell it with commits to git

Niemelä, Pia; Hukkanen, Jenni; Nurminen, Mikko; Sand, Antti; Järvinen, Hannu-Matti

Tampere University, Finland

In the realm of higher education and software development, team work is considered a crucial factor in facilitating the development of collaborative and work-life skills among students. Studies have shown that collaborative tasks promote a sense of community, belonging, and well-being among students. However, uneven work distribution and vague team roles can lead to dissatisfaction and reduced commitment, ultimately resulting in assignment failure and impeding progress towards graduation. This paper examines students' feedback on Britton et al.'s (2017) team quality questionnaire, along with their contributions to team performance. Additional questions were added to gauge how students communicate and organize their work within their teams, with an analysis of their activity and contributions measured from their git repositories. Ultimately, this paper presents successful ingredients for team work and suggests strategies for ensuring a positive experience in dynamic team settings. These strategies include clearly defined roles, equal workload distribution, and accountability mechanisms.

Paper Session 2-18: Transformative Experiences in Teaching

Time: Tuesday, 12/Sept/2023: 2:30pm - 3:30pm · Location: EQ-118 Tiered Room
Session Chair: Mike Murphy

An Autoethnography of Becoming an Innovative Engineering Academic: Punk, Pirate and Guerilla Pedagogy

Murray, Michael

University Of Strathclyde, United Kingdom

In this Autoethnography (AE) I consider, “becoming” the Most Innovative Teacher (2018) at my university. My identity as a university teacher, my epistemic beliefs, and my choice of vocational pedagogical techniques, have been influenced by my working-class background. No school qualifications, becoming the wrong sort of engineer (plumbing), and a twenty-three-year journey to a doctoral qualification. In 2013 my employer declared that I did not have a ‘significant responsibility for research’ (SRR). I was transferred to a teaching only contract as a punitive measure for not fulfilling my employers research expectations. My lateral migration to a teaching post was the catalyst for my re-engagement with pedagogy. I became aware that my teaching & learning practice had theoretical (constructivist) foundations. Engaging in scholarship, I read publications on teaching like a pirate, guerrilla teaching, and being a punk educator. It became clear that I had taken similar risks, to do engineering education differently. In this paper I will examine what motives I had for going “off-piste” and, whether my practice truly constitutes “innovative” engineering pedagogy. I conclude with a caveat on the research methodology (autoethnography) employed.

THE POWER OF PERSPECTIVE DIALOGUE: UNLOCKING TRANSFORMATIVE REFLECTION IN ENGINEERING EDUCATION (PRACTICE)

Hermesen, Pleun¹; Van Dommelen, Sjoerd¹; Hueso Espinosa, Paula¹; Van den Bogaard, Maartje²

¹Delft University of technology, Netherlands, The; ²The University of Texas El Paso

Engineers need to be socially responsible, ethically aware and deliver positive contributions to the wicked problems of today's global challenges. In navigating these challenges, being able to reflect is a necessary prerequisite. But if we simply ask students reflective questions, they tend to give us mostly socially desirable answers. Our university initiated an institute-wide program focused on creating learning experiences and environments for transformative reflection instead of superficial reflection. In this paper we present design principles for transformative reflection based on a literature overview and the program's accumulated experience. The principles are I) Six domains for reflection on engineering issues, II) The differentiation between the internal and external perspectives, III) Our approach to design for context-specificity of transformative reflective experiences, and IV) Four mechanisms that foster transformative reflection.

Engineering curriculum redesign: Is my school ready for this?

Bagiati, Aikaterini; Reynolds-Cuéllar, Julia

Massachusetts Institute of Technology, United States of America

As humanity keeps facing grand challenges engineers are expected to be at the forefront and keep providing sustainable solutions to extremely complex problems. In the meantime we have reached an era where technological advancement moves at a very rapid speed. That poses a big question to academia. “How should we educate engineers to ensure that they are best prepared for a complex world?” For an engineering curriculum to remain effective and relevant, frequent redesign is critical. Despite this generally agreed upon understanding, universities sometimes operate under great pressure and move into initiating curricular change without having considered how multifactorial this process can be. At the same time there are little to no tools to help them determine institutional readiness for engineering curriculum redesign. The Massachusetts Institute of Technology (MIT) has placed quality engineering education at the core of its mission since its founding in 1861. Since then MIT has not only founded a great number of very advanced forward thinking engineering programs, but has also collaborated with a big number of international governments and schools in order to guide and support their engineering curriculum change.

[XXX] is a global consortium within MIT working on this exact topic. [XXX] staff are currently working with experts on said matter to develop a tool that universities could use in order to self-assess their initial readiness as well as their progress as they move on with their curriculum redesign process. This practice paper presents the first iteration of said tool.

Engineering students emotional intelligence and neuro-linguistics programming (NLP) as developmental tool

Khefacha, Ahlem; Séleli, Beatrix

Budapest University of Technology and Economics, Hungary

Emotional intelligence (EI) has been increasingly recognized as a critical skill for successful personal, educational, and professional life.

This article aims to investigate the strengths and weaknesses of the emotional intelligence of engineering students and the possibility of using neuro-linguistics programming (NLP) as a developmental tool.

Students' emotional intelligence was assessed using the Bar-On Emotional Quotient Inventory (EQ-I) with 5 points Likert scale. First-semester engineering students were approached by part of a broader study at the Budapest University of Technology during 2018-2022. In the article, we describe the emotional intelligence profile of more than 3600 students in various fields of engineering. NLP professionals around the world filled out the second questionnaire. We got answers from 35 professionals based in Tunisia, Hungary, the UK, the USA, and Australia who reported their own experiences using NLP to enhance EI. In this way, we got quantitative and qualitative data. Findings confirm the possibility of using NLP techniques to develop EI and that logical levels and rapport techniques are best suited to improve engineering students' weaknesses which we determined to be general mood, stress management, empathy, problem-solving, and interpersonal skills.

Paper Session 3-19: Engineering Graduate Attributes 2 - Competency, Policy and International Outlook

Time: Wednesday, 13/Sept/2023: 8:00am - 9:00am · Location: EQ-002 Lecture Hall
Session Chair: Eugene Coyle

Defining a European Engineer Profile within a European University Alliance

Villarroel, Morris¹; Ülker, Nilüfer²; Bigey, Pascal³; Bertrand, Pierre⁴; Martínez, Ramón¹; Griveau, Sophie³; Barboux, Philippe³; Garrido, Alberto¹

¹Universidad Politécnica de Madrid - WP2-EELISA University Alliance; ²Istanbul Technical University - WP2-EELISA University Alliance; ³Université PSL - WP2-EELISA University Alliance; ⁴École des Ponts ParisTech - WP2-EELISA University Alliance

The world needs more engineers and Europe provides a rich and diverse environment to train them, including shared values of sustainability and interculturalism. In this paper we attempt to build a profile for a “European engineer” based on skills and competences acquired in a European University Alliance centred around engineering education (EELISA, European Engineering Learning Innovation Alliance). We carried out an on-line survey for students and staff of partner universities as well as nine in-depth interviews (50 min) with relevant stakeholders. The questions included in the survey are described as well as general results from 75 respondents. The overall results from the in-depth interviews are also presented and discussed within the framework of the training concepts also promoted by international associations, including SEFI. Finally, we use our findings to suggest four conceptual fields for a European engineer profile: 1) Scientific and theoretical knowledge including digital skills, 2) Addressing sustainability, 3) Interculturalism: an engineer embracing the European project, and 4) Business and communication skills: practical and applied knowledge.

Improving Employability with a Competence Profile (PRACTICE)

Velmurugan, Gajenthiran; Friedrichsen, Dennis

Aalborg University, Denmark

Employability has become a central focus for Higher Education Institutions. The European University Association's report states that graduates should acquire a mix of transversal and discipline-specific skills. An educational approach known for providing students with this is Problem-Based Learning. An institution known for successful implementation of PBL is Aalborg University located in Denmark. In this paper we will look at an initiative they have recently launched to improve the employability of their engineering graduates. Employability can be defined from different perspectives. In this paper we develop a framework where employability is viewed from three different perspectives. 1) Internal values, beliefs and aims for a future career, 2) Skills and competencies, both transversal and subject specific, 3) External factors such as the state of the labour market and utilising one's knowledge and skills to navigate it. The initiative introduced here focus on perspective one and two. Here the students attend a mandatory competence profile workshop, in which they must hand in a competence profile where they describe their competences from four predetermined sets of competences: reflective, problem-oriented, interpersonal, and structural. This is done in a 3-step model where the students interview each other, then provide peer feedback to their fellow students' profiles and then receive feedback from staff on their individual profile. The students complimented the initiative and the peer-feedback session. This confirms previous research done in relation to how to facilitate reflection among students in higher education, where the recommendation is to do it as an iterative process

Quantitative Analysis of China's Application-oriented Talents Cultivation Policies

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¹Institute of China's Science, Technology and Education Policy, Zhejiang University; ²School of Public Affairs, Zhejiang University

Faced with a new wave of scientific and technological revolution and industrial transformation, the Chinese government has implemented policies to cultivate application-oriented talents. Application-oriented talents utilise engineering theories and technical methods to achieve engineering objectives. Cultivating such talents enables Chinese engineering education to meet better the needs of local economic and social development, promoting the differentiated development of Chinese higher education. We use quantitative methods to analyse China's application-oriented talents cultivation policies. The analysis focuses on the changes in policy contents and characteristics of policy responses to capture the developmental trends and critical stages of these policies. Findings from our study indicate that China's policies and measures are more and more specific according to the practical demands. There has been a shift in emphasis from scale expansion to quality improvement in application-oriented talents cultivation. The evolution of these policies follows a path-dependent pattern with gradual changes over time. Most provinces have actively responded to the Chinese central government's policies. However, there is a specific time lag in their responses. The number of single policymakers is higher than that of multi-policymakers. Our study can provide educators and policymakers a clearer understanding of the critical focuses and characteristics of cultivating application-oriented talents and references for formulating and implementing engineering talent cultivation.

RESILIENCE-RELATED COMPETENCIES IN ENGINEERING EDUCATION – MAPPING ABET, EUR-ACE AND CDIO CRITERIA

Winkens, Ann-Kristin; Engelhardt, Felix; Leicht-Scholten, Carmen

RWTH Aachen University, Germany

In view of the increasing intensity and frequency of natural disasters due to climate change, engineers need to be able to design systems and infrastructures that are resilient to disruptions. Resilience, here, describes the ability of systems to not only be prepared for sudden crises and to recover from these, but also to learn in order to build adaptive capacity. However, research has shown that there is a lack of system resilience and related competencies in engineering education at various levels. First, there are only a few studies that address resilience on a system level in engineering education. Second, studies on teaching experiences show that engineering students have little knowledge about resilience and skills to design resilient systems. And third, an analysis of engineering programs in Europe has shown that resilience-related topics and competencies are rarely addressed in curricula. Based on these results this study will explore the extent to which resilience-related competencies are included in accreditation guidelines and frameworks such as ABET, EUR-ACE and the CDIO Syllabus. This will then be discussed in the context of previous research on the qualification objectives of engineering degree programs, questioning to what extent these are consistent with accreditation guidelines and frameworks regarding systems resilience. This provides a baseline for recommendations for curriculum development in engineering.

Paper Session 3-20: Problem and Challenge Based Learning 1

Time: Wednesday, 13/Sept/2023: 8:00am - 9:00am · Location: EQ-116 Flat Room
Session Chair: Raffaella Manzini

Conceptualizing socially shared regulation in Challenge-based learning

Doulougeri, Karolina; Bombaerts, Gunter; Bots, Michael; Vermunt, Jan D.

Eindhoven University of Technology (TU/e), Netherlands, The

Students in Challenge-based learning (CBL) courses are working in multidisciplinary groups for the development of a solution to an open-ended and ill-defined challenge. Thus, in CBL students need to regulate their learning individually and collectively to learn. Socially shared regulation of learning (SSRL), refers to the development of collective and co-constructed task perceptions or shared goals by multiple students working as a group. Existing knowledge about how to conceptualize and research SSRL in CBL is currently lacking. In this paper we provide evidence from a qualitative study we conducted in a CBL course, using analysis of individual learning portfolios and in-depth interviews about students' perceptions of SSRL. We discuss firstly, which individual characteristics students perceive as important for SSRL. Secondly, we discuss the identified processes of SSRL identified in our data. Finally, we discuss how groups with high and low SSRL differ from each other. For example, groups with high-SSRL spend more time in task planning and role division. They also engaged in discussions about shared goals early in the process and frequently monitored and evaluated their collective work and progress more. On the other hand, groups with low-SSRL need guidance individually and as a group to plan and evaluate their activities in different project stages. In addition, they had fewer conversations as a group about their shared goals, and they had more difficulties getting along at a social level. Finally, theoretical implications, practical recommendations, and future directions for research are discussed.

Sources Fostering Academic Well-being: Students' Perspectives in A PBL Context

Chen, Juebei¹; Bai, Shaoping¹; Chaaban, Youmen²; Du, Xiangyun¹

¹Aalborg University, Denmark; ²Qatar University, Qatar

In a post-pandemic learning era, student academic well-being emerges to the attention of educational researchers. Referring to students' thoughts and behaviors that contribute to doing well in an educational context and their academic life satisfaction, student academic well-being has a significant influence on their recruitment and retention, learning experience, academic achievement, and competence development.

However, while academic well-being has been regarded as an important indicator of student persistence in their current study and learning outcomes, limited studies have explored engineering students' academic well-being and other supportive factors in engineering education. While several studies have examined how well-being is constituted and how it can be measured from medical, mental health, and eudaimonic philosophical perspectives, understanding engineering student academic well-being from social-cognitive and sociocultural aspects is also important. This is because well-being is not only influenced by personal feelings, but also dynamically framed by interpersonal relations, as well as contextual and institutional conditions. To increase retention and help engineering students to become agentic professionals, it is desirable to help them to become proactive and purposeful learners in their studies.

Thus, aimed at filling in this literature gap, this study will adopt Q methodology to explore how engineering students perceive the sources contributing to their academic well-being in a Danish university. Suggestions will be proposed to optimize future curriculum design to support student academic well-being.

Congruence and Friction between Teachers' Intentions and Students' Perceptions of CBL courses

Helker, Kerstin¹; Michel, Selina²; Bots, Michael¹; Mottl, Patrik³; Michelson, Aet⁴

¹Eindhoven University of Technology, Netherlands; ²Technical University of Munich, Germany; ³Czech Technical University in Prague, Czech Republic; ⁴Tallinn University of Technology, Estonia

Challenge-Based Learning (CBL) has become specifically popular in higher engineering education as it embraces authentic, active, and interdisciplinary learning that requires students' self-direction and collaborative decision-making. The CBL compass (van den Beemt et al. 2023) has been widely applied to capture the variety of educational innovations under the CBL label regarding their vision, teaching and learning, and support. As the tool only captures the teachers' intentions and goals, the question remains whether discrepancies occur with student perceptions of the CBL learning environment that may cause friction.

Therefore, this research project explored these discrepancies more thoroughly with teachers and students from CBL courses at four technical universities across Europe.

First, to understand the commonalities and differences between the courses, all courses were mapped with the CBL compass. Analyses of the outcomes showed that the courses varied regarding their implementation of the 36 indicators of CBL represented by the tool – most strongly regarding collaboration with internal and external stakeholders, assessment, and aspects of learning technologies, facilities, and support.

In the next step, we applied the student version of the CBL compass to understand student perception of these indicators and capture differences with teachers' intentions. The results mostly show a high agreement between teachers' intentions and students' perceptions. Friction arises in indicators regarding the complexity of the challenge, the involvement of external stakeholders, and the assessment. The results do not only help our understanding of student learning gains and experiences in CBL but may feed back into teachers' CBL design processes.

The study of the effectiveness of design-based engineering learning (DBEL): the mediating role of cognitive engagement and the moderating role of modes of engagement

Wei, Lina¹; Wang, Liang²; Zhang, Wei²

¹School of Education, Peking University; ²School of Public Affairs, Zhejiang University

Aim: Design-based engineering learning (DBEL) offers a potentially valuable approach to engineering education, but its mechanism of action has yet to be verified by empirical studies. Accordingly, the present study aimed to establish whether DBEL produces better learning outcomes, thereby building a strong, empirically grounded case for further research into engineering education.

Methods: To build a more comprehensive model of design-based engineering learning, the variables of cognitive engagement (the mediator) and modes of engagement (the moderator) were introduced to build a theoretical process model. Questionnaires and multiple linear regression analysis were used to verify the model.

Results and discussion: All four features of DBEL (design practice, interactive reflection, knowledge integration, and circular iteration) were found to exert significant and positive effects on learning outcomes. Moreover, cognitive engagement was found to both fully and partially mediate the relationships between these features and the outcomes of engineering learning; under two different modes of engagement, the positive effects of the learning features on cognitive engagement differed significantly.

Conclusions: The paper concluded the following: (1) a design-based learning approach can enhance engineering students' learning outcomes, (2) cognitive engagement mediates between design-based engineering learning and learning outcomes (3) a systematic mode of engagement produces better learning outcomes than a staged modes of engagement.

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Paper Session 3-21: Innovation in T&L 4 - Assessment Methods

Time: Wednesday, 13/Sept/2023: 8:00am - 9:00am · Location: EQ-211 Flat Room
Session Chair: Greet Langje

The use of Peer Assessment and Group Peer moderation to develop 'soft' skills in Engineering students researching Sustainable Energy

Cole, Reena

School of Engineering, University of Limerick, Ireland

Since the change to an outcomes-based approach in Engineers Ireland's accreditation criteria almost 20 years ago there has been an emphasis placed on 'soft' skills such as teamwork and ensuring graduate engineers are not only well versed in their chosen discipline, but that they can communicate their knowledge – to other Engineers and also non-Engineers. Energy Management is a module taught to 4th year Mechanical Engineers, and the learning outcomes are best assessed by how students can communicate the energy topics they are researching. As an individual they will research an area that interests them and write a paper at the end of semester but leading up to this there are two 'patchwork' assessments from which they receive feedback and can use to formulate the introduction to their final paper. The second of these is peer assessed using the same Rubric as for the first assessment, and they must also review their own writing following this. Feedback has shown that this develops a greater understanding of their writing and what constitutes a good technical writing style. Teamwork is developed in this module through a 35% sustainable energy group project which involves a presentation and a written group report. On completion the students submit a peer moderation form online which allows the grade to be moderated if the work was not evenly shared. The approach taken for each element has evolved over 15 years and will be explored as part of this practice paper.

CONTINUOUS ASSESSMENT IN ELECTRIC POWER ENGINEERING FOR MARINE ENGINEERS

Ehnberg, Jimmy; Lundberg, Stefan

Chalmers University of Technology, Sweden

To tackle the climate challenge, all sectors need to contribute, including electrified shipping. Electrified shipping is not only propulsion but also loading and unloading equipment. This transformation requires increased skills and understanding of electric power engineering for the personal onboard, not least for the marine engineers. Therefore, a change in the curriculum was needed. However, when more theoretical course content was added to two consecutive courses, the student view and passing rate dropped. Although the student view improved quickly, the passing rate recovered slower. To address this issue, continuous assessment was introduced to counteract the drops. The aim of this study was to evaluate the theoretical parts and determine if continuous assessment could contribute to improve student learning and increase passing rate. The students expressed satisfaction with the changes, and the passing rate has increased. Most students also claimed that they learned more compared to standard assessment methods.

Self-assessment or peer assessment? Which is better predictor of test results

Kulcsár, Nárcisz

Széchenyi István University, Hungary

Internationally accredited engineering programmes are becoming increasingly important in the internationalisation agenda of universities. ABET has highlighted transversal skills in its accreditation criteria for engineering degrees. Preferred transferable skills include the ability of students to reflect on their own performance, the ability to give constructive feedback and the ability to make judgements.

Students' self- and peer-assessment was examined in the context of a basic mathematics course. During the maths midterm tests, students self-assessed on each task, and assessed another student's test. These assessments were compared with the points given by the teacher. 84% of students overestimated their actual performance and more than 60% of them overestimated their peer's performance, and both overestimations were moderate. According to students' opinion, peer assessment is as easy as self-assessment, it is not easier for them to spot mistakes in other people's work than in their own. In contrast, the research results showed no significant difference in the accuracy of peer and self-assessment.

Contrary to our previous research, now we did not find a significant correlation between students' performance and assessment accuracy in the first test. One reason for this may be that these students have failed this subject at least once. As further learning is only possible once we have identified what needs to be learned, the ability to assess the gained knowledge as accurately as possible is appreciating. In addition to meeting accreditation requirements, the different type of assessments' cognitive and affective effects on learning outcomes make it a good choice for classroom use.

"Keep it simple: Optimized Student Evaluations with Moodle"

Mailänder, Marius; Rullmann, Edward; Di Lenarda, Felix; Forbrig, Christian; Rappsilber, Juri

Technische Universität Berlin, Germany

Acquiring representative feedback from students is a common issue for universities, often due to low response rates and participation bias. To address this problem, we developed and implemented a new tool for collecting feedback by sharing an accessible short survey on our Moodle-based e-learning platform. To simplify the evaluation process and improve user-convenience, this new Moodle evaluation tool allows surveys to pop up visibly but non-invasively within every Moodle course offered by our university. After voting, the survey disappears automatically. By condensing a questionnaire to three main queries using a 6-point Likert scale, we gathered data on overall satisfaction with the course, satisfaction with its structure and navigation, and satisfaction with its course elements and content.

Within two weeks, we collected 65,000 votes from over 1600 courses, with an average response rate of 30% among all active students using the Moodle platform.

This paper describes the design and implementation of the short survey, provides an overview of the new evaluation tool and its features, and shares preliminary results and interpretations of the data. Based on these findings, we outline our plans for the continuation and extension of the short-survey approach.

Paper Session 3-22: Work Based and Experiential Learning

Time: Wednesday, 13/Sept/2023: 8:00am - 9:00am · Location: EQ-203 Flat Room
Session Chair: Donal McHale

Lessons from redefining traditional work placements for university students in TU Dublin

Delaney, Kevin Dominic; Cussen, Norah; Ryan, Deirdre

Technological University Dublin, Ireland

There is strong support for ensuring all university students have an option to undertake relevant work placement. Work-placements enable students to engage with enterprise and develop experiential learning while linking their academic study and theory to real industrial practice. Such placements, or internships, offer students an opportunity to build their self-confidence while refining their transversal skills such as creativity, innovation, communication, team-working and problem solving, broaden their knowledge base and improve their employability upon graduation.

While student cohorts benefit from engaging with enterprise the enterprise also benefits, such as from the energy, new perspectives and ideas interns can bring to the workplace. Multiple models (such as professional apprenticeships and Earn and Learn models) highlight the importance of this symbiotic relationship. The need to support and expand work placement opportunities to benefit all graduates is also a key element of government policy. Supporting this ambition and reflecting changing student profiles, employer expectations and the nature of work, there is a need to re-imagine the traditional understanding of work-placements to safeguard talent pipelines and increase graduate employability.

A concise literature review of existing work placement models is presented. This is followed by a description of the approach developed by the Enterprise Academy within Technological University Dublin to help students achieve learning outcomes typically associated with work-placements in a new, innovative and sustainable way. The approach described was successfully piloted for 2 student cohorts during the Covid pandemic. It highlights the value of redefining traditional placements for students, enterprise and higher education providers.

The Bell Academy: A Bridge Semester where Engineering Students Transform into Student Engineers who Thrive in Industry Placements

Christensen, Darcie¹; Singelmann, Lauren¹; Mann, Cody¹; Johnson, Bart²; Ulseth, Ron¹

¹Minnesota State University Mankato, Iron Range Engineering, United States of America; ²Minnesota North College, United States of America

Iron Range Engineering is an innovative learning program using project-based and work-based pedagogies. The Bell Academy (BA) is a semester-long bridge experience between the first two years of STEM foundation and the final two years spent in full-time industry co-op placements. The curriculum within the academy is delivered within three domains: technical, design, and professional. The transformation to thriving as a student engineer in an industry placement is intentionally embedded in each stage of the program as students develop higher levels of self-awareness, professional responsibility, and self-directedness.

Students not only gain technical engineering knowledge, but also apply that knowledge within team-based, ill-structured design projects, acting as engineering consultants to industry clients. Technical learning is delivered in one-credit modules, which supports both the development of the individual as a student engineer and the execution of the project. Professional competencies are learned in-situ as teams encounter natural struggles. Development is supported through workshops, which cover topics such as conflict management, leadership, technical writing, data science, public speaking, inclusive action, etc. Through iterative assignments and practice, such as resume development, negotiation, and interviewing, students develop a skills portfolio to identify and acquire a position to begin and maintain their career.

Through more than a decade of implementation, several unique learning strategies have been developed and refined. The paper will briefly describe the model used and provide the strategies as potential tools for adaptation and implementation in engineering programs worldwide.

Workplace spaces as Learning spaces – Engineering students' experiences with co-op

Van den Bogaard, Maartje¹; Strobel, Johannes²

¹University of Texas at El Paso, United States of America; ²University of Texas at El Paso, United States of America

Many authentic learning environments in formal schooling contexts mimic elements of authentic engineering environments, yet do not afford students to experience the full complexity of a real work environment. Workplace learning is a powerful way for students to close these gaps. In this exploratory study we interviewed 11 students about their experiences in a co-op program in a Midwestern research university in the USA pre-COVID. Our qualitative study was guided by the three dimensions of learning by Illeris: personal, cognitive and social learning. We added the perspective of epistemic learning. Our preliminary findings include a variance of workplace experiences, the tensions between execution of specific tasks and the exploration and ideation of new solutions. In addition, our findings indicate that workplace engineering was demystified as issues students shared were very specific context related and not career choice related. Students also report they learned about relationship building with people from all levels of the organization, the importance of soft skills, and awareness of evaluation as a tool for reflection on the projects and their own professional development.

Students' Views of Taught Professional Competencies: Investigating the Impact of Previous Work Experience

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¹The University of Sydney, Australia; ²University of Technology, Sydney; ³University College London

The ability of Engineering graduates to function as successful professionals depends not only on technical disciplinary knowledge but also on a wide range of professional competencies. Students' reactions to the teaching and assessment of these competencies is often negative. An ongoing study by the authors has been exploring the nature of these reactions and in particular, the various factors that contribute to students' views on the teaching of professional competencies (a detailed survey, with N=339 responses). A preliminary factor analysis showed that the students' level of professional experience was a key factor in shaping students views. In this paper we explore this issue in more depth. For example, when asked on the pair of survey questions "do you agree or disagree that each competency type [professional / technical] should be a core component of your Engineering degree program", the impact of increasing professional experience on the average response was only marginally greater for professional competencies than for technical competencies. In contrast to this, when asked the pair of questions "for each competency type [professional / technical] indicate whether it is easier to learn it at University or at work", the analysis of the responses shows that as the level of experience increases, there is a small shift for technical competencies towards being taught at University, whereas for professional competencies, there is a significantly greater shift towards work environments. We explore these, and other related findings, and consider their implications for the design and delivery of engineering degree programs.

Paper Session 3-23: Interdisciplinarity in Engineering

Time: Wednesday, 13/Sept/2023: 8:00am - 9:00am · Location: EQ-204 Flat Room

Session Chair: Jye Benjamin O'Sullivan

Reshaping the Bio Medical Curriculum to include Socialisation and Subjectification

Klaassen, Renate Gerarda¹; Bossen, Linette R.H.²; Milano, Costanza³; Hellendoorn, Hans⁴

¹TU Delft, Netherlands, ²TU Delft Centre for Engineering Education; ³TU Delft, Netherlands, 3ME; ⁴TU Delft, Netherlands, IDE; ⁵TU Delft, Netherlands, 3ME, Robotics

According to Biesta, the current pedagogical assignment for Education is the tripartite development of students on qualification, socialisation and subjectification. Qualification ensures our students in Higher Engineering Education become competent in one or multiple disciplinary engineering fields. Socialisation relates to students becoming aware of the values and norms embedded in academia and the professional environment they will enter after graduation. Subjectification is an ambition to develop the qualification, socialisation and whom they become. This pedagogical ambition requires repurposing and shaping our curricula.

In the Bio-Medical Engineering (BME) programme, we have embedded a design-based vision of the future engineer. The vision suggests three dimensions our students will encounter in their future engagement with technology, collaboration models and fast and slow production cycles and helps them become developed engineers. The emergent engineering roles are a guiding tool for going through a reflective cycle of development leading to subjectification. Transversal skills are used to ground the socialisation process of future engineers.

Several workshops were held with the BME teachers to embed the pedagogical aspects of Biesta in accordance with the vision of the future engineer. Student focus groups and evaluations provided feedback on the success of our ambitions.

The curricular design concept has resulted in a roadmap with supportive principles to apply throughout the Master's programme design in BME and beyond. Furthermore, it resulted in an overview of skills (already) used in the courses of the Master's programme and a reflection model to guide students through the programme.

Does Interdisciplinary Creative Coding Boost Creativity? A Mixed Methods Approach

Duyver, Arne; Groeneveld, Wouter; Aerts, Kris

OVI @ ACRO, Department of Computer Science, KU Leuven, Belgium

This study explores the influence of an interdisciplinary intervention on creative problem-solving skills. Literature deems such skills as vital for software engineering (SE) students in higher education. 39 SE students and graphic design (GD) students were randomly paired to work on an open-ended creative coding assignment in p5.js, an online JS-based Processing editor that makes it easy for novices to quickly and easily code visual webpages. Three categories were formed: the test group SE+GD (18 students), and control groups SE+SE (10) and GD+GD (11).

A mixed methods approach was taken to gather and interpret results: Amabile's Consensual Assessment Technique provided a global creativity score for the finished product, the Creative Programming Problem Solving Test assessed three dimensions of the creative process (*Ability, Mindset, Interaction*), and 9 semi-structured follow-up interviews provided context and revealed underlying themes. The results indicate that, while the creativity of the end product initially takes a hit, the SE+GD groups' socio-interactive creativity levels increased. We also observed fixed mindsets towards creativity ("design students are more creative than we") that call for future work.

Draw education: graduate student perceptions of education using an arts-informed approach

Schibelius, Lisa; Murzi, Homero

Virginia Tech, United States of America

Education has been shifting to foster better learning environments for students with instructors as co-constructors of knowledge in the classroom. Part of this educational transformation has been accomplished through graduate student education in preparing the next generation of educators to adopt student-centered teaching approaches. Change, however, can be slow, and implementation in the classroom looks different across disciplines. The purpose of this study is to gain a better understanding of graduate students' perceptions of education when enrolled in a course on contemporary pedagogy. We seek to answer RQ: How do perceptions of education compare between graduate students in engineering and non-engineering academic disciplines? Arts-informed approaches provide an avenue to understand student perceptions and allow students to express their ideas in a creative and non-traditional way. For this study, we gathered drawings from 38 graduate students from multiple disciplines enrolled in a graduate-level course on contemporary pedagogy. Data were analyzed to compare disciplines along the spectrum of concrete, active, reflective, and abstract. Results from pre-course drawings indicate a breadth of student expressions and perceptions of education, including metaphors and discipline-specific content. Students draw on their prior experiences, but also look to the future in how they envision education to be. Themes include education as: an active-learning approach, cognitive development, futuristic, a global endeavor, knowledge acquisition and transfer, lecture-based, metaphors for education, and influence from personal experiences. Future work will include analysis of post-course drawings and reflections to gain a full understanding of how the course impacted students' perceptions of education.

Use of the triple-bottom line framework to examine the design tendencies of first year engineering students

Moozeh, Kimia; Zacks, Josh; Chabot, Michael; Hungler, Paul

Queen's University Canada, Canada

Engineering design often requires the examination of multiple different factors and a design selection based on compromise between these factors. An engineer's preexisting values and experiences can influence design decisions. Therefore, knowing and understanding these design tendencies can prove valuable in guiding engineering students with their future design selections.

The purpose of the project is to examine the design tendencies of first year engineering students using an interactive web-based virtual reality (VR) module focused on the triple-bottom line framework. The triple bottom line sustainability framework measures design in three key areas: people, profit and planet.

The course for which the interactive module has been developed is a first-year engineering course called Chemistry of Natural and Engineered Systems. The activity is based around the chemical production of 6-aminopenicillanic acid through hydrolysis of Penicillin-G.

This paper presents an explanation of the web-based VR module, compares student design tendencies before and after the VR experience, and analyzes student reflection. Determining students design tendencies before the VR activity will help the teaching team gain insight into student thinking process about engineering design and determine the extent of variability of first year student design tendencies. We also envision this project as the first step of a longitudinal project to investigate the influence of undergraduate engineering education on student design tendencies.

Paper Session 3-24: Teacher Training and Development

Time: Wednesday, 13/Sept/2023: 8:00am - 9:00am · Location: EQ-112 Flat Room

Session Chair: Cian Farrell

Engineering Faculty & Staff Inclusive Excellence Training: Broadening Engineering Pedagogy for All

Uddin, Mohammad Moin; Johnson, Keith

East Tennessee State University, United States of America

As our classrooms become more and more diverse, the need for cultural competency in engineering faculty is more important than ever. Cross-cultural competency has been named among the 10 most important skills for the future workforce. Historically there is a lack of cultural diversity at X University. The university did not offer any formal training opportunity for faculty and staff in cultural competency. As such, faculty effort in cultural pedagogy is minimal resulting in persistent achievement gaps among culturally diverse students. In this project we have developed and implemented an inclusive excellence cultural competency training program for engineering faculty and staff primarily in the College of Business and Technology. The project aimed to train these faculty and staff in cultural competency so that they can implement inclusive pedagogy and communication in and out of their classrooms. Cross-Cultural Adaptability Inventory and post workshop assessment were used to measure the efficacy of the training program. Assessment data showed that the training program improved faculty and staff's awareness in wide variety areas of cultural proficiency and provided them with a toolbox of ideas to implement them in their classes and workplaces. Lessons learned are: 1) To make an institution a culturally inclusive institution diversity, equity and inclusion need to be part of the organization DNA and leadership buy-in and advocacy is a must; 2) Whenever possible, create developmental approaches that engage faculty and staff with different levels of content over a period of time and 3) Provide flexibility in training delivery.

Teaching excellence programs – lessons learned at two universities

Edström, Kristina¹; Poortmann, Cindy²; Magnell, Marie¹; Pereira, Priyanka²

¹KTH Royal Institute of Technology, Sweden; ²University of Twente, The Netherlands

Universities are seeking novel ways to strengthen the collective educational competence of their faculty and promote educational merits. In this paper we describe and compare the experiences of two recently started initiatives for teaching excellence, the *Program for Future Leaders for Strategic Educational Development* at [a Swedish technical university] and the Teaching Fellowship Programme at [a Dutch technical university]. Both programs have recently completed one complete round of implementation. The programmes are similar in that the participants work on a project of their own for an extended time, while also being part of a community with regular meetings and supported by mentors. The main differences are the programme duration, number of participants, and whether the projects are in a specific theme or wholly formulated by the participants. In this study, both programs are evaluated using similar survey questions. We analyse this data, and reflect on the context, conditions and design of the programs and our lessons learned from these first experiences.

Impact of teacher training on enhancing sustainability integration into engineering education

Schönach, Paula; Jaakkola, Noora; Karvinen, Meeri

Aalto University, Finland

Engineering education institutions face a growing demand to provide graduates with adequate skills to respond to the sustainability crisis at hand. One approach to address this is to integrate sustainability as a cross-cutting theme into programmes and courses. At the same time competence development of academic staff is seen as an essential, yet an underdeveloped prerequisite for a sustainability paradigm shift.

Aiming at enhancing sustainability integration to engineering education, this study investigates the impact of a pedagogical training on teachers' skills and motivations to embed sustainability in their teaching. A new pedagogical course (3 ECTS) on sustainability in teaching was developed and executed at Aalto University four times during 2021-2022. The research data consists of course feedback, written reflection assignments, questionnaires to course participants, and a set of semi-structured interviews of teaching personnel who had completed the training. In the analysis we utilized an application of the four-level Kirkpatrick model of evaluating training impact. Preliminary results indicate that training is effective, especially when providing hands-on and customized support for teachers with different starting points for sustainability integration, and that both interdisciplinary and field specific peer-support and -learning are important elements of an impactful training.

Apart from providing new knowledge on the impact of training on teacher capabilities, the study contributes to the development and improvement of pedagogical support for engineering educators to integrate sustainability in their teaching.

The stability of pre-enrolment prediction of academic achievement: criterion-referencing versus norm-referencing

Hanssens, Jolan^{1,2,3}; Van Soom, Carolien^{1,2}; Langie, Greet^{1,2,3}

¹KU Leuven, Belgium; ²Leuven Engineering and Science Education Center (LESEC); ³Engineering Technology Education Research (ETHER)

Positioning tests are organized in Flanders for prospective STEM students. They provide a low-stakes opportunity to assess their level of starting competences before enrolment. Predictive validity for subsequent academic achievement is an important quality measure of these positioning tests. However, the content of the tests varies over the years. This could be problematic for making accurate predictions based on data from previous years. Therefore, the objective of this study is to compare the stability over time of the predictions of academic achievement using either criterion-referenced (absolute grading) or norm-referenced (relative grading) positioning test grades of engineering and science students.

Comparisons of classifications over six academic years yielded various results (n=1258). For the engineering students, all predictions were unstable in those academic years when the tests were held online due to Covid-19 measures, and when positioning test participation became obligatory. However, in the years when aforementioned special events were absent, norm-referencing yielded the most stable prediction. For the science students, norm-referencing yielded a stable prediction over all six academic years, and criterion-referencing yielded a stable prediction when the tests were not held online. This clearly suggests that the implementation of norm-referencing in positioning tests may lead to more accurate predictions of academic achievement over time, regardless of changes in test content, despite the current use of criterion-referencing in practice.

Plenary 3: Plenary Keynote by Professor Anette Kolmos - Interdisciplinary Projects – Moving From Transfer To Transformation In Learning

Time: Wednesday, 13/Sept/2023: 9:00am - 10:00am · Location: EQ-010 Performance Hall & EQ-002 Lecture Hall

Interdisciplinary Projects – Moving from Transfer to Transformation in Learning

Kolmos, Anette

Aalborg University

Anette Kolmos is Professor in Engineering Education and PBL, Founding Director (Director 2014-2023) for the UNESCO category 2 Centre: Aalborg Centre for Problem Based Learning in Engineering Science and Sustainability. She was Chair holder for UNESCO in Problem Based Learning in Engineering Education, Aalborg University, Denmark, 2007-2014. Guest professor at KTH Royal Institute of Technology 2012-2017. President of SEFI 2009–2011 (European Society for Engineering Education). Founding Chair of the SEFI-working group on Engineering Education Research. Was awarded the IFEES Global Award for Excellence in Engineering Education, 2013 and the SEFI fellowship in 2015.

During the last 20 years, Dr. Kolmos has researched the following areas, primarily within Engineering Education: gender and technology, project based and problem- based curriculum (PBL), change from traditional to project organized and problem- based curriculum, development of transferable skills in PBL and project work, and methods for staff development. She is Associate Editor for the *European Journal of Engineering Education*. She has been supervising more than 20 PhD students and has more than 310 publications. She has been member of several organizations and committees within EER, national government bodies, and committees in the EU.

Interdisciplinary Projects – Moving from Transfer to Transformation in Learning

In the PBL communities, we have always argued that the deep learning in the projects would compensate for the lack of knowledge from taught courses by the students' ability to transfer knowledge to new areas. Within the disciplinary discourses, this has proved to be valid as the transfer of learning works within the same language and disciplinary thinking and the projects share similarities. However, we have learned that in an interdisciplinary context, where students are to transform their experiences from a disciplinary to an interdisciplinary context, the students do experience difficulties in leading and managing their projects.

This keynote will be based on results from the research project funded by Poul Due Jensen Foundation on interdisciplinarity and problem- and project-based learning (PBL). Key concepts in interdisciplinary types of projects will be presented together with research findings on students learning experiences. These findings are leading to a discussion on transfer and transformation in engineering learning – both in terms of scientific knowledge and generic competencies. The main message is that in order to facilitate interdisciplinary and flexible learning, the engineering curricula needs to be built on a higher degree of transformation and variation.

Paper Session 3-01: Sustainability in Engineering Education 2

Time: Wednesday, 13/Sept/2023: 11:00am - 12:00pm · Location: EQ-002 Lecture Hall

Session Chair: Waqas Saleem

Conversations: teaching sustainability in engineering

Gonzalez Buelga, Alicia¹; Cserzo, Dorottya²; Lazar, Irina³

¹University of Bristol, United Kingdom; ²Cardiff University, United Kingdom; ³UCL, United Kingdom

Our research focuses on embedding sustainability in the engineering curriculum in ways that are efficient, coherent and inclusive. An important strand of work within this wider remit is finding suitable approaches for promoting collaboration between institutions and academics and advance the understanding of what 'sustainability' means in engineering education in the first place, by producing reliable data that can inform our future practice, leading to institutional change. In this paper, we report and discuss the organisation and the findings of a series of inter-institutional conversations that took place during two in person workshops, with the central theme of embedding sustainability in the engineering curriculum, held at a University in the UK during spring 2022 and the online meetings and interactions that followed. These meetings provided an opportunity for engineering educators from universities in the southwest of England to share experiences from their current practice when teaching about and for sustainability. The workshops explored the feasibility of setting up of an online platform for sharing teaching and learning resources and techniques, all relating to sustainability issues in an engineering education context. They also spoke to the importance of collaboration and cooperation.

Sustainable Engineering Education Embedded Curricula Research Project

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A previous conference paper with case study report findings began this research to be of use to and inform the International Association for Continuing Engineering Education (IACEE) institutions and its membership on the importance of sustainability is embedded in all engineering education courses from the beginning to the end of the Degree. This research project aims to continue to qualitatively research and investigate the extent to which and how Engineering Learning Curricula (ELC) incorporate and embed sustainability as central to the future work practice of all engineers. This research project now takes a more comprehensive and longer-term approach to be of ongoing use to all engineering education faculties and institutions, corporate and government policy development, and Continuing Engineering Education (CEE) providers. We used the digital platform of Sustainability Education & Research IN Action (SERinA), the IACEE Global Initiative, as a future database reporting on best ELC practices in all forms of Engineering Education and post-CEE practice. IACEE's academic engineering member organisations, member institutions, and other engineering institutions outside of the IACEE will be incorporated in the long term into this research project. Initially, information will be obtained via each institution's external website and its academics for this research project and this report paper. This project will also, in the future, seek to interview graduate engineering students on how effective their degrees were in embedding sustainable learning understandings useful in their post-graduate world of engineering practice.

SUSTAINABILITY ENGINEERING EDUCATION – AN OUTLOOK ON UK HIGHER EDUCATION PROVIDERS

Morar, Nicolau Irala¹; Livada, Maria¹; Chrysanthopoulos, Nikos²

¹City University of London, United Kingdom; ²University College London, United Kingdom

The aim of this paper is to assess the extent to which United Kingdom (UK) universities are incorporating sustainability into their engineering curricula. To achieve this, data from the Universities and Colleges Admissions Service (UCAS) and university websites were analysed using a text mining approach. The findings reveal that UK higher education providers are gradually increasing their offerings of Sustainable Engineering (SE) courses at both undergraduate and postgraduate levels. The most prominent sustainability themes integrated into engineering curricula are energy, design, and construction. Furthermore, the analysis of courses and their modules shows that 50% of UK postgraduate sustainable engineering courses contain between 25% and 50% sustainable engineering content. In contrast, almost one-third of traditional engineering courses that incorporate sustainability contain between 10% and 25% of sustainable engineering subjects. The study also examined the SE courses and their module descriptions to identify gaps and how UK higher education providers are contributing towards the United Nations Sustainable Development Goals (SDGs). The most dominant SDGs addressed in the UK SE courses analysed are SDG 7 Affordable and Clean Energy, SDG 9 Industry, Innovation and Infrastructure, SDG 11 Sustainable Cities and Communities, and SDG 13 Climate Action.

This paper provides valuable insights into the integration of sustainability into engineering education and its alignment with the SDGs.

Exercising UNESCO Competencies in Students through Research-Based Education for Sustainable Development

Strachan, Scott; Crichton-Allen, Claire; Logan, Louise; Marshall, Stephen

University of Strathclyde, United Kingdom

Today's complex global challenges call upon a different pedagogical approach to higher education that is fit for the purpose of preparing our students not only for the world of work, but the work of the world – to paraphrase the words of Sir Jonathan Porritt. Indeed, we can and should be preparing students for both, as it is through their professions they will arguably be able to have the most positive impact on these global challenges. Consequently, re-focusing teaching on ways of thinking, being and practicing, the so-called 'head, hearts and hands framework', should be done in a way that actively stretches students beyond the comfort of their disciplinary subject boundaries and skill sets.

This paper will present the University of Strathclyde's practice and experience of establishing their award winning Vertically Integrated Projects for Sustainable Development (VIP4SD) programme, an exemplar of 'how to' embed Research-Based Education for Sustainable Development in undergraduate curricula.

The programme currently involves 25 student-centred research projects consisting of almost 200 undergraduate students. These projects are not only of students from different disciplines working on common challenges, but also different year groups also – that is to say they are both horizontally and vertically integrated.

This paper will show how VIP4SD develops key sustainability competences in engineering (and other) students within the context of their core discipline; offering a more authentic real-world, experiential and potentially transformational learning experience, that can inspire, educate and equip our students to work collaboratively, now and in the future, in the pursuit of the global goals.

Paper Session 3-02: EDI 5 - Background and Belonging 2

Time: Wednesday, 13/Sept/2023: 11:00am - 12:00pm · Location: EQ-116 Flat Room
Session Chair: Sophia Economides

A look at vocational and academic student backgrounds in ability to solve practical problems

Thomson, Gareth; Prince, Mark

Aston University, United Kingdom

The work presented in this paper looks at the issue of student problem solving based on pre-university educational background.

While most students in the UK will enter engineering degrees with traditional academic qualifications a significant proportion will come from backgrounds which use vocational based qualifications to gain entry to degree level study. Indicators (Gicheva N, Petrie K, (2018), Richards (2016)) show that students from lower socio-economic backgrounds are more likely to be among those using vocational qualifications to gain entry to University and may not progress as well. (Shields, R & Masardo, A, (2018), HEFCE (2018), Gill T., (2018)). To look at ability in practical problem solving a trial was devised.

Students in their first year of a range of engineering degree programmes were recruited from a range of disciplines including those on mechanical, electrical and chemical engineering degrees and a range of educational backgrounds.

Students were paired up to work on a series of short problem solving exercises designed to require an element of logical and creative thought of the type needed in engineering problem solving but were such that no specific technical knowledge was needed. Work was videoed and then encoded to help with analysis.

The work, while from a small sample size, appeared to illustrate that students on engineering programmes want to solve problems and capability appeared to be independent of educational background suggesting this skill may be lost to society if engineering students from vocational backgrounds drop out early due to struggles with more academic topics.

Engineering student belonging to prevent early leavers through curriculum decolonization, academic self-concept, and psychologically safe teamwork

Cooke, Neil; Chetty, Jacqueline; Favero, Claudia; Green, Zena; Drury, Neil; Joubert, Pieter

University of Birmingham, United Kingdom

The proportion of early leavers from engineering degrees closely follows the higher education sector throughout Europe; around 10% leave before graduation. Students are more likely to drop-out if they do not feel that they belong in the learning community. While research shows that academic achievement is a primary factor contributing to student drop-out, other student-centric social factors, such as belonging are equally important to student drop-out rates within higher education. The aim of this paper is to present a model constructed on student belonging. The model consists of 3 pillars, namely academic self-concept and professional identity, psychologically safe teamwork, and decolonisation. The study was based on the development and continuous refinement of interventions that could assist students with feeling a sense of belonging. While the primary intention of this project is to present a body of work that highlights belonging as a contributing factor that may be pivotal to a student remaining in higher education or dropping out, readers will also learn about how best to support students in gaining a sense of belonging through self-concept, providing safe teamwork and by decolonising the curriculum.

Amplifying new voices and making space for alternative knowledge systems in engineering curricula – the example of Ubuntu

Occhio, Anita; Saunders, Fiona Caroline; Chikwa, Gladson; Nicholson, Dawn Theresa

Manchester Metropolitan University, United Kingdom

Engineering projects are ubiquitous; from developing COVID-19 vaccines to building new cities and developing climate change solutions. An inclusive approach to teaching engineers how to master the complexities of engineering project management is vital to the deliverability of sustainability and net zero initiatives (Hockings 2010). Yet, our engineering curricula remain deeply rooted in Western epistemology (Winter *et al.* 2022, Mbembe 2015). Arguably, this is an opportune time to consider decolonising our curricula.

At a fundamental level, 'decolonising the curriculum' means introducing previously ignored voices, images, authors, theories and arguments into our teaching (Rogers *et al.* 2022). This is a challenge in the subject of engineering project management, where we have a rigid body of knowledge that forms the backbone of our curricula. In this paper, we argue that we must not lose the richness of theory, models and processes taught in our engineering curricula. However, we do need to search out or build knowledge of how projects in the Global South or among indigenous peoples may be managed differently and listen to and amplify voices from those cultures and communities. Ubuntu is one such alternative knowledge system, which we propose as an example of how we can amplify new voices within our engineering curricula and begin the work of decolonising our discipline (Metz 2007, Naude 2019). Our paper is based on a critical review of extant literature. We challenge readers with an evidenced call to action to embed the Ubuntu values and its benefits for students into engineering education.

A look inside the engineering students' backpack: Differences in engineering capital according to gender or migration background.

Cannaerts, Mieke; Craps, Sofie; Draulans, Veerle; Langie, Greet

Ku Leuven, Belgium

Every student has a unique combination of experiences, resources and social networks related to engineering, called 'engineering capital', derived from Archer's concept of 'science capital'. The engineering capital gathered throughout life creates a backpack that impacts someone's aspirations to study engineering, as well as the performance and persistence in the programme itself.

Engineering technology is one of the most homogeneous fields within the STEM domain, being mostly white and male. To stimulate a more diverse engineering technology field, this research paper investigates the relationship between the level of engineering capital and gender or migration background, as well as the influence of engineering capital on aspiration and performance within the engineering technology field.

Through an online survey, last-year secondary education pupils in math/science tracks (N = 490, March 2023), and first-year engineering technology students (N = 391, October 2022) in Belgium were asked about their engineering capital, and engineering aspiration (pupils) or performance (students). Results disclose little difference in engineering capital, engineering aspiration, or engineering performance for students with a migration background. However, female pupils appear to have less engineering capital than male pupils, and in need of more engineering capital to gain an interest in engineering technology compared to male pupils. Once women start the engineering technology program, engineering capital does not influence female students' performance differently than male students. It is possible that only those with a heavy backpack of engineering capital find their way to the program. That is why it is important that educators stimulate students' engineering capital.

Paper Session 3-03: Innovation in T&L 5 - Student Engagement and Feedback

Time: Wednesday, 13/Sept/2023: 11:00am - 12:00pm · Location: EQ-211 Flat Room
Session Chair: Paul Francis Leamy

Using ICT to motivate and achieve learning outcomes in live teaching of 650 students

Petrović, Juraj; Pale, Predrag

University of Zagreb Faculty of Electrical Engineering and Computing, Croatia

This paper describes efforts and practices used in teaching a *Communication skills* course with two full time teachers to approximately 650 enrolled students. It is focused on issues including motivating students if they consider this course to be non-essential for their professional development and a nuisance in their study, achieving learning outcomes in an efficient way, and using of ICT for assessment and self-assessment of communication skills. The ways and means of leveraging ICT in achieving these goals are presented in the paper. The potential of ICT and multimedia to motivate, keep students on schedule, gain their attention in lectures and assess their knowledge is discussed, and lessons learned from six generations of students and how they influenced course re-design are elaborated.

Why do students dislike peer feedback?

Selwyn, Becky; Ross, Joel; Lancaster, Sean

University of Bristol, United Kingdom

Engineers are required to communicate in a range of formats, including written reports, but this skill does not come naturally to undergraduates. Typical approaches to teaching writing skills require small class sizes, expert staff, and multiple cycles of feedback. These approaches, while successful, are difficult to scale and do not always result in students being able to transfer their writing skills to other units/topics.

The School of Civil, Aerospace, and Mechanical Engineering at the University of Bristol teaches writing skills mainly within a single 20-credit first-year unit, delivered to 550-650 students per year. Students are required to complete a number of at-home labs and write up various sections of a lab report for a series of four formative assessments. A peer review process follows each formative task to encourage engagement with the assessment criteria, encourage reflection and self-regulation, and provide prompt feedback on work.

The benefits of peer review and feedback are well known and are carefully explained to students. However, each year, a relatively small but vocal number of students are reluctant to engage with it and express a strong preference for staff feedback. This project evaluated student perceptions and experiences of the peer review process using a survey and focus groups. Results suggest that although students recognise many benefits of peer reviews, they lack confidence in their ability to provide it, leading to apparent reluctance to engage. This highlights the importance of providing support and training as part of the process.

Student's Experience of Feedback Practices and Recommendations for Improvement

Willey, Keith; Gardner, Anne

The University of Technology Sydney, Australia

There have been numerous research studies and recommendations as to what feedback should look like to improve student learning and the learning experience. These recommendations include being timely, fed forward, provided using different modes and sources and to support students to know how to best use the feedback they are given.

The Faculty of Engineering and IT (FEIT) at The University of Technology Sydney (UTS) is currently focusing on improving the quality, effectiveness and delivery of feedback provided to their students on their learning and demonstrated achievement in a variety of settings.

This paper reports the first stage of this project where students were asked about their previous experience of receiving feedback, how they are able to use it and their preference as to the type and timing of the feedback they prefer.

Students reported feedback was often was non-existent, extremely limited, non-specific, or too late to be useful. They found feedback was most useful when it was specific, could be used for improvement and was not just focused on correction.

Measuring effects of mini-lectures on improving student engagement and outcomes

Engbers, Vincent¹; Gündlach, Rowel¹; Regis, Marta¹; Vlasίου, Maria^{1,2}

¹Eindhoven University of Technology, The Netherlands; ²University of Twente, The Netherlands

In the current age, digital advancements have shaped the educational landscape by providing numerous possibilities for a fast and on-demand influx of information for students. This brings an additional difficulty for course designers in how to incorporate such technologies in teaching in an optimal way. Key examples are educational videos, which are especially relevant now due to the increase in accessibility of pre-made videos and recording technology since the pandemic. This puts post-pandemic teaching in the new but revolutionary position to complement in-person teaching with videos.

In this study, we examine the effect of videos combined with in-person teaching in a mathematics master course in motivation and grades. This experiment is specifically insightful due to our course consisting of three different topics (A,B,C). In Year 1 (control group), the course was taught traditionally. In Year 2 (experimental group), we provided additional video lectures on (A), while keeping (B) and (C) as before. We compare assessment and survey results between and within years.

Videos did not increase the students' motivation for the topic (Fisher exact test = 0.06182). The intervention did not improve the midterm or final exam grades on (A) between years. Students who watched videos did not score significantly better on their assignments (2MWUt = 0.275) nor on their exams (2MWUt = 0.745) than students who did not watch the videos. However, a positive effect size was observed between years, while the intervention led to a negative effect size within the same year.

Paper Session 3-04: Competencies for Lifelong Learning

Time: Wednesday, 13/Sept/2023: 11:00am - 12:00pm · Location: EQ-203 Flat Room
Session Chair: Sonia M. Gomez Puente

Problematising and Framing Spatial Research in Engineering Education

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¹School of Engineering, University of Limerick; ²School of Education, University of Limerick

Spatial research has experienced a surge in popularity across the global community in recent years, with an undeniable rise in the favourability of spatial thinking approaches in academic and higher education settings. An engineer's spatial ability is dependent on their capacity to engage a set of cognitive skills to visualise, reason and communicate spatial relations between objects and space. With the recent growth in popularity around spatial research, new spatial terms are frequently introduced resulting in a definitional overlap between terms and ideas. This may sometimes result in a lack of clarity regarding spatial terms and definitions, with the definitions of such terms varying amongst the literature. The eight most researched spatial terms over the last ten years are included in this study: *Spatial Ability*, *Spatial Skills*, *Spatial Intelligence*, *Spatial Visualisation*, *Spatial Literacy*, *Spatial Reasoning*, *Spatial Factors* and *Spatial Thinking*. A review of literature supported the unpacking of spatial terms and related research and the subsequent synthesis of the same. Particular focus centred on the various definitions and conceptualizations of these terms, as well as the contexts in which they are used to improve the accuracy, validity, and value of spatial analysis and its potential applications across different fields and disciplines. This paper aims to unpack and synthesise the various interpretations and dimensions of spatial competencies in the body of international research, ensuring that the pertinent research information is more readily accessible to practicing engineering educators.

Innovative engineering education in the wake of smart agriculture. Revision of the agricultural engineering curriculum

Mandler, Andreas²; Carabin, Giovanni¹; Becce, Lorenzo³; Nicolosi, Francesco Fabio¹; Mazzetto, Fabrizio¹

¹Faculty of Agricultural, Environmental and Food Sciences, Free University of Bozen-Bolzano; ²Competence Centre of Mountain Ecosystems, Italy, Free University of Bozen-Bolzano; ³Competence Centre for Plant Health, Free University of Bozen-Bolzano

Global developments request ever more productive agricultural production systems to ensure food security. Agricultural production must be environmentally, socially sustainable and economically efficient. Innovative digital technologies are central to sustainable production systems. This poses challenges to the education of agricultural engineers, as technologies for real world challenges result from highly interdisciplinary innovations.

Agricultural engineering (AgEng) as an academic discipline is not universally established, which leaves voids in educational curricula and formal training areas. A substantial conflictual dualism remains between the biological and engineering domains. There are currently no homogeneous pathways through which these domains merge on common scientific and cultural foundations, cumulating in consistent training areas. The diffuse institutional situation damages the position of AgEng as an academic discipline. The ambiguity of AgEng has become evident during the evolution of Smart Agriculture (SA), where digital technologies deeply interact with conventional agricultural technologies.

The present paper formulates a rigorous approach to defining competence formation in AgEng to integrate cross-competences, which can be offered through lifelong learning (LLL) opportunities.

From Rookies to Synthesis: Agile solutions for sustainable doctoral studies

Taka, Maija; Suviniitty, Jaana; Varis, Olli

Aalto University, Finland

Modern doctoral education in engineering lies at the intersection of three topical phenomena: firstly, the surge of wicked sustainability concerns and the subsequent burgeoning demand for cross-disciplinarity. Secondly, the rapidly developing new technologies and global knowledge economy provide a thriving problem-solving potential, although – thirdly – this requires proactive and innovative collaboration beyond the scope of a single discipline. Thus, doctoral education needs new practices to ensure that students are equipped with new kinds of competencies to solve unpredictable and wicked sustainability problems. In order to reach these demands, we need to favor collaboration over competition. Here we approach these issues by presenting key findings from a five-year empirical study on doctoral education in engineering. Data were collected by using a journey mapping method on recently graduated doctors in engineering at Aalto University, Finland. Students from the examined research group were compared with a control group. The data were clustered and the main factors contributing to the individual journeys were analyzed. Community, colleagues, and collaboration turned out to have the strongest positive impact on their doctoral journey (average +1.26, scale -3...+3), and they were distributed across the thesis process. Most observations were related to external academic factors, such as funding and journal decisions. Additionally, we present research group practices, such as "Rookies club" and "Synthesis groups" that strengthened students' resilience and internal support on these factors. These practices initiated positive interdependencies among the students and supported sustainable supervision practices. Our results are applicable to a wide range of doctoral education.

DEVELOPING GLOBAL ENGINEERS- A COMPARISON BETWEEN SCOTLAND, USA AND CHILE

Munoz-Escalona, Patricia¹; Medina, Luis²; Marquez, Mervyn²; Murzi, Homero³; Smith, Christopher¹; Miligan, Colin¹

¹Glasgow Caledonian University, United Kingdom; ²Universidad Austral de Chile; ³Virginia Tech

Engineering-accredited programmes are reviewed every 4-5 years by professional bodies with the aim of assuring standards that guarantee that graduate engineers can fulfil the highest technical demands of the industry workforce in order to achieve a sustainable economy and society. The approaches to develop these require global engineering competences (GECs), such as international and intercultural teamwork, language skills, critical thinking, and ethical and human-centered problem solving, are proving insufficient to meet the emerging challenges that this century's society is facing. To develop these GECs, engineering programmes have been working on including physical and virtual mobility such as Collaborative Online International Learning (COIL) together with other experiential learning interventions in order to provide the necessary requirements to become a global engineer. The aim of this practice paper is to compare and to discuss how three different universities, located in Chile, Scotland, and the United States have designed their engineering programmes to develop global engineers. This research provides preliminary results, based on an auto-ethnographic approach to analyse the curriculum design approaches and structures, that highlight opportunities for collaborative interdisciplinary experiences as well as more country- and institution-specific approaches (Engineers Without Borders) that support the development of these GECs. Analysis showed that the majority of the GECs are achieved by the three universities, however Virginia Tech is the only university that explicitly encourages and motivates other students through an assignment and cultural simulation activity. This research is part of a larger investigation that will analyse how engineering graduates perceive their development of GECs.

Paper Session 3-05: Education with Artificial Intelligence 2

Time: Wednesday, 13/Sept/2023: 11:00am - 12:00pm · Location: EQ-204 Flat Room
Session Chair: Diana Adela Martin

A Framework for Teaching Machine Learning for Engineers

Singelmann, Lauren; Covarrubias, Jacob

Minnesota State University, Mankato, United States of America

As machine learning and artificial intelligence become increasingly prevalent in our day-to-day lives, there becomes an even greater need for literacy in machine learning for those outside of the computer science domain. This work proposes a framework for teaching machine learning to engineering students with the goal of developing the knowledge and skills needed to apply machine learning techniques to engineering problems.

Many machine learning courses in computer science, math, and statistics focus on the theoretical basis of machine learning algorithms and assessment. This framework takes a fundamentally different approach by creating a course structure for machine learning practitioners rather than machine learning developers.

The presented framework breaks machine learning into four fundamental principles that should be used in any machine learning solution: data (what information we can use to develop our solution), task (what we are trying to accomplish with our solution), algorithms (what computational models we are using to create our solution), and assessment (how we are measuring the success of our solution). To teach this framework, the structure of the course includes creating concept maps of the four fundamental principles and relevant topics, completing coding tutorials, and creating in-class presentations that use and apply the four fundamental principles.

The paper will present the need for machine learning and artificial intelligence education within engineering, the framework and supporting learning theory, suggested activities for implementation, and lessons learned from the implementation of this framework in a 1-credit course for engineering students.

Ethical Concerns and Responsible Use of Generative Artificial Intelligence in Engineering Education

Johri, Aditya¹; Lindsay, Euan²; Qadir, Junaid³

¹George Mason University, Fairfax, United States of America; ²Aalborg University, Aalborg, Denmark; ³Qatar University, Doha, Qatar

The use of educational technologies that use elements of machine learning (ML) and artificial intelligence (AI) are becoming common across the engineering education terrain. With the wide adoption of generative AI based applications, this trend is only going to grow. Not only is the use of these technologies going to impact teaching, but engineering education research practices are as likely to be affected as well. From data generation and analysis, to writing and presentation, all aspects of research will potentially be shaped. In this practice paper we discuss the ethical implications of the use of generative AI technologies on engineering teaching and engineering education research. We present a discussion of potential and futuristic concerns raised by the use of these technologies. We bring to the fore larger organizational and institutional issues and the need for a framework for responsible use of technology within engineering education. Finally, we engage with the current literature and popular writing on the topic to build an understanding of the issues with the potential to apply them in teaching and research practices.

Educating future Robotics Engineers in multidisciplinary approaches in Robot Software Design

van der Niet, Astrid; Claij, Cilia; Saunders-Smiths, Gillian

Delft University of Technology, Netherlands, The

In 2020, a new two-year MSc programme in robotics was launched. Unlike most existing robotics programmes, which approach robotics from a specific discipline, this programme aims to train multi-deployable robot generalists using a cognitive approach (no hardware creation). The field of robotics is multidisciplinary by nature and educating students on how to approach projects with a multidisciplinary mindset is at the forefront of the programme.

Hence, at the end of the first year, students are thrust into experiencing the true multi-disciplinarity of the robotics field in a synthesizing, multidisciplinary project-based course. In this 5 ECTS course, students work together in groups of 5 on an industry-based assignment making a translation of societal issues from different perspectives (human, sustainability, safety, ethics, economic, etcetera) into intelligent robot solutions. Each team develops and tests a complete, integrated software package for a complex robot system in a simulated environment and implements it in a real robot at the end of the course. Various robots (all mobile manipulators) are used, each related to a different case study which is taken on by multiple teams. Students are supported in their project with workshops and minilectures on transferable skills, systems engineering and the Robot Operating System (ROS).

This paper describes the development, implementation, and results of the course over its first three years of running. It will present lessons learned from the perspectives of all parties involved: lecturers, technical staff, industry, and students as well as future plans and recommendations for others looking at creating similar courses.

ETHICS4EU: DESIGNING NEW CURRICULA FOR COMPUTER SCIENCE ETHICS EDUCATION: CASE STUDIES FOR AI ETHICS

O'Sullivan, Dympna¹; Gibson, J Paul²; Curley, Andrea¹; Becevel, Anna¹; Murphy, Emma¹; Gordon, Damian¹

¹Technological University Dublin, Ireland; ²Telecom Sud Paris

The computing ethics landscape is changing rapidly, as new technologies become more complex and pervasive, and people choose to interact with them in new and distinct ways. The resultant interactions are more novel and less easy to categorise using traditional ethical frameworks. It is important that developers of these technologies do not live in an ethical vacuum, that they think about the consequences of their creations, and take measures to prevent others being harmed by their work. To equip developers to rise to this challenge and create a positive future for the use of technology, it is important that ethics becomes a central element of computer science education. To this end, the Ethics4EU project has developed curricula on a wide range of topics including privacy and agency of personal information, digital literacy, data governance and accountability, surveillance applications, algorithmic decision and automating human intelligence for robotics and autonomous vehicles. Crucially the content examines computing ethics, not only in terms of hardware and software, but how systems, people, organisations and society interact with technology. In this paper, we present our interdisciplinary approach to developing educational content for AI Ethics. This includes accessible teaching materials, in-class activities, sample assessments, practical guidelines and instructor guides. We discuss findings of an evaluation of the developed content with undergraduate computer science students.

Paper Session 3-06: Engineering Skills 1

Time: Wednesday, 13/Sept/2023: 11:00am - 12:00pm · Location: EQ-112 Flat Room
Session Chair: Uchenna Sampson Igwe

Addressing Challenges of the SDGs: Stakeholder Perspectives on Skills Required by Engineering Students on the Island of Ireland

Henry, Rosalind M¹; Morgan, Margaret¹; Beagon, Una²; Bowe, Brian²; Jani, Ruchita²; McKennedy, Janet²

¹Ulster University, United Kingdom; ²Technological University Dublin, Ireland

Living sustainably on a shared island poses both challenges and opportunities for engineers of the future. Whilst at a European level, the professional skills that engineers will need to achieve Sustainable Development Goals (SDGs) have been identified, less has been written on how these skills should be contextualised for a national, regional and/or local level. This research paper considers the specific professional skills required for engineers on the island of Ireland. It examines differing perspectives of stakeholders, comparing and contrasting views according to local context (Northern Ireland (NI), Republic of Ireland (RoI)).

A professional skills survey was designed, drawing on previous research which had identified 53 competences in six sets (Fundamental Technical Skills, Application Skills, Outward Facing – People Orientated Skills, Inward Facing – Ways of Thinking, World View, Character and Ethical Orientation). The survey was completed by 235 academics, students and engineering employers (ranging from SMEs to large multinationals) on the island of Ireland in 2022. Analysis highlighted interesting similarities and differences in stakeholder perspectives between the two jurisdictions. Whilst awareness of SDGs was markedly higher in RoI compared to NI, average importance ratings for many competences were generally similar in both jurisdictions.

These findings have improved engineering educators' understanding of the stakeholder perceptions including how those vary by location. Such improved understanding, including regional insights, should help to inform engineering curriculum development at tertiary level and ensure that engineering graduates are equipped with the appropriate skill set to contribute solutions to the big global challenges of our day.

Returning to on-campus activities for first-year engineering skills development - a comparative study

Buskes, Gavin; Chan, Huey Yee

The University of Melbourne, Australia

Prior work by the authors on student skills development detailed the implementation of a suite of skills modules in a first-year engineering subject. These modules were instrumental components in supporting the subject's project-based framework that offered flexibility of choice and timing in a low-risk setting. It was found that, while receiving overall favourable student feedback, most students only completed the minimum requirements and largely chose technical modules according to the relevance to their project topic.

Due to the cessation of on-campus teaching activities caused by the COVID-19 pandemic, these modules were delivered wholly online. With the lifting of restrictions the following year, the modules were made available with several distinctions: (a) the option of completing wholly online or a mix of online and on-campus activities; and (b) a change to a graded assessment scheme to encourage students to put more effort into their completion.

An evaluation performed on the modules revealed that online-only modules were attended at a rate comparable to on-campus activities. The distribution of module completions over the semester was influenced by module availability, students' time management and module alignment with their project. A higher concentration of module completions occurring closer to deadlines indicated that students were more time pressed and completed the modules just in time. The change to the grading scheme did not appear to affect the take up rates of the modules but did result in better quality of work. Students still elected to complete modules aligned with their project, consistent with previous trends.

Planned, Taught, Learnt: Analysis of Transversal Skills through Curriculum using Portfolio

Kovacs, Helena; Milosevic, Tamara; Niculescu, Alexandra

EPFL, Switzerland

There is an everlasting effort in education to successfully ensure that the intended learning objectives are clearly taught and effectively learnt at the end of the educational cycle. This has been especially difficult in teaching and learning complex sets of competencies, for example, transversal skills in domains such as engineering education. Yet, studies focusing on transversal skills often address student learning outcomes, but rarely how teachers teach them, and even less so how they are represented in the written curriculum.

In order to create a more comprehensive understanding of how transversal skills are communicated, taught and learnt in engineering education, we designed a qualitative case study with a focus on teaching and learning transversal skills. The data was collected from five distinct sources within one master course. This included examining the written curriculum as presented in the course syllabus, the taught curriculum with data from the teacher interview and teaching materials, and the learnt curriculum coded from student portfolios.

In our results, we reflect on alignments, gaps and potentials in teaching and learning transversal skills. Alongside, through our case we argue that alignment in learning intentions and outcomes is stronger due to using a training portfolio and explicitly requiring reflection as part of the assessment, which does not prevent other learning outcomes from evolving spontaneously. We also discuss suggestions for portfolio design and its use in teaching and learning transversal skills in engineering education.

EXPLORING THE DEVELOPMENT OF ENGINEERING DESIGN CREATIVITY AND THE ROLE OF SPATIAL SKILLS IN THIS PROCESS

Reid, Clodagh²; Sorby, Sheryl¹

¹University of Cincinnati, United States of America; ²Technological University of the Shannon

This study aims to investigate the development of creativity in engineering education and how spatial skills relate to creativity of design solutions.

Undergraduate students in the first (n=86) and fourth/fifth year (n=48) of their engineering programme were invited to participate. Students completed four spatial tests to precisely measure visualisation skills. In a separate session, students were invited back to solve two engineering design tasks: a ping pong problem where they designed a ping pong ball launcher game to meet specified criteria and a rain catcher problem where they were tasked with developing as many ideas for capturing rainwater as a water source for a remote location as they could. Students were asked not to consider feasibility, cost, etc. and to come up with multiple radical solutions to the rainwater capture problem.

The creativity of design solutions was assessed using Adaptive Comparative Judgement. Statistical analysis indicated significant relationships between spatial skills, students' year of study and gender. A statistically significant relationship was also found between students' creativity scores on both design challenges. No statistical differences were determined in the creativity of first and fourth/fifth year students' solutions. These findings will be discussed relative to existing research, future work, and potential implications for education practice.

Paper Session 3-07: Problem and Challenge Based Learning 2

Time: Wednesday, 13/Sept/2023: 11:00am - 12:00pm · Location: EQ-208 Flat Room
Session Chair: Emanuela Tilley

Challenge-based Learning in Courses: The Implementation Continuum

Imanbayeva, Adina; de Graaf, Robin; Poortman, Cindy

University of Twente, the Netherlands

Given the increasing criticality and complexity of societal challenges, higher education institutions are urged to equip students with the ability to develop sustainable solutions for 'wicked' problems. Consequently, the Challenge-based Learning (CBL) framework has attracted considerable interest in higher engineering education. However, transforming existing course curricula to CBL is a challenging endeavour since it requires careful and paced execution for maintaining the quality, synergy, and flow of existing education. Therefore, this paper proposes a perspective on CBL implementation that exemplifies a gradual transition towards educational CBL innovation while reflecting on the alignment, consistency, and coherence educators aspire to when designing courses. Accordingly, we introduce a CBL implementation continuum as a conceptual model, which connects CBL elements to Van den Akker's Spider Web for curriculum design and describes a continuum of Mild, Moderate, and Intense CBL levels per Spider Web component. Moreover, the paper describes an online CBL implementation tool, which helps educators thoughtfully evaluate the current level of CBL in their courses and provides practical recommendations for a transition towards higher levels of CBL intensity.

Challenge-Based Learning and Constructive Alignment: A Challenge for Information Systems' Educators

Moreira, Joao; Ugulino, Wallace; Machado, Marcos; Ferreira Pires, Luís

University Twente, Netherlands, The

Challenge-Based Learning (CBL) is an emerging approach to the design of education activities known for its benefits in fostering student engagement and, consequently, positively affecting their learning outcomes. For the educator, the 'challenge in the challenge' is to guarantee that the CBL-based education design follows certain regulations, like ensuring proper curriculum coverage with Constructive Alignment. This challenge becomes particularly difficult to address in the field of Information Systems, within Computer Science, where multiple practices can be followed to solve the same problem. This is even more challenging when CBL is applied in the courselevel, where the curriculum of the course focuses on a subset of those practices. This paper targets two central questions for the educators willing to apply CBL while keeping Constructive Alignment in their course design: (1) How to ensure that the results based on solutions designed to address student-defined challenges can be successfully aligned to the course's intended learning outcomes? (2) How to use these results as evidence of learning and as an assessment component? We discuss our experience and lessons learned in applying CBL for the redesign and execution of the Smart Industry Systems course of the University of Twente, while ensuring proper curriculum coverage and Constructive Alignment.

A GAME-BASED LEARNING APPROACH TO ENHANCE UNDERSTANDING OF INTERFACE DESIGN PRINCIPLES IN DESIGN EDUCATION

Carberry, Deborah²; O'Kane, Colm¹; Delaney, Kevin¹; Kruhne, Ulrich²; Andersson, Martin²; McHale, Donal¹

¹TU Dublin, Ireland; ²DTU, Denmark

The design of user interfaces is an important and challenging topic for student designers to understand and master. The eight principles of good User Interface design are often taught using primarily cognitive approaches, which can leave room for improvement in students' ability to apply the principles in a variety of contexts. Game-based learning tools are recognised to be beneficial in university classrooms across a variety of discipline areas and topics due to their capacity to increase engagement. This project aims to leverage the advantages of gamification and embodied learning to enhance students' understanding and application of these principles, while drawing on the areas of experiential education, multisensory learning and social constructivism. In the proposed intervention, students will work in groups to perform a range of tasks, each designed to challenge a different sensory or motor ability. The tasks will be repeated on several occasions by each cohort, with sensory/motor capacity varied on each occasion. In order to evaluate if the students have internalised the learning objectives, study participants will then be presented with a User Interface problem, for which they must sketch out a design solution. The quality of these solutions will be compared to that of a control group.

Staff Experiences of Leading Large-Scale Multi-departmental Project-based Learning for Year 1 Engineering Students

Truscott, Fiona¹; Tilley, Emanuela¹; Mitchell, John²; Nyamapfene, Abel³

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There is increasing consensus that Engineering programmes must include space for skills learning, particularly in interdisciplinary contexts. Active learning methods, such as project-based learning, are the gold standard for teaching interdisciplinary skills. However much of the literature on these approaches focuses on relatively small class sizes, making the application in larger contexts seem unfeasible. The Integrated Engineering Programme (IEP) at University College London (UCL), is one of the most comprehensive and largest applications of active learning methodologies within undergraduate engineering curricula in the UK. Central to the IEP are active learning approaches threaded throughout the common, cross-faculty teaching framework.

A key part is the cornerstone module, Engineering Challenges. This first-year undergraduate module aims to introduce students to project work and key skills such as teamwork and communication through undertaking an interdisciplinary project. Run by 20 academic staff and 50 PGAs and taken by close to 1000 students each year across seven departments, with material tailored to students' disciplines, this is a complex undertaking. Team-teaching has not been widely used in HE contexts but the IEP uses it regularly. Here, the teaching team is led by the module lead, based at faculty level, and contains one to four academics from each department that takes the module. Given the rarity of this situation, this paper aims to understand how staff describe their experience of active learning and team-teaching within this large-scale context, key elements for the success, what barriers and challenges they have faced and how they overcame them.

Paper Session 3-08: Technology for Support of Teaching and Learning

Time: Wednesday, 13/Sept/2023: 11:00am - 12:00pm · Location: EQ-117 Tiered Room
Session Chair: Colm O'Kane

Podcasts as a Learning Method in Engineering Education

Engzell, Jeanette; Norrman, Charlotte

Linköping University, Sweden

Multimedia has been integrated in education the last 40 years but podcasts have more recently become popular. Since 2006 podcasts have become increasingly popular in Sweden and nowadays podcasts are used in all types of contexts but are yet to find a place in engineering education. Students do not acquire knowledge or solve problems in the same way. Using a mix of methods in teaching is therefore important if one has the ambition to democratize the learning processes and give students the same opportunity to learn. Traditionally, much of the university education has been based on lectures in classrooms and reading literature. During the pandemic, teachers switched to video lectures and online lectures. Even though all types of multimedia are involved in teaching today, podcasts have not become established as a learning method. This paper explores in what ways podcasts can be beneficial in engineering education. Specifically, the paper investigates what preferences students have on how podcasts for engineering education and how teachers effectively can design and develop podcasts in courses as a learning method. By addressing the gap of evidence on podcasts in engineering education, the findings contribute with effective solutions on how podcasts can be developed and implemented that will help students in their learning processes.

Integrating AR Technology into CBM Laboratory Experiments

McDonnell, Alan¹; Vaughan, Brian¹; McDonnell, David¹; Capraro, Bernard²

¹TU Dublin, Ireland; ²Intel Research and Development Ireland Ltd, Ireland

This paper examines the pilot phase integration of Augmented Reality (AR) technology into a Condition Based Monitoring (CBM) engineering taught module.

Students participate in a laboratory cycle within the CBM module, engaging in multiple experiments on a weekly basis, including Shaft Alignment, which provides meaningful, industry-relevant experience in an engineering environment. During the laboratory sessions, multiple pairs of students complete the experiment simultaneously on multiple custom engineering rigs. The Shaft Alignment procedure, although very relevant to industry needs, is also complex and time consuming, with students often struggling to complete the task within the designated laboratory time.

AR technology has been introduced into this module to improve the experimental instructional design, improve the learning experiences for the students and reduce unavoidable practical delays during the experimental cycle. Existing experimental procedures have been implemented as AR content including re-crafted instructional content, multimedia content (videos and images), and custom CAD data overlaid on the engineering rigs as AR reference geometry.

The newly-introduced AR-based experiments were completed by multiple students over the course of a number of weeks in April/May 2023. Students provided participant feedback via survey before and after engagement with the AR technology. Test groups were aligned within the class as comparators in terms of using existing non-AR procedures versus new AR-enhanced procedures.

The outcomes from this pilot phase are presented in this paper, with particular focus on student and lecturer experience, knowledge gained in the context of content creation pathways for future AR integration and increased productivity within the laboratory.

Becoming an expert in soft robotics in one week and beyond!

Stassen, Peter; Van Looy, Guy; Peerlinck, Sam; De Smet, Elias; Mundial, Imran Qayyum; Van Merris, Alexis; Gorissen, Benjamin

Faculty of Engineering Science, KU Leuven, Belgium

The Athens network of technological institutions and universities offers students international exchange experiences through intensive specialization courses during a short period. Yet, it is challenging to effectively explain complex research topics to students in only one week, while offering at the same time self-paced learning perspectives instead of absorbing expert lectures as a passive student. Furthermore, students often experience a knowledge gap with the 'international experts' they are consulting, which hinders vibrant participation and exchange during discussions. In this context, we report our experiences of a newly designed crash course within the field of soft robotics that was offered to a group of international students. Our approach is a concept of combining flipped teaching, peer learning and student empowerment within engineering sciences. A scenario is elaborated and finetuned in which students experience a set of (semi-)self-paced activities and achieve the learning goals in a (semi-)independent way. This includes a preparatory activity and, on the spot, (re-)active learning through peer-discussion on emerging topics in the field of soft robotics and collaborative creation of a simple, functional, soft robot. The daily progress of the research topic and design challenge is checked, and the progression of the associated expertise is mapped. Students especially appreciate the positive atmosphere with a focus on a growth-mindset, the teamwork experience, and the opportunity to discuss on an expert level. The message we wish to pass is that our transferrable educational setup generates strong learning dynamics that radiates out to the students and the supporting didactic team.

Innovating Pedagogy, Space and Technology in a South African Engineering Classroom

Darsot, Fatima Mohamed; Simpson, Zach

University of Johannesburg, South Africa

The rapidly changing technological context of higher education has led researchers to reconsider the learning environment – both physical and digital. Current advances in information and communication technologies (ICTs) might enable new learning spaces and support a more effective pedagogy. Furthermore, engineering should undergo change in order to achieve sustainable development and, as a result, teaching and learning should change. While ICT offers many opportunities, the challenge is to ensure that teaching and learning adapts to and utilizes new techniques and tools in pedagogically meaningful ways. The aim of this study is to discuss how academic learning spaces transform teaching practice, in a sustainable way, by investigating one lecturer's perceptions of a "future-fit" classroom and how such classrooms impact the lecturer's approaches to teaching and learning. "Future-fit" classrooms are technologically advanced and flexible learning spaces in which innovative and multimodal teaching approaches can be implemented. This research focuses on engineering modules in which a blended teaching and learning approach was used, combining ICT-mediated and web-based activities, online learning on the learning management system platform, face-to-face collaborative tasks and teacher-directed instruction. We observed these classes in all their various formats and conducted reflective interviews with the academics involved. The findings revealed three important themes: the design principles of learning spaces must be carefully considered; in order to create rich, engaging learning experiences pedagogical modes/practices must match learning spaces and finally technology can have a transformative impact on teaching and learning in higher education institutions (HEI).

Paper Session 3-09: Engineering Students - Self Development 1

Time: Wednesday, 13/Sept/2023: 11:00am - 12:00pm · Location: EQ-118 Tiered Room
Session Chair: Kevin Gaughan

Engineering Science Students' Self-Regulation: A Baseline

Tuyaerts, Shan; De Laet, Tinne; Van den Broeck, Lynn; Langie, Greet

KU Leuven, Belgium

Today's society is characterized by swift technological advancements. Engineers cannot solely rely on what they learned at university, as new technologies pop up quickly. They need to participate in lifelong learning (LLL) in order to keep up with the state-of-the-art. Self-regulation is a core competency for lifelong learning that can be used as a proxy for it in an educational context. This study aims to establish a baseline for engineering students' self-regulation. Their levels are measured by the Self-Reflection and Insight Scale (SRIS), consisting of three subscales: need for self-reflection, engagement in self-reflection, and insight. 1128 students enrolled at [UNIVERSITY]'s Faculty of Engineering Science (response rate = 36.6%) completed the SRIS. Mean scores are compared across study phases by use of Kruskal-Wallis and post-hoc Wilcoxon tests. Effect sizes are interpreted using Cohen's d. Students' engagement in reflection does not differ significantly across cohorts, but some significant differences are found in terms of need for reflection, insight, and self-regulation as a whole. The engineers' results are compared to other SRIS measurements reported on in the literature. Our study shows differing scores between males and females, which contrasts other studies' findings. Over the next three years, the SRIS will be administered to the same cohorts to determine whether a natural growth exists. These results will be supplemented with qualitative methods to gauge the effectiveness of future interventions.

The 'Engineering First Year': "Step Up" to Success

Knowles, Nicola; Andrews, Jane; Cooke, Gill; Schrock, Lauren; Clark, Robin; Knowles, Graeme

University of Warwick, United Kingdom

The nuanced nature of engineering as a profession is highlighted in a recent statement by the EPC (2023) in response to the UCAS publication 'The Future of Undergraduate Admissions' (2023). Focusing on the value of Personal Statements within the University Selection System, the EPC asks UCAS to provide more practical information to prospective students about the nature of engineering and what prerequisite qualifications are needed to study engineering. Such clarity is particularly important when considering Engineering Degree Apprentices.

Starting with the research question "How can the gap between school and university be bridged in engineering education?" the paper critically discusses a project currently being undertaken by a multi-disciplinary team of colleagues working together to enhance the student experience.

Located in one of the UK's largest Engineering Education Departments, the "Step Up" Project analyses the barriers and drivers to engineering education faced by first-year Degree Apprenticeship students from three distinctive engineering and computing science disciplines. This paper represents a small part of a much larger project where the student experience is being prioritised and high-quality learning and teaching is expected. The paper is built upon the emergent findings of a three focus groups with engineering degree apprentices. Whilst the findings are relevant to all years of study, the recommendations and conclusion highlight the importance of 'getting the first year right' and empowering students to 'step up to success' in university and in work. This evidences a demand for clearer explanations of the knowledge and skills expected of incoming students

Assessing Engineering Students Preparedness for Lifelong Learning and Self-Reflection Competency

Dujardin, Rani; Van Den Broeck, Lynn; Langie, Greet

KU Leuven, Belgium

With the continuous technical and social developments, lifelong learning (LLL) is becoming increasingly important in the engineering setting. Higher education institutions (HEIs) are responsible, not only for the transfer of engineering-specific knowledge, but also for preparing engineering students for lifelong learning. To do so, HEIs need a clear view of the extent to which engineering students have the necessary LLL competencies.

Research suggests two approaches in the assessment of LLL, namely (1) a holistic approach measuring a general preparedness for LLL and (2) a specific approach measuring a specific subcompetency of LLL. The current study combines both approaches by using the Kirby's LLL questionnaire and the Grant's Self-Reflection and Insight Scale (SRIS). Self-reflection is a core competency of LLL, necessary to reach learning goals.

The first objective of the current study is to evaluate the relation between LLL and self-reflection. The two-factor structure of the self-reflection measurement is replicated and both factors correlate positively with the LLL measurement. This result further supports the suggested relationship between the two concepts. The second objective is to outline the preparedness of engineering students for lifelong learning which is achieved with an in-depth analysis of both measurements. Early engineering students already have a relatively high preparedness for LLL, but with considerable room for growth, resulting in a challenge for engineering educators and HEIs.

The immersive placement experience: sink or swim?

Shaikh, Mohammed; Alaswad, Abed; Junaid, Sarah

Aston University, United Kingdom

To excel in their respective engineering fields, engineering students need to be equipped with a combination of technical and interpersonal skills. Central to excellent interpersonal skills is good communication. The aim of the study is to evaluate how well-prepared mechanical and design engineering students felt entering into their industrial placements, using a UK university as a pilot case study. For the study interviews were carried out with final year students who had previously completed an industrial placement year, focussing on communication, workplace diversity, technical working methods and university teaching styles. Responses were anonymised, coded and analysed using quantitative and qualitative methods. Nine engineering students were interviewed regarding their placement experience and were asked to rate how well they thought their engineering programmes helped in developing these skills. Two key findings were: 1) students on average spent 60 % or more of their placement work using their communication skills and 2) students felt more could be done to prepare them for individual presentations and individual projects before placement. On average the students felt marginally more prepared with the interpersonal skills element compared to the technical skills element. The survey also highlighted that the students' understanding of what falls under the umbrella of workplace diversity was narrow, and they did not classify skill differences as a component of diversity. The student's honest feedback allowed a collation of proposed recommendations for both the mechanical and design engineering courses.

Poster Session

Time: Wednesday, 13/Sept/2023: 12:00pm - 2:00pm · Location: EQ-212a-d (All)

A possible solution to avoid the consequences of the COVID-19 pandemic and reduce dropout in calculus education

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The effects of COVID-19 are likely to stay in education for a long time to come. First-year students of 2022 have completed the last two years of their high school education, which are the most important for further studies, during the worst period of the pandemic. Compared to previous years, far fewer students could meet the requirements of Calculus 1. Although there was a wide range of support material (interactive online interface, films, notes, elaborate calculation exercises) available to the students, they were not able to catch up and progress independently, regardless.

The calculus course consists of 2x90 minutes of lectures and 90 minutes of weekly practice. The lectures are attended by all the students in the year's batch - nearly 200 students - while the exercises are done in groups of 35. In the second semester, we introduced a new course for Calculus 2. The 90-minute-per-week course provides an opportunity to introduce routine calculation methods and thus provide more personalised teaching in small group sessions. The new course gives a chance to understand Calculus 2 and thus could reduce the dropout rate.

In our research, we investigate the effectiveness of this new intervention. We analyse student satisfaction. We will examine the extent to which such a cost-effective intervention helps students to acquire a solid mathematical foundation so that they can successfully overcome obstacles in their studies with less help in the future.

How does involvement in student associations contribute to the development of an engineer's skills? Example of Magiepoly: raising awareness of gender equality through games.

Lamy, Vinciane; El Addouli, Sarah; Zitzmann, Cathel

EPF Ecole d'ingénieurs, Campus de Montpellier, France

Some engineering students get involved in student associations during their studies. They develop multiple skills such as: leadership and management, communication, project management, supervision and transmission of knowledge, service to others, etc. However, they are not always aware of it.

Helphi, a student association of EPF Engineering School, was responsible for organising an afterwork event to be held on International Women's Rights Day. As student members were brainstorming, the idea of a board game, both informative and entertaining came up: MagiePoly was born. MagiePoly is a game, inspired by a well-known board game, which aims to raise awareness of gender inequalities.

During their studies, engineering students have access to an eportfolio, but they do not always have the habit of using it to identify how they develop their skills, what they need to improve or how their career plans could evolve. Students also attend an introductory course on the research process. It is within the framework of this course that students co-write with their teacher an article on the acquisition of engineering skills through involvement in student associations.

This article describes how the creation of MagiePoly has contributed to the engineering students' skills and how the realisation of a project have been key to the motivation, commitment and success of these students.

Curriculum Workshops as a Method of Interdisciplinary Curriculum Development: A Case Study for Artificial Intelligence in Engineering

Schleiss, Johannes; Manukjan, Anke; Bieber, Michelle Ines; Pohlenz, Philipp; Stober, Sebastian

Otto von Guericke University Magdeburg, Germany

The integration of tools and methods of Artificial Intelligence (AI) into the engineering domain has become increasingly important, and with it comes a shift in required competencies. As a result, engineering education should now incorporate AI competencies into its courses and curricula. While interdisciplinary education at a subject level has already been explored, the development of interdisciplinary curricula often presents a challenge. This paper investigates the use of the curriculum workshop method for developing interdisciplinary, competence-oriented curricula. Using a case study of a newly developed interdisciplinary Bachelor program for AI in Engineering, the study evaluates the instrument of the curriculum workshop. The communicative methods of the tool and various aspects of its implementation through self-evaluation procedures and surveys of workshop participants are discussed. The results show that the structure and competence orientation of the method facilitate alignment among participants from different disciplinary backgrounds. However, it is also important to consolidate the mutually developed broad ideas for the curriculum design into concrete outcomes, such as a competence profile. Interdisciplinary curriculum development needs to take into account different perspectives and demands towards the curriculum which increases complexity and requires a more structured design process. The findings of the paper highlight the importance of interdisciplinary curriculum design in engineering education and provide practical insights in the application of tools for the creation of competence-oriented curricula in curriculum workshops, thereby contributing to the development of future engineers.

Should teaching guides be used as indicators of gender dimension in a university degree?

Mas de les Valls, Elisabet; Peña, Marta; Olmedo-Torre, Noelia; Lusa, Amaia

Universitat Politècnica de Catalunya · BarcelonaTech, Spain

In order to achieve a real equality society, universities are doing a significant effort towards gender mainstreaming. One of the main pillars of this mainstreaming is the introduction of gender dimension in teaching. To assess the degree of achievement of such a goal, suitable indicators, both qualitative and quantitative, are desirable. At this point is where teaching guides seem to play a key role. Teaching guides are here understood as those open access documents where the public can find the subject's description, goals and contents, among other university-specific features. However, it is still unknown if the systematic analysis of these teaching guides can lead to realistic results.

In the present study, the detailed analysis of 16 subjects belonging to different areas of knowledge of a Spanish university is carried out. The analysis was conducted during a 5-week training with the aim of transforming the teaching guides by introducing the gender dimension. As a result, a systematic quantitative analysis is successfully proposed. However, some requirements need to be fulfilled.

The present study might help academic gender policy design bodies to define strategies towards monitoring and promoting gender dimension in teaching.

Bachelor's thesis seminar in computer sciences and information technology

Haavisto, Matti; Järvinen, Hannu-Matti; Kilamo, Terhi; Ovaska, Salla; Poranen, Timo
Tampere University, Finland

A Bachelor's thesis is typically an individually written literature review on a scientifically relevant topic. Additionally, some theses also describe empirical work or report an experiment. Firstly, we introduce how Bachelor's theses are supervised in a joint thesis seminar for Computer Sciences and Information Technology at our university. The thesis seminar is organized three times a year. It consists of six small group meetings led by a supervisor and contains compulsory pre- and post-assignments and active peer discussions. In 2022, there were in total of 187 students participating in the spring, summer and autumn seminars. Secondly, we give an overview of the 98 completed theses. We classify the theses using ACM's Computing Classification System and analyze keywords, the number of references and some other bibliometrics to learn about the students and the potential effects of their different study orientations. We also analyze 14 theses that reported practical work, like the implementation of an algorithm or using existing software tools. The main result of our work is to give a research-based view on the supervision of Bachelor's theses, the organisation of the thesis seminar, and the bibliometrics of the completed thesis.

Revolutionising Engineering Education: Creating Photorealistic Virtual Human Lecturers Using Artificial Intelligence and Computer Generated Images

Moolman, Johannes H; Boyle, Fiona; Walsh, Joseph
Munster Technological University, Kerry, Ireland

The COVID-19 pandemic has disrupted traditional classroom learning, making virtual and remote education increasingly important. In this context, the use of photo-realistic virtual humans, or avatars, powered by Artificial Intelligence (AI) can offer an immersive and engaging environment for delivering traditional classroom-based lectures. This paper proposes a process that combines AI and Computer Generated Images (CGI) to create photorealistic virtual human lecturers for educational purposes.

The proposed process flow involves generating audio from text inputs, which is passed to a 3-Dimensional (3D) facial animation rig that matches lip, tongue, eye, and facial movements to the audio using AI. This generates a base mesh for speech animation which is refined using morph targets and blend shapes, resulting in a highly realistic facial animation. Game engines and photogrammetry generate a photo-realistic human avatar, to which the base mesh is mapped to generate a photorealistic animated avatar.

Virtual humans offer several advantages over real persons, including the ability to customise their appearance, voice, accent, language, location, mannerisms, etc., making them an ideal solution for global education.

The process flow will describe the methods, analysis, and interpretations for using AI to generate natural photo-realistic avatars and the potential contributions to the advancements in engineering education.

In conclusion, virtual humans can potentially revolutionise how education is delivered in a post-COVID world. By combining AI and CGI, photorealistic virtual human avatars can be created that are highly engaging, customisable, and accessible to students all over the world.

Comparing XR and digital flipped methods to meet learning objectives

Bangert, Kryst; Browncross, Edward; Di Benedetti, Matteo; Day, Harry; Garrard, Andrew
The University of Sheffield, United Kingdom

Digital learning has become increasingly important over the last decade as students and educators adopt new types of technology to keep up with emerging trends. In this study we compare different digital learning simulations to see which has the most beneficial effect on practical student laboratory experiences. Multiple cohorts of engineering students were divided into groups that have exposure to different forms of digital pre-lab simulated laboratory experiences. The groups were then assessed on how their academic performance varies in the actual physical laboratory itself.

The digital experiences took the form of a 2D photography based "iLabs" simulation, a web based "low fidelity" simulator and an Unity immersive Virtual Reality (iVR) lab simulator. All three of the different simulation methods were based on the same empirically derived data, that was taken from the physical laboratory equipment that the students used in the final part of the study. As a control, another group of students did not receive a pre-lab simulation, but a pre-lab quiz that is typically used as the standard departmental teaching approach.

This study builds upon existing work carried out in the field of virtual labs, that indicate these experiences can help reinforce student learning outcomes, whilst also unpicking the complex relationship between simulation immersion, fidelity and memory recall in a learning context. In addition, the study will give an opportunity to perform a detailed cost versus pedagogical impact assessment, as each of these simulations has been designed and built from the ground up in the department.

Empowering students with Geospatial solutions through Challenge Based Learning

Dadrass Javan, Farzaneh¹; Nex, Francesco¹; Samadzadegan, Farhad²; Alsadik, Bashar¹; Buuk, Luuk¹; Askari, Omid³
¹University of Twente, Netherlands, The; ²University of Tehran; ³plant protection organization of Iran

Today, the field of Geospatial Solutions primarily focuses on spatial and mapping data, analysis, and technologies that primarily revolve around place and space. It is considered more as a tool or means rather than the ultimate objective of various interdisciplinary activities, where minimal attention is given to theoretical aspects, equations, and underlying principles of the subject. Conversely, despite advancements in science and technology and a broader audience for geospatial subjects, it is predominantly taught conventionally, disregarding the diverse needs and expectations of students. In recent years, there has been an exploration of innovative educational methods to utilize new pedagogical frameworks and enhance academic performance among students.

The present study aims to develop a framework and provide guidelines for the integration of Challenge Based Learning into Geomatics education. This framework consists of three interconnected phases: engage, investigate, and act. Subsequently, an educational pilot program is created and implemented to apply the designed framework to key topics such as food security and cultural heritage. Finally, the project refines the educational framework based on real pilot attempts and evaluation results, identifying potential issues and making necessary adjustments. The designed framework and the attained results are made publicly available for reference and utilization.

Exploring the potential for scripting with simulation in engineering education – practical examples using Python and Ansys

Cooke, Susannah; Derrick, James; Coleman, Susan
Ansys, Inc

The ability to use scripting tools to harness the power of complex engineering software is not only critical for research and industry, but also offers opportunities for student learning and development. This paper covers two ways in which undergraduate engineering students have been exposed to Python Ansys simulation tools to be controlled from Python programs.

A pilot series of 'CodeFests' have been held in partnership with university engineering departments, offering a fun way for students to engage with Python coding while exploring the power of scripting to optimise or iterate on solutions. These have used the PyMAPDL structural simulation library, leveraging students' existing understanding of mechanical engineering problems to provide a 'way in'. Students tackled simple mechanical challenges, but with a twist – such as an optimisation requirement which would be beyond manual ability to solve in the time available.

In parallel, the potential for scripting tools to provide 'lab in a box' type experiences harnessing the most powerful simulation tools has been investigated. A basic prototype to replicate a Fluids lab exercise involving a cylinder in a wind tunnel was created inside a Jupyter Notebook running Ansys Fluent through the PyFluent library. This provided a simple, customizable way for students to interact with a 'lab' powered by simulation, without needing to teach them the Ansys Fluent interface and controls first.

Both these projects show the potential for harnessing simulation power further in engineering education through scripting methods, to engage and empower the engineers of tomorrow.

Engineering solutions for a more inclusive society: a case study with Europe-wide challenge-based learning

Osterhus, Lennart; Bulmann, Ulrike; Schneider, Viktoria Constanze; Furlan, Kaline
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Engineering practices directly impact our society and yet, traditional engineering courses often present a lack of emphasis on social and sustainable responsibility. Therefore, a course was designed to increase societal awareness and promote social-conscious engineering practices, and also interdisciplinary and intercultural collaboration. The course followed the concept of challenge-based learning (CBL) and was offered within the framework of the European Consortium of Innovative Universities (ECIU). In such framework, students from 13 European partner universities could join, as well as professionals and citizens as so-called continuous learners. The challenge addressed the issue of an increasingly aging European society and the physical hurdles brought by aging. In cooperation with a local senior citizens' residence, the participants of the challenge identified everyday challenges in dialogue with senior citizens, and jointly developed 3D printed solutions for such. The article deals with the conception and the accompanying reflection throughout the project. Students were asked how they evaluated the CBL course and how they reflected on the development of their social awareness. Based on the "mixed-method" approach, data were collected, analysed and evaluated with questionnaires (pre- and final survey) and student reflection questionnaires at milestones meetings. This paper emphasizes on students' experiences, obstacles and teachers' solutions in the first CBL phase called Engage.

Feature Model Construction of Learning Factories Based on Authentic Learning Theory: A Case Study of the School of Micro-Nano Electronics at Zhejiang University

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The learning factory is an educational environment that simulates real-world production systems to bridge the gap between theoretical knowledge gained from academic settings and practical skills required by businesses. To improve the construction of learning factories at the early stage, a case study of the School of Micro-Nano Electronics at Zhejiang University has been conducted. First, an analysis framework based on authentic learning theory was developed to determine the critical elements of a learning factory based on four dimensions, including context authenticity, task authenticity, individual authenticity, and impact authenticity. Second, taking the School of Micro-Nano Electronics at Zhejiang University as the research object, qualitative analysis is utilized to further identify the essential elements of the construction model of learning factories. Additionally, an overemphasis on physical settings and a lack of industrial involvement have been identified. It suggests that it is essential to focus on effective industry engagement and strike a balance between the construction of the physical environment and the learning process. The findings provide construction insights for learning factories in their early stages of development.

SURVEYING POST-LEAVING CERTIFICATE STUDENTS TO INVESTIGATE THEIR LEVEL OF MATHEMATICAL PREPAREDNESS FOR PROGRESSION TO HIGHER EDUCATION STEM COURSES: A PILOT PROCESS

McHugh, John; Carr, Michael; Faulkner, Fiona
Technological University Dublin, Ireland

A student's level of mathematics as they begin degree courses in STEM disciplines has been recognised as a key indicator of their success. While much research has taken place into secondary school mathematics teaching, a comparatively under-researched area has been that of Further Education, which supplies a smaller proportion of degree courses' student intake. The vast majority of Further Education students seeking progression opportunities to such courses study one of three mathematics modules: 'Mathematics 5N1833', 'Maths for IT 5N18396', or 'Maths for STEM 5N0556'.

As part of the author's PhD research project on the mathematical preparedness of students at FE level hoping to progress to a STEM degree course, it is envisaged that a survey of FE students be collected at the end of the 2023/24 academic year as one part of a broader, mixed-methods approach. In the interim, a pilot survey using a convenience sampling method was distributed and collected in April 2023 and is the focus of this paper. 57 responses were collected as part of this pilot process, indicating significant differences between the three module groups.

Engaging Students Through Innovation in Computer Science Education

Klonowska, Kamilla; Teljega, Marijana; Frisk, Fredrik

Kristianstad University, Sweden

This contribution addresses how the innovation activities have been implemented in two bachelor programmes in computer science at Kristianstad University in Sweden. The goal of the innovation activities is to equip students with essential skills and abilities like developing technical and analytical skills, communication, collaboration, problem-solving, critical thinking, and creativity to prepare them in their professional role, to actively contribute to their workplace and work to identify and find innovative solutions to societal challenges.

To achieve this goal, the programmes provide project-based learning to enhance the learning experience for students and, additionally, include the events like Imagine or Hackathon, where students work in teams to develop innovative solutions to complex problems. Imagine event provides an opportunity for students to showcase their skills and creativity and receive feedback from experts in the field. It is offered at Kristianstad University several times a year with different focus areas linked to the University's profile area of environment, health and water, which for computer science students give a chance to work interdisciplinary. Hackathon event is provided by older students and the goal is to challenge and encourage younger students in programming.

By providing students with practical experiences and exposure to modern technologies and teaching methodologies, the programme prepares them to navigate the ever-changing demands of the workforce. The incorporation of team-based learning and events enhances students' collaboration and creativity, providing them with the skills (effective communication, leadership, project management) they need to succeed in the modern workplace.

Engineering education evolution

Szpytko, Janusz

AGH University of Krakow, Poland

Over the years, human needs have been subject to evolution, which translated into economic development and was the result of research, development of knowledge and technology, lifelong learning and the development of skills combined with engineering competences. The paper attempts to analyze the evolution of education with a focus on engineering in the context of the development of technology over the years in conjunction with the significant achievements of technology and engineering craftsmanship. As a result, conclusions were formulated regarding the challenges in the areas of new techniques and engineering solutions that fit into the activities aimed at sustainable development and building a friendly environment for education in the field of technology.

Towards perceiving teaching as a joint task in an individualized teaching qualification program for mid-level academics at a German university of technology

Bulmann, Ulrike¹; Podleschny, Nicole²

¹Hamburg University of Technology, Germany; ²HafenCity University Hamburg, Germany

Empowering teachers for facilitating modern engineering education is essential. Thus, universities put much effort in qualifying teachers in didactical training programs. Especially individualized programs have been positively evaluated in the Covid-19-year 2020. However, participants missed (informal) networking opportunities. Two questions arise: How do participants perceive their qualification program in the following years. And, how can we design a program that balances the participants' thirst for individual program compilation while establishing university-wide networking opportunities among teachers. This paper presents participants' perceptions on a qualification program of a German University of Technology in the years 2021, 2022 and a revised program design. After four groups completed their program, data was gathered through online questionnaires and descriptive analyses (45 responses of 106 participants). Also, four semi-structured interviews were conducted and content analysis was used as interpretation method. Results show that this qualification program is positively perceived in terms of acceptance, learning, behavior and program characteristics. Participants define their training group as trustful, but only a part of them feel to share responsibility for teaching. Their personal teaching networks consists foremost of staff by the same institute and status group. Also, they appreciate that professors support their attendance in the program. Interestingly, they encourage to tackle teaching challenges within the wider university community. Thus, a topic-wise open program allowing both individual pathways as well as informal, cross-disciplinary options for dialogue is illustrated. Hence, qualification programs should be designed to address the challenges of contemporary higher education as a teaching community rather than as individual.

Comparing Engineering Students Perceptions of Online and Traditional Face to Face Environments During a Problem and Project Based Learning (PBL) Module

O'Connor, Sean; Power, Jason Richard; Blom, Nicolaas; Tanner, David A; Stack Mulvihill, Eamonn

University of Limerick, Ireland

Research examining the future of engineering education has highlighted forthcoming challenges for engineering institutions, such as increasing cohort sizes, limited budgets and a demand for the delivery of flexible, diverse and student-centred curricula. To this end, scholars have suggested the use of problem and project based learning (PBL) methodologies that can be implemented within hybrid learning environments. This paper examines and compares students' perceptions of a PBL module that was delivered by means of online and traditional face-to-face environments. The goal of this paper is to highlight the students' voice over other stakeholders to provide valuable insights into their preferences of current pedagogical practices. This in turn can provide information to improve teaching and learning in hybrid learning environments. This study was carried out with two student cohorts of first year engineering students. One of the cohorts completed the module in 2021 (N=94) in an online environment and the second in 2022 (N=89) in a traditional face-to-face environment. This paper focus on analysing the 2022 cohort and comparing the results against the findings presented at SEFI 2022 in Barcelona for the 2021 cohort. The findings revealed areas of significance for educators conducting PBL within online and hybrid environments. This includes the role of communication, module planning, dealing with conflict, and flexibility in learning.

Why and how do students need to have their mental health considered in engineering schools?

Bayle, Shirley; Bocahut, Manon; Champeau, Loïc; Muneaux, Alya; Zitzmann, Cathel

EPF Ecole d'ingénieurs, France

This paper addresses the students' mental health in higher education and more specifically in engineering schools. Several studies have shown student mental health and wellbeing can affect students' academic performance. We investigate how student's mental health is considered in engineering schools as well as how it should be and study the case of our engineering school.

First, we present several research and studies conducted on how mental health is considered in higher education and its impact on academic performance.

In the second part, we study the case of our engineering school with the implementation of a survey among students and teachers to collect their feedback. We add to this survey a collection of testimonies from students. We will analyse how mental health is considered and the impact of addressing mental health on student success in an engineering school.

Finally, we present possible solutions to improve the consideration of mental health. These solutions are aimed at administrations, teaching staff and engineering school students. Indeed, the consideration of mental health must be global and concern the entire educational organisation.

The conceptual understanding of basic electricity concepts by junior engineering students: an update

O'Dwyer, Aidan

Technological University Dublin, Ireland

The paper reports, analyses and reflects on the results of a multiple-choice diagnostic test to assess student understanding of basic electricity concepts (developed for U.S. high school and college students [1]) taken by nine cohorts of first year engineering students (n=1286) at the authors university, from 2014 to date. The diagnostic test was taken prior to instruction by all student cohorts, and post-instruction by some student cohorts. This paper updates a previous contribution by the author which described the application of the test to seven cohorts of junior engineering students (n=203) from 2008 to 2013. The manner in which this work has influenced instructional methods is outlined.

Screw Loose Toolbox

Schaefer, Anton

TU Berlin, Germany

Blue Engineering is a student-driven course on the environmental and social responsibility of engineers. It has been developed by student initiatives at two German universities since 2010. By 2023, there are more than 15 courses at German universities and in the Netherlands using the open source course design.

In assessing the learning outcomes of the participants, the need to promote the skill of transfer of learning of the students became clear. This practice paper presents the current approach: 24 metaphorical tools have been developed, each of which functions like a special lens, allowing to recognise certain patterns of action, discussion and collective decision-making that can be identified in many fields.

The *tools* are intended to point out shortcomings in our familiar environment and to offer starting points for the search for possible alternative ways of negotiating, with the normative goal of strengthening democratic process to balance interests.

This paper gives an overview of the competences addressed by the course, defines "transfer of learning" for the research, presents the developed tools and describes their current use in teaching and beyond.

Findings show that the Screw Loose Toolbox can successfully be used to promote student discussion and reflection. As there are no generally agreed methods to measure transfer of learning and no quantitative results have been obtained.

The effect of Campus Praktikum on the choice of university studies

Gimenez-Carbo, Ester; Collado López, M.Francisca; Torralba Navarro, M.Asunción; Gómez-Martín, M. Esther

Universitat Politècnica de València, Spain

In some Spanish universities in recent years, there has been a decrease in the number of students, mainly due to the drop in the birth rate and the increase in the number of universities throughout the country. In addition, the number of (unknown)bachelor's degrees that can be studied at university has also increased.

For these reasons, since 2010, an activity called Campus Praktikum has been carried out at the Universitat Politècnica de València to bring the university studies taught at this centre closer to secondary school students. The aim is to show the studies taught at the UPV (mainly engineering studies), to find out about the professions linked to these studies and to be able to have testimonials from university students who are currently studying. During one week, secondary school students take part in workshops related to university studies, which give them an in-depth understanding of the content of their studies and university life.

The main objective is to increase the number of students in general and, above all, to increase the number of women who choose the UPV for their university studies.

The paper describes what the activities of the Campus Praktikum consist of and compares the opinions obtained through surveys of students who enjoyed the activity right after finishing the campus and the information obtained from the student's registration at the university.

With all this information conclusion will be drawn, analysing the actual effect of this type of activity on the student's choice of university studies.

Developing a Flexible Materials Testing Curriculum for Future Engineers

Pfennig, Anja

HTW Berlin University of Applied Sciences, Germany

Engineering students as future maker of things will face the challenge of keeping pace with rapidly evolving technologies and staying up-to-date with the latest innovations in their field. To cope with these demands a flexible course concept is developed for an undergraduate Materials Science lab course: Materials Testing at HTW Berlin based on a blended learning teaching concept implementing inverted classroom lecture scenarios. High quality micro modules are defined that may individually be combined or restructured and therefore offer sufficient flexibility to match the individual scientific background of the lecturer, the course learning outcome, main study subject or actual need based on recent developments. The Moodle course offers different teaching materials, such as micro-lectures, guided questionnaires, lecture and lightboard videos, H5P-activities, etc. Lecturers will find detailed information on the course concept but independently decide on the main aspect of their individual teaching and are therefore granted time for various activating methods in class. With providing well-arranged individual work packages the pressure especially for lecturers from industry -who are teaching on their full time jobs- is relieved and they have more time to interact with students involving them in future common engineering challenges.

Are e-Assessments the Future of Assessments for Engineering Students?

Akhtar, Zohaib; Perea Borobio, Esther

Imperial College London, United Kingdom

Replacing traditional examinations with electronic assessments (e-assessments), also known as digital assessments, is gaining more popularity. However, it has become controversial as people have raised serious concerns about the limitations of these e-assessments, especially when the assessments have high stakes, like the end-of-term examinations. In this paper, we have evaluated whether e-assessments will replace the traditional end-of-term exams for engineering students in the future. Although this topic is equally valid for non-engineering fields, a few factors that make it unique to engineering are discussed. Different aspects of e-assessments are critically compared to paper-based (off-print) examinations based on existing literature and experiences from personal teaching practices to assess the suitability of these assessments. Furthermore, feedback is collected from students who appeared in the e-assessments to form an opinion on the perception of students about e-assessments. Finally, the factors influencing a shift toward e-assessments and the problems that arise from this are discussed to form an opinion about the future of e-assessments for engineering students.

Learn and Work: A Hybrid Educational Model for Engineering Education

Looby, Katherine A.; Deegan, Catherine M.

TU Dublin, Ireland

Traditional models of education are undergoing significant change in recent times due to evolving graduate attributes, shaped in no small part by the changing demands of modern industrial practices. Technology is one of the key elements of the factory of the future. Advances in manufacturing and digital technologies facilitate automation and offer significant benefits in a variety of areas. Academic programmes that feature industrial work placement have long been a feature of engineering education in TU Dublin. The BSc in Process Instrumentation and Automation is a three-year programme that goes further in that it evenly balances on-campus instruction with work placement in each year. The programme was specifically devised in response to industry feedback that had identified significant skills shortages in the areas of industrial instrumentation and automation. It is a hybrid between the apprenticeship model of education and the traditional engineering degree model and directly addresses the industry's immediate need for experienced graduates. Participation in the programme is sponsored by Irish Medtech Skillnet, a learning network for companies in the medical technology and engineering sector that responds to the training needs of the medtech sector. Providing a quality education (SDG 4) and decent work (SDG 8), these graduates are contributing to improving efficiency in manufacturing (SDG 9). This is one step in the lifelong learning path of a modern graduate. This paper will provide a detailed critical review of the Learn and Work model; strengths, challenges and opportunities offered by this mode of engineering education.

Teamwork Satisfaction and Student Attitudes Towards Online Learning During an Engineering Problem and Project Based Learning (PBL) Module

O'Connor, Sean; Power, Jason Richard; Blom, Nicolaas; Tanner, David A; De Brún, Victoria

University of Limerick, Ireland

Research has shown that students that report high levels of learner satisfaction and positive attitudes are more likely to succeed within the online environment. This is reflected in the considerable body of research that focuses on these factors across a range of academic disciplines. By assessing students' attitudes and satisfaction, educators gain a valuable affective perspective that allows for a more complete examination of strategy effectiveness. This paper examines teamwork satisfaction and student attitude towards online learning, while also highlighting elements of successful online collaboration as identified by students using the instruments developed by Hasler-Waters & Napier, Ku et al, and Tseng et al. This case study was carried out over a seven-week period with first-year engineering students (N=94), in a module entitled *Design for Manufacture*, during the COVID-19 pandemic. The findings revealed high levels of student satisfaction and attitudes towards working in teams in the online environment while participating in problem and project-based learning (PBL). Additionally, the findings outline multiple factors that affect the success of online collaboration. The relevance of these findings is then discussed in the context of an increasing move towards blended and online engineering education provision.

Designing a Curriculum for a Sustainable Entrepreneurship Major: a Case Study

Kuikka, Meri

Aalto University, Finland

This practice paper explores the process of developing a curriculum for a sustainable entrepreneurship major program in a higher education institution. The paper aims to address the need for embedding sustainability and entrepreneurship into higher education, considering global challenges such as climate change, social inequality, and unsustainable consumption and production. The paper fills a gap in the existing body of knowledge by providing a case example of a curriculum development process that can be adapted to integrate sustainable entrepreneurship into curricula at other universities.

The paper outlines a three-part curriculum development process which involves identifying stakeholders and clarifying the program's purpose, determining program-level learning outcomes, and developing courses that align with the program's purpose and intended learning outcomes. The paper's findings emphasize the importance of involving stakeholders (such as faculty members, potential students, alumni, industry professionals and decision-making bodies within the university) in curriculum design. The paper concludes with a discussion on the iterative nature of identifying program-level learning outcomes, the challenges of balancing dual themes from a rapidly changing field of study in the curriculum, and academic resource limitations. A well-designed sustainable entrepreneurship major can benefit students, faculty, business and industry, and society at large by providing the knowledge, skills, and opportunities necessary for socially and environmentally responsible entrepreneurship.

First steps towards gamification of online physics and mathematics assignments

Immonen, Paula; Ratava, Juh; Naukarinen, Johanna K; Sadiqa, Ayesha; Paatero, Jukka V; Kuosa, Markku; Mankonen, Aleks; Bhayo, Barkat; Äijälä, Mikko

LUT University

The objective of this practice paper is to describe and analyse the use of online learning tasks on engineering mathematics and physics courses. The development of learning tasks was inspired by the promising effects of gamification techniques in higher education. Hence, some gamification elements, such as bonus points and immediate feedback were integrated into the learning tasks. Course results and student feedback demonstrate the positive impact of gamification of online learning tasks on students' motivation and learning. In the end, further possibilities of increasing the number and repertoire of gamification techniques in engineering mathematics and physics courses are discussed.

Supporting teaching staff: A Phenomenological study of the innovation readiness of teacher support staff

Chapel, Leonie; Imanbayeva, Adina; Petrova, Nikola; Borst, Sonja

University of Twente, Netherlands, The

Educational institutions that want to successfully innovate the education they provide must synchronise organisational growth with educational growth. A maturity model can be useful for supporting innovation in education by providing an instrument for identifying successful teaching and learning practices by encouraging experimentation, collaboration, and alignment with strategic goals. Maturity models Although maturity models that can support staff in the process of innovating education are valuable, they are scarce. This phenomenological study explored the views of the Centre for Expertise in Learning and Teaching (CELT) staff on the readiness for innovation of the University of Twente (UT). We conducted a survey at UT that targeted staff members who were actively involved in projects or teacher initiatives aimed at innovating education. The questionnaire consisted of 137 closed-ended multiple-choice questions (e.g. 'Is teaching support guided by the latest research findings?') with answers on a five-point scale ('not', 'partly', 'largely', 'fully' and 'I don't know'). The structure of the survey was based on the structure of the maturity model. The questions were divided into five themes: learning (processes that directly impact pedagogy), development (processes related to the creation and maintenance of resources), support (processes related to support and operational management), evaluation (processes related to evaluation and quality control through its entire lifecycle) and organisation (processes related to institutional planning and management). In this paper, we present the results of identifying the innovation readiness of the educational support staff at UT and discuss how these results might influence the impact of teachers' innovative practices.

DC Grid Power Congestion Management Laboratory Experiments

Engelbrecht, Holly; Zuidervliet, Diego; van Duijsen, Peter

The Hague University of Applied Sciences, The Netherlands

In the process of the electrical energy transition, a new curriculum for bachelor electrical engineering is developed. A new development is DC grids, as they are shown to be promising in solving the power congestion management problem. Particularly when adding solar power, battery storage, and load appliances including power electronics, DC grids are replacing AC grids, especially in micro-grids.

The development of new laboratory experiments using three educational methods is described in this paper. First, theory combined with online calculation tools is used to prepare the students for the subject. Second, the experiment has to be prepared using simulation tools, and third, the experiment is conducted using a hardware trainer, specially developed for DC grid education.

The purpose of laboratory experiments is to learn how power congestion management is regulated in a DC grid. For this, students have access to a Grid Manager, with a current control add-on. This so-called Droop Controller enables the control of a bidirectional current flow.

There are four learning objectives.

1-Control voltage level, 2-Control current level, 3-Regulate output power from a Grid Manager, 4-Regulate bidirectional power flow using emulated appliances. These learning objectives are spread over four weeks.

Students will learn how to control the voltage in a DC grid in week 1. In the second lecture, they will use a current controller and notice a difference in controlling the output power while maintaining a stable output voltage. In Lectures 3 and 4, the grid manager and droop control with bidirectional power flow is explored.

SEARCHING FOR YOUNG TALENT: UNDERSTANDING INDUSTRIAL RECRUITMENT PRACTICES FOR HIRING ENGINEERING DEGREE APPRENTICESHIP STUDENTS

Kövesi, Klara; Gillet, Christiane; Krien, Nathalie

ENSTA Bretagne, France

This study aims to investigate industrial companies' recruitment practices and standards for hiring their engineering degree apprentices. We examine (1) how they find their future engineering degree apprentices, (2) their recruitment standards and (3) to what extent organisational characteristics shape their recruitment decisions.

To answer these questions we have carried out an online quantitative study, comprising exclusively closed questions, with the participation of workplace mentors of engineering apprenticeship students (n=70). Subsequently, we have conducted a descriptive statistical data analyse on SPSS.

Our results indicate that industrial companies find their engineering apprentices by means of students' speculative applications or via engineering schools which have already conducted their academic recruitment process. Surprisingly, technical knowledge or transversal competences have a limited influence on their recruitment decisions, but students' motivation and personal attitudes (e.g.: personal engagement, perseverance, adaptability) have a very marked, nearly decisive influence on their hiring choices. In addition, we have identified some slight differences between large international and domestic industrial companies' and SME's recruitment decisions.

Based on our results, we highlight the importance of collaboration between industrial companies and engineering schools in order to develop a more inclusive engineering apprenticeship recruitment process.

Nurturing community: Using Community-based service learning in biopharmaceutical engineering education.

Jiménez-Pérez, Miriam I¹; Perfecto-Avalos., Yocanxóchitl²; Orellana- Haro, Mariana C¹

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This project evaluates the use of CBSL as a strategy for teaching clinical investigation in the development of biopharmaceutical products based on the nutritional needs of children of a low-income community. To achieve this purpose, our students formulated various functional foods that provided the necessary nutrients for the children in the target community. Afterwards, they drafted the corresponding clinical protocols for each formulation, considering possible ethical implications. The academic evaluation was based on the comparison of courses with and without CBSL. The study found that students showed a slight improvement in academic performance with CBSL. This suggests that CBSL can promote academic excellence while fostering engagement with the local community. Pre- and post-course surveys were used to measure the impact of community work on students and its impact on social commitment. The results showed that students had a greater social commitment to the community after completing the service-based learning activity. This finding suggests that CBSL can play an important role in developing social awareness and responsibility in students. In conclusion, this study supports the use of CBSL as a strategy to promote academic excellence while fostering social engagement and responsibility. CBSL empowers students to make a significant contribution to the local community while also enabling them to learn through practical experience. By incorporating CBSL into the curriculum, students develop a greater sense of social responsibility, which can benefit both their academic and personal lives.

Effects of Gaze Distribution on Woodworking Knowledge and Skills

Usuzaka, Takashi¹; Mochizuki, Yujin²; Shoji, Hiroaki¹

¹Ibaraki University, Japan; ²Houenji temple, Japan

This study investigates the gaze distribution of learners who watched a video about making a screw joint (a woodworking process) and explores its relationship with knowledge comprehension and skill acquisition levels. Twenty university students who had never taken a specialized class on screw joints participated in the study. They watched approximately a three-minute video on making a screw joint and completed knowledge comprehension and skill acquisition surveys based on the video content. Gaze measurements were conducted using Tobii T120, a screen-based eye-tracking device manufactured by Tobii Technology. In the line-of-sight distribution analysis, the objects appearing in the video were categorized into four areas of interest (AOI): human faces, processed areas, subtitles, and tools. Further, the viewing rates for each AOI were calculated. The rates were ranked in descending order: processed areas, human faces, subtitles, and tools. Correlation analysis showed no significant correlation between knowledge comprehension and AOI. However, significant correlations were found between skill acquisition and human faces ($r = .477, p < .05$), subtitles ($r = -.531, p < .05$), and tools ($r = .510, p < .05$). Furthermore, multiple regression analysis showed that human faces ($\beta = 0.52, p < .01$) and tools ($\beta = 0.49, p < .05$) positively affected skill acquisition. These results suggest that focusing on human faces and tools may enhance skill acquisition.

Can oral examinations replace written examinations ?

Mu, Zixuan; Marquis, Fred

Imperial College London, United Kingdom

The purpose of any assessment is to determine students' learning. While oral examinations have been adopted in many education systems, such as the PhD thesis viva and medical assessments (Huxham, Campbell, and Westwood 2012), they are rarely used in undergraduate engineering courses (Baghdadchi et al. 2022) which traditionally rely on written papers. This is not surprising given, generally, the large cohort sizes and the need to efficiently conduct such examinations in a timely manner. It has been shown that widening the range of assessments that a student experiences can lead to a more comprehensive development of the student (Rust 2005) and generally increases accessibility to the increasingly diverse student populations we find in engineering.

In this review, the effectiveness of oral exams is discussed and analysed in terms of their historical development, key features and differences from written exams and experience from case studies. The issues of validity, reliability, and fairness are outlined and the feasibility of replacing traditional written exams by oral exams in undergraduate programs, specifically the Mechanical Engineering program, at Imperial College London discussed.

It is recognised that while numerous benefits could be provided by oral exams there are significant hurdles that require careful planning and the review concludes with a number of guidelines for a pilot scheme to be enacted over the coming year.

Parallel Workshops 3-01: Parallel Workshops 3-01

Time: Wednesday, 13/Sept/2023: 2:30pm - 3:30pm · Location: EQ-116 Flat Room

Engineering Education Research: Reviewing journal manuscripts fairly, constructively, effectively

Edström, Kristina¹; Knight, David²; Main, Joyce³; Mitchell, John⁶; Bernhard, Jonte⁴; Chance, Shannon⁵; Beagon, Una⁵; van den Bogaard, Maartje⁷; Broadbent, Rebecca⁸; Du, Xiangyun⁹; Langie, Greet¹⁰; Martin, Diana¹¹; Power, Jason¹²; Saunders, Fiona¹³; Tormey, Roland¹⁴

¹KTH Royal Institute of Technology, Sweden; ²Virginia Tech, USA; ³Purdue University, USA; ⁴Linköping University, Sweden; ⁵TU Dublin, Ireland; ⁶University College London, UK; ⁷The University of Texas at El Paso, USA; ⁸Aston University, UK; ⁹Aalborg University, Denmark; ¹⁰KU Leuven, Belgium; ¹¹TU Eindhoven, The Netherlands; ¹²University of Limerick, Ireland; ¹³Manchester Metropolitan University, UK; ¹⁴EPFL, Switzerland

This workshop focuses on peer review of journal manuscripts in the field of engineering education research.

Participants and facilitators

We invite both experienced and new reviewers, with a particularly warm welcome to doctoral students in engineering education research.

Maximum number of participants: 50.

The workshop is facilitated by a team of editors of three leading journals:

- *European Journal of Engineering Education* (published by SEFI)
- *Journal of Engineering Education* (published by ASEE)
- *IEEE Transactions on Education* (published by IEEE)

Background: Fair, constructive, and effective reviewing

The function of the peer review process is first to support *fair* decisions by helping journal editors identify which manuscripts deserve to be published. The task is further to *constructively* support the authors in improving their manuscript before publication. The peer review process often goes through some iteration to help authors improve their research ideas and processes, as well as how they communicate these ideas and methodologies to the readers. It is through this process of selection and enhancement that the quality of publications is safeguarded. By extension, this is how the whole research field can establish and maintain respect. Reviewers play a vital role – without peer review there can be no respected field.

It is a rewarding task to review manuscripts, as much can be learned from it. It can be helpful to experience the editorial process from the inside, particularly when taking one's own manuscript from submission to successful publication. As reviewing can also be time consuming, it is a wise investment to improve one's skills to do it *effectively*.

Aims

The workshop will guide the participants through the following aspects:

- Introduction to the three journals' aims and scope
- Discussing the general review criteria and review processes used in engineering education research journals, and how to apply them
- Taking into consideration particular aspects of a manuscript that a reviewer should consider
- Providing constructive suggestions to authors in improving their manuscripts and to editors in making their decisions on how to reply to authors
- Time management, enabled with effective strategies for producing articulate reviews

Workshop outline

Introductions

- Brief introductions: participants and session leaders. [5 minutes]
- The three journals: aims and scope, review criteria and review process. [15 minutes]

Group activity

- Make a virtual poster in groups facilitated by editors: "Advice for reviewers". [20 minutes]

Synthesis

- Plenary discussion of results. Collected wisdom and conclusions. [18 minutes]

Finish

- Participants are invited to sign up to receive documentation from the session, and to volunteer as reviewers for the journals. [2 minutes]

Parallel Workshops 3-02: Parallel Workshops 3-02

Time: Wednesday, 13/Sept/2023: 2:30pm - 3:30pm · Location: EQ-211 Flat Room

Practical toolkit for embedding ethics in the engineering curriculum

Hitt, Sarah Jayne¹; Fowler, Stella¹; Junaid, Sarah²; Rich, Johnny¹

¹Engineering Professors' Council, United Kingdom; ²Aston University

The need to embed ethics into the engineering curriculum is a collective imperative if we are to successfully navigate complexity, uncertainty and challenging ethical issues to build a sustainable society that works for everyone. To maximise positive impact, behaviours such as inclusivity and sustainability must become instinctive – golden threads running through everything that engineers think and do. Proactively, bringing engineering ethics to the fore in engineering programmes is one way UK higher education equips future engineers with the skills and mindset they need to succeed.

This workshop brings together best practice from expert practitioners across the UK, introducing a nationally curated 'Engineering Ethics Toolkit'. To help educators to know and use the toolkit the workshop will be an attractive translation of engineering ethics teaching theory to the practice of engineering education.

In this workshop, participants will be introduced to a pragmatic approach to integrating ethics content into their teaching, using examples and a detailed and interactive curriculum map, which connects the elements of the toolkit. The workshop will introduce:

- the need for a better understanding of the concept of ethics and support for issues surrounding its teaching;
- real-life examples of ethics teaching practice across dozens of UK university engineering departments;
- where and how in the engineering curriculum, ethics teaching can be embedded and teaching resources to support with this.

Participants will share applied and hands-on access to practical case studies and supporting articles to help them integrate ethics content into their teaching. We will access the fully searchable library catalogue, ensuring it is easily searched and understood and users are equipped to apply the toolkit to different teaching contexts.

Workshop participants will take away strategies and high-quality open-source engineering ethics teaching resources to enable engineering students to be able to identify ethical issues, exercise ethical thinking and use ethical judgement within their projects and coursework.

Our aim is to ensure the toolkit becomes an ongoing, regular component of engineering teaching and highlighting excellence in integrating ethics. The workshop will act as a seed to encourage further case studies to be developed and will also explore what can yet be done in this space to ensure the next generation of engineers are well-equipped to address the ethical issues they face.

Parallel Workshops 3-03: Parallel Workshops 3-03

Time: Wednesday, 13/Sept/2023: 2:30pm - 3:30pm · Location: EQ-203 Flat Room

Supporting students from different universities and backgrounds to improve their academic and social outcomes:

EUniWell MASOEE project workshop

Cooke, Neil¹; Forss, Jörqen²; Caporali, Enrica³; Charge, Pascal⁴; Hawwash, Kamel¹; Andersson, Jesper²; Bartoli, Gianni³; Chung, Sarah¹; Cottle, Daniel¹

¹University of Birmingham, United Kingdom; ²Linnaeus University, Sweden; ³University of Florence, Italy; ⁴University of Nantes, France

Introduction

There is a notable discrepancy between the relative prosperity of Europeans and the global security and sustainability challenge. The mission of the ERASMUS+ 2020 European University for Well-Being (EUniWell) alliance is address this. Our project, "Maximizing Academic and Social Outcomes in Engineering Education" (MASOEE) interprets this contradiction for engineering educators, exploring how to ensure graduates make the utmost contribution to societal wellbeing by narrowing attainment gaps. We are combining the expertise of British, French, Italian, and Swedish faculties to identify, share, and ultimately transfer best practices for professional, business, and sustainability skill teaching that is aligned to the EU competency frameworks including EntreComp and GreenComp. Furthermore, we are finding out how disadvantaged cohorts in each partner faculty are characterized and supported. The project is guided by the following research questions:

- What are the similarities and differences between our students, staff, teaching, and culture?
- How are skills taught and embedded in programmes? What are student attitudes to learning these? How do we currently define and measure social outcomes?
- Which new approaches can we employ improve social and academic outcomes?

What you are expected to learn

We will share our preliminary findings with participants through case studies will provide insight into how the differences between faculties manifest through different course designs as well as student cohorts. In the workshop we seek your views as engineering educators, industrialists, and students across Europe on how students develop their competencies, in addition to distinguishing factors for disadvantaged students, and how our case studies relate to your own contexts. The workshop motivates you to consider ways of improving the academic and social outcomes of their students. The learning outcomes are:

- Compare a diverse range of strategies for undergraduate learning of engineering in the themes of technical skills, entrepreneurial skills, professional skills, and sustainability skills.
- Understand more about the learning needs of engineering students from a diverse range of less advantaged backgrounds and explore ways of modifying curriculum and culture to better meet these needs.

These outcomes are realized through:

- Presenting a variety of case studies of best practice for skills teaching in engineering from a range of university contexts in Europe.
- Discussing current engineering undergraduate students' attitudes to the learning of these skills and interrogating how differences in culture and curriculum in institutions can affect these perceptions.
- Exploring comparison data that reveals how students from less advantaged backgrounds engage with the learning of engineering skills and using this to propose interventions to narrow attainment gaps and promote social mobility through engineering education.

The background of this workshop coincides with the broader mission of the EUniWell University alliance to understand, improve, measure, and rebalance the well-being of individuals and our communities in the face of political, societal, and environmental challenges, as well as renewing European research and education. In this context, engineers, and engineering education, play an important role. We will discuss the comparison of

experiences, analysis of similarities and differences among participants in curricula structures, teaching methods, organization of institutions, and students' learning attitudes, particularly about non-technical skills. Knowledge of students' attitudes in terms of learning these skills and how educators can better teach them once learning objectives are defined will also be explored. It is planned that participants will be divided into diverse groups, which will depend on who attend i.e., the groups might reflect different geographical locations.

Schedule

Following a 10-minute initial introduction by the project team, participants will be asked to, in the context of several case studies shared by the project, consider how a specific skill set under consideration is developed, and how they assess the extent to which they students report their development. An important aspect of the feedback sought will be the challenges faced in developing the skills and the ability of students to reflect on that important aspect of their learning. It would be important to report on any differences in perceptions by the three stakeholders, faculty, students, and industry. Depending on time, groups may consider several sets of case studies, each focusing on one of the skill sets under consideration (40 minutes). We will run the workshop as a "World café" format.

The project team will summarize the workshop discussions for the final 10 minutes of the session, identifying examples of good practice that can be shared between the participants and might even be developed into additional case studies to complement those developed in the project from the four universities. To ensure the widest possible engagement, participants are also invited to report from the different groups.

Key takeaways

The results of the workshop and MASOEE project report will be distributed to all workshop participants later in the year in the form of a link to a website and document as well as a write-up in the SEFI conference proceedings.

Why you should attend

The significance of this work to engineering education is to identify and explore how disadvantages manifest in student cohorts studying in different countries across Europe. In making these comparisons, we might better understand how to share best practice to narrow attainment gaps by how we change our cultures and learning environments; understanding what works across borders, and what might be unique yet adaptable to other contexts.

We have a responsibility to increase the diversity of the engineering workforce to make it more creative and responsive to the world's needs. This is a positive social outcome. For individual engineers from disadvantaged backgrounds, the social outcome is positive because the profession is well-paid and offers varied career paths; students can join professional engineering institutions to access an established network not reliant on via family connections and their previous education. This workshop will contribute to ensuring that we capitalize on this advantage.

Parallel Workshops 3-04: Parallel Workshops 3-04

Time: Wednesday, 13/Sept/2023: 2:30pm - 3:30pm · Location: EQ-113 Flat Room

Campfire Talk game, an Unsupervised Intervention Game for Students and Staff

Hermsen, Pleun; van Dommelen, Sjoerd; Hueso Espinosa, Paula

Delft University of technology, Netherlands, The

Are you witnessing students facing similar concerns, difficulties, and problems throughout their educational journey? Perhaps you are acquainted with PhDs, lecturers, or support staff who encounter challenges in their educational, research, or teaching paths. Openly addressing these issues can prove beneficial in all of these scenarios! While coaching is a potential solution, it can be time-consuming and demanding, right? Instead, let them have a Campfire Talk: a non-intrusive and socially safe serious game that requires no supervision. It provides a platform for discussing struggles that in practice are often difficult to address or overlooked but can deeply affect individual or group behavior. During this workshop, participants will have the opportunity to experience the game firsthand, followed by an exploration of its underlying mechanisms and potential application in their own educational settings and our own. A version of this game will be open source available to use in their own context.

Parallel Workshops 3-05: Parallel Workshops 3-05

Time: Wednesday, 13/Sept/2023: 2:30pm - 3:30pm · Location: EQ-315 Flat Room GD

Building Collaboration and Learning Mechanisms for Sustainable Development

Guerra, Aida; Jiang, Dan

Aalborg University, Denmark

The United Nations's Sustainable Development Goals (SDG) goals provide a framework for action to achieve sustainability targets for 2030. Engineering plays an important role in the achievement of the goals through the development of innovative, sustainable solutions (ICEE, 2021). Said that, engineering education must prepare and educate its graduates accordingly, with knowledge and competences to act locally and positively impact globally (Sterling, 1996). Engineering education for sustainable development (EESD) calls for transformative, problem-oriented, contextual, collaborative (inter-and transdisciplinary), student-centred learning environments, where students and academic staffs develop a deeper understanding of SDGs in relation to their own field, solve complex and ill-defined sustainability problems, possess anticipatory and systems thinking skills, and collaborate across different disciplines, institutions, cultures, and wider community to engage in knowledge co-creation, change and transformation (Schloz and Steiner, 2015; Guerra, 2017). We take the point of departure on the challenges that students and academic staffs face in integrating sustainable development (SD) into their learning activities and courses, namely being capable of relating one subject area with SD and building leaning mechanisms for transdisciplinary collaboration. Based on Boundary Crossing theory and four learning mechanisms propose by Gulikers and Oonk (2019), the workshop proposes an approach to learn how to address sustainable complexity by enabling participants to relate their discipline, teaching and/ or research with sustainability as a point of departure to build collaborations across different sectors and foster transdisciplinary to address sustainability. Participants in this workshop will collaborate with each other and use SDG as objects to cross disciplinary, cultural, and institutional boundaries, with aim to formulate problems and co-create new knowledge and solutions, working toward innovation or transformation for sustainable learning and practice. By the end of the workshop, the participants are expected to achieve the following learning goals:

- Identify to which SDGs their research, or teaching, practices contribute
- Use SDG as objects to cross 'boundaries' for collaboration and interdisciplinary learning
- Negotiate about how SDG-relevant focus area may contribute to each other
- Reflect on one's own practice and unfold potentials for curriculum innovation and integration of SDG

The workshop utilizes small lectures in combination plenary discussion, hands-on group exercises, and targets students, academic staff, and researchers in engineering education, who intend to integrate sustainability in their own studies and practice.

Parallel Workshops 3-06: Parallel Workshops 3-06

Time: Wednesday, 13/Sept/2023: 2:30pm - 3:30pm · Location: EQ-112 Flat Room

Supporting undergraduate engineering student mental health

Jensen, Karin¹; Tait, Jo-Anne²; Wilson, Sarah³

¹University of Michigan; ²Robert Gordon University; ³University of Kentucky

The culture within engineering education can lead to the normalization of stress, which has the potential to impact student mental health. Through promoting mental health and wellness in the classroom, faculty can help to normalize discussions around mental health and promote a culture of wellness in engineering. Through this workshop, participants should be able to 1) define the current state of research on mental health in engineering, 2) reach out to and support students who might be struggling in the classroom and 3) implement research-based strategies for integrating mental health into the classroom. In particular, we will highlight literature that shows that mental health concerns can differentially impact students based on their social identity and that engineering students in distress are less likely to seek help for their mental health. We will provide research-based strategies for reaching out to students who might be struggling in the classroom and encourage faculty to become referral agents for students in mental health distress. Finally, to create an environment that is more supportive of student wellness, we will provide faculty with tangible and research-based ideas to integrate mental health and wellness into the classroom. Examples include: 1) distributing student check-ins, 2) modeling wellness in the classroom, 3) creating a supportive community, 4) integrating wellness activities (mindfulness, breathing, etc.), 5) providing students with resources and 6) creating syllabus statements. In addition to these ways of integrating and modeling wellness in the classroom, we will also provide strategies for creating an inclusive classroom environment through integrating flexibility and accommodations into the course structure. Faculty will leave with a toolkit of research-based strategies for developing a classroom environment that promotes prioritization of mental health and wellness. In this way, we aim to shift the needle from a culture of stress to a culture of well-being in engineering.

Parallel Workshops 3-07: Parallel Workshops 3-07

Time: Wednesday, 13/Sept/2023: 2:30pm - 3:30pm · Location: EQ-208 Flat Room

Promoting Engineering to K12 students through Spatially Challenging Making and Outreach Activities

Duffy, Gavin; Westerhof, Marten; Keogh, Deborah; O'Kane, Colm

Technological University Dublin, Ireland

Outreach activities are an important and valuable approach to promoting engineering education and careers to young people. They provide an excellent way to show that engineering can be fun, challenging and rewarding. With some careful thinking, they can also be used to promote and develop spatial ability, a cognitive ability that is very important to engineering.

Exposing children to spatially challenging tasks can help them to develop spatial ability which can transfer to improved performance in mathematics and other STEM subjects that are foundational to engineering. In this workshop, we present a range of hands-on activities that can be used to both promote engineering education and careers to young people and expose them to spatially challenging activities, thereby achieving more through an outreach activity. The target age group for the workshop is 8- to 12-year-olds but a wider range of age groups will be discussed during the workshop.

The workshop will begin with a short outline of why spatial ability is so important to achievement in engineering education with reference to several research studies on the topic. We will then present three different outreach activities to participants that have been designed to expose children to engineering and to challenge them to exercise their spatial ability. These activities involve design thinking, problem-solving, 2D and 3D visualization and making and have been informed by an extensive review of the literature on this topic.

We include an active phase by dividing the workshop attendees into groups of four members and asking them to

1. explore a condensed version of one of the outreach/maker activities
1. list engineering attributes and programme outcomes that could be achieved through these activities
1. think critically about these activities in small groups and provide feedback on them – what is good, what could be changed and improved
1. Think of how they might adapt this activity, or something similar, to the age group or subject they teach themselves
1. discuss if they would deliver these activities or reach for something else during an engineering week for this age group

We finish the workshop by asking each of the groups to report back with a summary of their discussions under each of the above points.

Parallel Workshops 3-08: Parallel Workshops 3-08

Time: Wednesday, 13/Sept/2023: 2:30pm - 3:30pm · Location: EQ-204 Flat Room

Questioning implicit assumptions – proactively fostering inclusion in engineering activity design

Pearson, Ashlee¹; Deters, Jessica²

¹University of Melbourne, Australia; ²University of Nebraska-Lincoln, USA

Within discussions of inclusion work in engineering education, calls have been made to shift to a shared responsibility model where all are responsible for proactively fostering inclusive environments. In an academic setting, it is through pro-active design of learning activities that academics can preemptively meet the needs of diverse students such that they may feel included. This design work often relies on academics being educated or aware of what is inclusive or exclusive for different groups that have traditionally underrepresented identities and lived experiences. However, academics do not always possess this information. This workshop proposes an approach that asks academics to employ a process-based approach to consider what assumptions underpin the design of a real-life student-centered activity and seek information to challenge those assumptions. Participants will employ this approach as well as a suggested method for drawing on evidence-based practice to consider structural and design changes that may make the activity in question more inclusive.

Parallel Workshops 3-09: Parallel Workshops 3-09

Time: Wednesday, 13/Sept/2023: 2:30pm - 3:30pm · Location: EQ-207 Technology Room

Empathy in Engineering and Ethics Education: resources to support the Engineering Education global community

Bairaktarova, Diana¹; Direito, Inês²

¹Virginia Polytechnic Institute and State University (US); ²University College London, Centre for Engineering Education (UK)

What can session participants expect to gain?

There is no question of the importance in the education of engineering students developing ethical decision-making abilities of future leaders and innovators. Literature suggests that when learners see how ethics and empathy together play role in guiding their actions, students tolerate ambiguity and are less influenced by their peers, for example, looking at problems from different perspectives (Krznaric, 2014; Feshbach & Feshbach, 2011). Recently, empathy is gaining growing attention in engineering education, being related to prosocial behavior, psychological safety in teamwork and the classroom. Empathy, simply said, is a human quality to "put oneself in another's shoes," feeling what they are feeling with the understanding that their emotions may not be one's own. While engineering educators have established instructional methods to teach engineering ethics, how to develop and enhance empathy competency is still challenging.

This workshop introduces practices in education that support the development and enhancement of empathy in engineering students. The relevance of empathy for engineering education will be discussed; criteria for empathy projects/assignments and an empathic teaching framework are presented. Together we will run through empathic pedagogies of inclusion and engagement while exploring teaching empathetically within content-specific environments. Participants will leave the workshop with steps to design assignments that will activate student empathy in design-thinking and demonstrate inclusive teaching practices, including learning empathic techniques, resources, and tools that could be beneficial to the Engineering Education global community in building students' empathic capacity.

Why is that session relevant?

Empathy is the human quality to understand or feel what another person is experiencing from within the other person's perspective. To exercise empathy means to understand the motives, needs and points of view of others, thus, empathy is considered an important factor of moral behavior, and an essential component in forming moral communities (Ehrlich & Ornstein, 2010). According to the European Educational Policy report (2020), both empathy and ethics are based on an understanding of the following four attributes: values (human dignity and human rights), attitudes (sense of responsibility and respect), skills (listening, observing, and cooperation), and knowledge and critical understanding of self. Having these four attributes, the report suggests, a person can perceive multiple perspectives and engage with people from diverse backgrounds. These attributes are perceived as essential active citizenship skills for teaching and learning in the digital age (Council of Europe, 2019). Further, research suggests that empathy education can produce citizens who care about community issues such as poverty, war, and climate change (Krznaric, 2014). In fact, empathy training could help the world come together to address significant issues such as "climate change, poverty, escalating violence, international conflicts, [or] illness" (Erlich & Ornstein, 2012, p. 15).

Caring for a fairer, more resilient future, it is our obligation to prepare students with the skills and human qualities that will foster good global citizenship. As educators, one of our jobs is to help students learn empathy as they also learn from current events and history about wider definitions of diversity, equity, and inclusion. In the engineering classroom, when we create and foster learning experiences, such as the practice of empathy, we support a broad set of important learning objectives that are not easily addressed in a traditional engineering curriculum (Author, 2022).

How are session participants engaged?

This workshop introduces creative ways of teaching empathy through empathic techniques and design thinking philosophy in an engineering content-specific learning environment. The relevance of empathy for engineering education will be discussed; criteria for empathy projects/assignments and empathy frameworks are presented. Participants will be engaged in creating learning activities that reward risk-taking and vulnerability; develop and enhance students' empathic ability; and ensure student success in designing human-centered projects. Through interactive activities and dynamic discussions that draw on the latest theories on empathy and design thinking (Kouprie & Visser, 2009) related to education, together we will propose techniques and strategies needed to successfully teach students to become adept with diverse peoples and ideas, to collaborate, and to contribute more and better ideas through listening, observation, and co-operation. Participants will leave the workshop with steps to design assignments that will activate student empathy in decision-making and design-thinking and demonstrate inclusive teaching practices.

How will results be summarized?

Each participant will take home (1) detailed handouts to be used during the ideation portion of the workshop; (2) descriptions of the empathic teaching techniques, assessment criteria, and the underlying theory; (3) an assignment outline for the empathy assignment unit that can be introduced in class; (4) an assessment rubric for such assignments; (5) a deeper appreciation for teaching inclusively; (6) ideas, ideas, ideas.

How is this work significant for Engineering Education?

Empowering engineering learners by including empathy in the engineering curriculum can help to produce altruistic, more compassionate citizens who can direct their energies toward problem-solving that improves society.

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Paper Session 3-10: Sustainability - Pedagogy and Programme Design

Time: Wednesday, 13/Sept/2023: 4:00pm - 5:00pm · Location: EQ-002 Lecture Hall
Session Chair: Fiona Truscott

Critical Consciousness and Engineering Design Teaching Framework

Revelo Alonso, Renata Alejandra¹; Mejia, Joel Alejandro²; Montero Moguel, Luis²; Stutts, Alex¹

¹University of Illinois, Chicago, United States of America; ²University of Texas San Antonio

Sustainability in engineering design is not just about the processes and practices established or the materials used and sourced, it is also about the mindset that engineers bring to design to carry forth solutions that promote a sustainable world. In this practice paper, we review a teaching framework for an engineering course on design with a contextual perspective. To contextualize engineering design, we incorporate critical consciousness topics to discuss alongside each design process topic. For example, during the unit when we discuss design alternatives in the engineering design process, we also discuss implicit bias and how implicit bias may impact the alternatives that engineers promote in the design. These critical consciousness topics allow for a dialogue that is rooted in history and an understanding of engineering design outside of a vacuum. An adaptation of this course is being taught at two different higher education institutions in the United States. In this paper, we share this teaching framework along with some examples of how we're implementing the framework as well as preliminary results from our study of what impact this work has on students' critical consciousness gains.

Teaching sustainability through a role-play case study of e-scooter use on college campuses

Mehta, Shruti; Hingle, Ashish; Johri, Aditya

George Mason University, United States of America

Sustainability has developed into a pressing concern across disciplinary domains, and the need for teaching sustainability concepts to students has grown significantly. In this paper, we present a research study that assessed undergraduate students' understanding of sustainability after participating in a case study discussion. We designed and implemented a role-play case study of e-scooters on a college campus. The case facilitated "near transfer," as it focused on an issue most students have personally experienced. Furthermore, the role-play component simulated a real-world context and allowed students to take different perspectives related to the topic, resulting in a discussion of social, political, economic, and technical factors related to sustainability. The case study was implemented with 38 students. Course readings and pre-case study assignments were used by students to prepare for the role-play. Students participated in groups of 6-7 participants in student-led discussions. To evaluate the development of perspectives, we undertook a thematic analysis of the pre-and post-assignment questions using a framework derived from Transformative Learning Theory (TLT). Findings show that students developed a holistic view of sustainability by co-constructing decisions related to the case study presented. The role-play case study and role descriptions are presented in the Appendix.

Are engineering teachers ready to leverage the power of play to teach transversal skills?

Isaac, Siara; Jalali, Yousef; Petringa, Natascia; Tormey, Roland; Dehler Zufferey, Jessica

Ecole polytechnique Fédérale de Lausanne, Switzerland

What conceptions do teachers hold about learning activities that develop students' transversal skills? This qualitative exploration at a research-intensive engineering school draws on interviews and focus groups to explore teachers' ideas about developing individual transversal skills. We frame our analysis with a model that distinguishes three phases for skill development: conceptual knowledge (knowing), procedural skills (doing) and meta-cognitive/emotional reflection (learning from doing). We are particularly interested in the potential for play to create favorable conditions for developing transversal skills by enabling (i) focused experiential learning, (ii) low-stakes experimentation, (iii) rapid feedback, (iv) opportunity for reflection. In the interviews, the potential to teach conceptual disciplinary knowledge dominated teachers' perceptions and transversal skills were sidelined. Focus group participants, just after a hands-on activity, primarily addressed transversal procedural skills in their comments and overlooked the conceptual knowledge underpinning these skills. The importance afforded to meta-cognitive and meta-emotional reflection varied greatly amongst teachers. Our analysis suggests that the three-level model can assist teachers by providing a structure to ensure each level is accounted for in experiential activities. We see promise for addressing transversal skills including sustainability, risk assessment, ethical reasoning and emotional regulation.

An Innovative Approach by ENTER Network: Integrating Sustainable Development into Professional Training for Engineering Educators

Quadrado, José Carlos^{1,2,3}; Zaitseva, Kseniia¹

¹ENTER, Portugal; ²ENAAE, Belgium; ³ISEL, Portugal

This paper discusses the development of a new pedagogical training program for engineering educators, created by the ENTER Network and funded by the EU. The program consists of modules that include courses designed to develop specific competencies. The selection of courses and competencies was based on surveys conducted with various stakeholders, including engineering educators, HEI administration, HEI engineering students, potential employers of HEI engineering graduates, and representatives of governmental bodies involved in education. The paper focuses on the relevance and origin of competencies addressed in the Sustainable Development Course, and presents the syllabus for this course, including information on its objectives, content, teaching materials, structure, and assessment procedures.

Paper Session 3-11: EDI 6 - Identity and Cognition

Time: Wednesday, 13/Sept/2023: 4:00pm - 5:00pm · Location: EQ-116 Flat Room

Session Chair: Natascha van Hattum-Janssen

Democratic Education within the standard curriculum at TU Berlin - a quantitative and qualitative analysis

Baier, André; Tenhagen, Noemi

Technische Universität Berlin, Germany

Introduction - Technische Universität Berlin (TU Berlin) was founded after the Second World War on the ruins of its predecessor. At its inauguration it was bound to promote democracy through its education. This view is further held up through the university law of the federal state of Berlin which states that the disciplinary competences are to be acquired in such a way so that students are able to act democratically. This spirit is still alive at TU Berlin and over the past decades it led to several educational concepts which reach beyond traditional methods of teaching/learning and which expand the limits of what is seen as classical content. Yet, a closer examination is needed as to what role democracy plays within higher education at TU Berlin.

Methods - A quantitative research provides descriptive statistics as to how many times the words "democracy" or "democratic" show up in study programs and modules. A limitation to these two terms is appropriate as they are the most comprehensive terms in comparison to others like participation or inclusion.

Results - The initial research shows that the two terms only show up in 3 out of 130 study programs as well as in only 16 modules out of thousands of modules.

Discussion - The curriculum at TU Berlin shows almost a clear lack of democracy/democratic education. An extension of this research to other universities is already on its way.

Once Upon a Time in the Castle of Engineering Education: The Magic of Storytelling for Neurodiverse Students

Guler, Beyza Nur¹; Stewart, Devin²; Martini, Larkin¹; Bairaktarova, Diana¹

¹Virginia Polytechnic Institute and State University, United States of America; ²Radford University, United States of America

Universal Design for Learning (UDL) framework implies that learning environments might pose barriers for neurodivergent students. In order to increase accessibility for learning, reducing cognitive load is essential for people with learning and intellectual disabilities. Storytelling is a unique approach for addressing this issue as for students it provides structure, encourages reflection, and engages multiple sensory experiences that overall enhances student interest in learning. Especially in engineering courses where multiple abstract and difficult concepts are involved, storytelling holds the potential to engage students while facilitating knowledge transfer and application. Therefore, this paper summarizes the benefits and challenges of utilizing storytelling as a pedagogical tool for neurodivergent students in engineering education. Further, it discusses subject-specific context where storytelling can be applied to improve the overall learning experience of neurodivergent students.

This paper starts with explaining the UDL framework by specifically addressing the challenges abstract and difficult concepts poses for neurodivergent students. Next, the paper lays out the benefits of storytelling by making the connection between cognitive load and the importance of structure in learning for neurodivergent students. Due to the varying processing abilities and executive functioning challenges of neurodiverse students, reducing cognitive load is necessary to ensure instructional effectiveness. Incorporating storytelling could be one way to improve learning outcomes for neurodivergent students pursuing an engineering degree. Finally, the paper concludes with suggested implications of the inclusion of storytelling in engineering curriculum for more accessible education.

First-generation engineering students' identity development: early forays into the workplace

Smit, Renee

Centre for Research in Engineering Education (CREE), University of Cape Town, South Africa

In the context of global shortages of engineering professionals, research into factors that impact on training and retention of qualified engineers is important – this includes first-generation engineering students, a largely under-researched group of students. Research has shown that an elaborated, well-developed engineering identity is important for the retention of both engineering students at university, and for engineers in practice. Professional identities are fluid, emerging and develop over the lifetime of the professional. However, we still know little about the nature of a professional engineering identity, and how it develops.

Drawing on insights from the philosophy of science, I make an argument for a heuristic that allows for the analysis of data on engineering identity: professional identity is marked by epistemic fluency, a process of ontological becoming, and axiological capacity. The paper reports on a set of interviews of new engineering professionals as they transition into their first few months in practice. The work is part a longitudinal study of first-generation engineers.

The study shows that the workplace environment expands the emerging identities the new engineers bring into their first jobs. The analytical framework allows the researcher to tease out aspects of the developing professional identity.

The study not only adds to conversations about the development of engineering identity in the transition into the workplace using the proposed analytical concepts, but also has implications for curriculum.

The contribution has been withdrawn.

Why we should teach engineering communication within the context of engineering practice: What cognitive-functional linguistics tells us about language learning.

Evans, Rick

Cornell University, United States of America

Paper Session 3-12: Climate Change and Sustainability 5

Time: Wednesday, 13/Sept/2023: 4:00pm - 5:00pm · Location: EQ-211 Flat Room
Session Chair: Waqas Saleem

How do Teachers Respond to Sustained Change?

Hadgraft, Roger¹; Trede, Franziska¹; Rummler, Monika²

¹University of Technology Sydney, Australia; ²Technische Universität Berlin, Germany

Overview

Higher Education is facing profound shifts. Employers seek graduates who can work effectively with others in rapidly changing contexts, defined by globalisation, diversity, digitalisation, climate change, complexity, a European war, and a global pandemic, which caused an instantaneous switch to online learning. The calls for sustained change are challenging academics to rethink their traditional teaching role and to develop a new understanding of future-oriented learning goals for their students.

This paper will describe the research we have conducted into how academics have responded to these challenges, both short term (emergency remote teaching) and the long-term shift to new ways of teaching (for transdisciplinary learning, working with diverse communities on their solutions).

Our research interest is about *Developing the Deliberate Teacher's Voice in the Age of Complexity, Sustainability, Globalisation, Digitalisation and Transdisciplinarity*. The research question is: How do Continuing Education Programs for Academics need to Respond to Enhance Teaching Competence at University?

Approach and Methods

The authors have explored this issue over the last two years using qualitative research methods through workshops and interviews that have been analysed for major themes. The results express a range of views that academics hold, from quite near-sighted (what changes are necessary in my discipline?) to far-reaching ones (related to the need for more sustainable, ethical, and equitable teaching practices).

Outcomes

The paper will explore what professional development approaches are needed now to prepare academics for sustained change and future trends in teaching engineering.

Taking curriculum reform to the next level: the need for decolonising work in engineering education

Orbaek White, Gabrielle

Swansea University, United Kingdom

As humanity is faced with unparalleled challenges, from the climate emergency to rising inequality, there is a renewed emphasis on the role of engineering professionals to contribute solutions to global problems. However, there is increasing recognition that the way that engineers are trained through higher education is inadequate to prepare them to address these grand challenges. This talk aims to deepen theoretical perspectives on *why* the engineering education status quo is falling short. Taking a British perspective, I will outline how the epistemology and cultural ideologies, or the "episteme," of engineering continues to act upon our practices and discourses within modern day engineering education, and shapes and constrains our ways of knowing, thinking, being, and acting. The episteme of engineering, shaped and shaped by the colonial era, has culminated in modern engineering education that produces technically competent, yet depoliticized engineers, who tend to eschew or neglect their social responsibility. I will present data from a critical ethnography to reveal how the discourses and practices of engineering continue to be steeped in coloniality and perpetuate Western, modernist narratives of the need for growth and technologically-driven development. I aim to demonstrate that approaches to curricular reform will continue to fall short without concerted efforts to decolonise our ways of knowing and doing in engineering. Finally, I provide some suggestions on pathways forward.

Project "Acércate a la Ingeniería": Impact assessment and satisfaction questionnaire

Narganes-Pineda, Annabella; Araña-Suárez, Roberto E.; Hernández-Pérez, Mariana; González-Suárez, Paula; Hernández-Castellano, Pedro M.; Marrero-Alemán, María Dolores

University of Las Palmas de Gran Canaria, Spain

Engineering is a key discipline in today's society, as it is sustainability. Therefore, this are concepts that must be introduced in early educational levels. In this context, the project "Acércate a la Ingeniería" (Get closer to Engineering), designed and carried out by the Department of Education of the Government of the Canary Islands in collaboration with the Industrial and Civil Engineering School (EIC) of the University of Las Palmas de Gran Canaria (ULPGC), has arisen. This project brings together eighteen secondary schools (IES) from five of the eight Canary Islands. The aim of this project is to educate students to prevent their rejection of engineering degrees by the participation in different activities that brings them closer to engineering. Various questionnaires have been carried out in order to measure the impact this experience had on said students, as well as the differences between boys and girls in engineering matters and the satisfaction level of the participating groups. This paper focuses on the results obtained from said questionnaires and their analysis.

EELISA Credential: the recognition of commitment and impact in the addressing of societal challenges in the EELISA Alliance

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¹UNIVERSIDAD POLITÉCNICA DE MADRID, Spain; ²ECOLE NATIONALE DES PONTS ET CHAUSSEES, France; ³UNIVERSITE PARIS SCIENCES ET LETTRES, France; ⁴BUDAPESTI MUSZAKI ES GAZDASÁGTUDOMÁNYI EGYETEM, Hungary; ⁵ISTANBUL TEKNİK UNIVERSİTESİ, Turkey; ⁶FRIEDRICH-ALEXANDER-UNIVERSITÄT ERLANGEN-NÜRNBERG, Germany; ⁷UNIVERSITATEA POLITEHNICA DIN BUCUREȘTI; ⁸SCUOLA SUPERIORE SANT'ANNA, Italy; ⁹SCUOLA NORMALE SUPERIORE, Italy; ¹⁰EELISA OFFICE

EELISA Credential is a unique recognition process provided to EELISA students, professional and alumni who are part of the mission-driven EELISA communities and represents the commitment and impact level achieved in the addressing of a societal challenge.

The EELISA Credential is an individual, progressive medium on which students collect badges. These badges are acquired after verifying the achievement of an educational outcome level after participating in a community's educational activity. A badge represents the unit of learning acquisition and impact comprising the EELISA Credential correspond to an educational outcome, which itself refers to an impact level and a sustainable development goal.

The impact level represents the badge measurement scale. In the EELISA Credential there are 5 levels of impact (discovery, knowledge, engagement, action, transformation) that correspond to learning objectives.

The education activities proposed by EELISA Communities are defined around a societal challenge defined by a problem owner (faculty, students, local communities). Each activity is centered in 1 or 2 SDGs, and recognises a maximum of 4 badges.

Through the involvement in the activities of EELISA Communities, students enrich their EELISA Credential in areas addressing Sustainable Developments Goals (SDGs), progressively improving their capacity for understanding, action and transformation.

In the final version of this *practice paper*, we will present the requirements for activities to be part of the EELISA Credential, representative and successful activities, the Quality Assurance system, the lessons learnt in the process of implementing the credential and how EELISA Credential will evolve in the future.

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Paper Session 3-13: Mathematics and Sciences 2

Time: Wednesday, 13/Sept/2023: 4:00pm - 5:00pm · Location: EQ-203 Flat Room

Session Chair: Deolinda Maria L. Dias Rasteiro

How do students use basic aspects of functions when learning mathematics in a chemistry context?

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¹School of Life Sciences, University of Applied Sciences and Arts Northwestern Switzerland (FHNW); ²RPTU Kaiserslautern-Landau

The mathematical concept of function is challenging for students in first-year undergraduate mathematics courses, especially when the concept is applied in the context of STEM courses. This difficulty is often due to a lack of conceptual understanding of functions. From a normative perspective, conceptual understanding of functions involves 1) dealing with the different representations of a function, namely table, graph, analytical term and verbal description, while 2) considering three different aspects of functions, namely correspondence, covariation and object. Previous research suggests that the covariation aspect is essential for achieving a sophisticated conceptual understanding of functions. In order to promote the conceptual understanding of functions, a digital self-learning environment was developed and implemented in the first-year basic mathematics course at the School of Life Sciences, University of Applied Sciences and Arts Northwestern Switzerland (FHNW). To facilitate the transfer of mathematical knowledge to applied STEM courses, the mathematical learning environment focuses on chemical reactions, where the concentration of the reactants is analysed. Initial findings from the qualitative content analysis show 1) how students use the different aspects of mathematical functions in the context of chemical reactions and 2) how the covariation and object aspects support students in linking the chemical context to mathematical representations.

Meaning making of the Mathematics in Engineering: the case of Linear models in statistical signal Processing

Tesfamicael, Solomon Abedom

Norwegian University of Science and Technology, Norway

Meaning making of the mathematics involved in engineering problems can boost students' learning, in general. Zooming in to a particular engineering course in signal processing, called Estimation, Detection, and Classification, given to 3rd-year students at NTNU, the potential for meaning making has been investigated using a mix of directed and summative content analysis methods for the specific content Linear models. The findings show that an attempt is made to present the linear model-based estimators in reduced complexity, i.e., without detailed, rigorous proofs that demand solid prior knowledge and concept image from the learner. The 18-page chapter is dominated by advanced mathematical symbols from different mathematical concepts with higher cognitive demanding tasks and activities, which can increase complexity in meaning making. Four types of representations (context, verbal, symbols, and graphs) and multimodal approaches (writing and mathematical symbols) are used to create the potential for meaning making to the user. Symbolic representation dominates the pages creating a higher extraneous cognitive load on the learner. Whereas examples and contexts contribute to lowering the complexity in the potential for meaning making of the mathematics in the chapter. This preliminary study does not include the instructors' and students' active meaning making processes yet.

Enhancing Engineering Students' Mathematics Learning Through Digitised Effective Feedback

Akkaya, Tugce; Kula, Fulya

University of Twente, The Netherlands

This practice paper explores the impact of effective digitised feedback on engineering students' mathematics learning in the digital environment. By using a schematic framework, an online repository will be developed to provide effective feedback to the first-year students taking mathematics courses. The repository takes into account calculus topics and focuses on providing guidance to students who give incorrect answers to questions by incorporating sub-questions based on Polya's heuristics. The sub-questions aim to motivate students to draw on simpler connections and stimulate learning by encouraging students to check their answers and reflect on their initial responses. This study is currently an ongoing project in the Netherlands and aims to improve outcomes in calculus courses and provide a database of online exercises for digital exams, which will save teachers time, in long term.

A Critical Approach to Engineering Mathematics Activities for Sustainable Development

de Andrade, Matheus Oliveira¹; Makramalla, Mariam²

¹Centre for Engineering Education, UCL, London, United Kingdom; ²Teaching Enhancement Unit, NewGiza University, Giza, Egypt

Engineering projects are frequently experienced through the complexity of knowledge co-production between experts and local communities. This involves an ability to work critically and creatively within unfamiliar epistemologies, drawing from quantitative, social and scientific methods to realise high-impact solutions. In this work-in-progress paper, we put forward a prototype for a case-control study aiming to evaluate student buy-in and learning outcomes for a cross-cultural implementation of critical mathematics approaches contextualised by sustainability challenges. We outline and discuss aspects of mathematical modelling activities that can scaffold an environment where human subjectivity amplifies the quality and relevance of quantitative arguments. As proof-of-concept, we analyse exemplary work of first-year engineering students as they design, implement, and evaluate a model of population dynamics towards proposing solutions for the endangerment of a wild species. We then identify critical learning outcomes springing from the social and subjective context that envelops the processes of mathematical modelling, analysis and communication in the real world. Our initial results show that interdisciplinary sustainability-driven mathematics activities have the potential to empower students to adopt a conscious approach to societal and environmental challenges.

Paper Session 3-14: Innovation in T&L 6 - Student Centered Learning

Time: Wednesday, 13/Sept/2023: 4:00pm - 5:00pm · Location: EQ-204 Flat Room
Session Chair: Joseph Little

Fostering individual learning types on online learning platforms to strengthen students' competencies

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Technische Universität Berlin, Department of Micro and Precision Devices, Germany

The availability of video lectures and hybrid formats in higher education has increased significantly due to the COVID-19 pandemic. Predominantly, however, instructional content is simply translated 1-to-1 into video formats regardless of effectiveness and students' needs. Interaction and diversity in content delivery are often missing.

This practice paper presents research investigating how lecture content can be presented within an online learning platform in order to meet the individual learning types of students and to address actual usage behaviour, thus enabling a positive effect on learning outcomes. By creating learning paths, students can choose from different content modes, such as interactive video material, image hotspots and text material, and internalize the content according to their individual learning types. In addition, surveys are used to identify their motivation for choosing the content form as well as the extent to which this was helpful to successfully complete examination assignments. The results of the surveys will be analyzed and used for further improvements.

Through the targeted use of different content modes, the positive aspects of online teaching can further be used while strengthening the knowledge of the students individually in order to best prepare students for the complexity of a future work environment.

Interconnectedness of Geometric, Linguistic, and Algebraic Thinking in Student Performance Measures: An Association Rules Approach

Sipos, Bence^{1,3}; Szilágyi, Brigitta^{1,2,3}

¹Budapest University of Technology and Economics, Hungary; ²Corvinus University of Budapest; ³MTA–ELTE Theory of Learning Mathematics Research Group

Assessing student performance is crucial in education for evaluating knowledge acquisition and competency development. Traditional grading systems often overlook the interconnectedness of learning domains, which can provide valuable insights into student understanding. This study investigates the associations between geometric, linguistic, and algebraic thinking and their impact on student performance measures and grading using association rules.

We analyzed a dataset comprising student responses to geometric, linguistic, and algebraic questions by applying association rule mining techniques. The extracted rules were used to evaluate question similarity, revealing deeper insights into student performance and problem-solving strategies.

Our findings demonstrate significant interconnectedness between geometric, linguistic, and algebraic thinking, with implications for student performance measures and grading. Students' ability to solve problems in one domain often translated into enhanced performance in others, suggesting a shared set of cognitive resources and strategies. Association rules proved valuable for identifying nuanced relationships between question types and domains, providing a comprehensive perspective on student performance.

These results have important implications for educational practices, emphasizing the need to consider the interconnectedness of learning domains when designing assessments and grading systems. By adopting a holistic approach to student evaluation, we can better support students' development of critical thinking and problem-solving skills across various domains, fostering deeper subject matter understanding and enhancing educational outcomes.

Shared interests in live case-based learning – students' dynamic role in an innovation ecosystem

Keiding, Villads; Grex, Sara; Carli Lorenzini, Giana; Pantano, Giulio

DTU Engineering Technology, Dept. of Engineering Technology and Didactics, Technical University of Denmark

Teaching engineering students to navigate complex innovation ecosystems and deal with wicked problems is vital for contributing to sustainable development. Research shows that case-based learning with real-life challenges boosts both the motivation and the learning outcome. This paper presents a course that is in the core of an ecosystem where engineering students engage with hospitals and work on the hospitals' documented innovation needs. By design, the course setup has a double purpose: in a learning context, the course strengthens intrapreneurship education, with students acting in an empowered role like professional consultants. In an organizational context, the course aims to boost knowledge sharing, filling in the gap of innovation competences and resources needed to create value and stimulate intrapreneurial initiatives. The ecosystem has evolved as result of an iterated development of the course including the tools and frameworks that empower the students to act as autonomous innovation consultants in constant interaction with the process of mobilizing the case partners. Thus, this paper presents a study based on current experiences and learnings, focusing on the relationship between the facilitation of student empowerment in live case-based learning and the impact on 1) engineering students' motivation and learning outcomes and 2) value creation for the participating ecosystem. The paper builds on qualitative data from two sources: yearly follow-up interviews with case-partners since 2018, and student reflection reports from 2022. The paper builds on qualitative data from two sources that is submitted student reflection-reports from 2022 and yearly follow up interviews with case-partners since 2018.

Academic procrastination in engineering students

Wilhelm, Pascal; Nijman, Jarick

University of Twente, Netherlands, The

Procrastination is a common phenomenon in students in higher education. To voluntarily delay an intended course of action despite expecting to be worse off for the delay can affect academic performance, cause study delay, but also lead to frustration and stress. This study set out to explore students' beliefs about what causes procrastination, the extent to which online education and the use of digital devices affects their level of procrastination, and their coping mechanisms and ideas about the kind of support a study program can offer to mitigate the effects of procrastination. Focus group interviews were conducted with first-, second- and third year engineering students. Interviews were transcribed and coded to detect general themes in the students' responses. Students hold several beliefs about what causes procrastination, for example situational temptations and distractions, and task aversion. Regarding online education, students tend to procrastinate more. Digital devices are regarded a serious threat for productivity, students use various settings and apps on their phones to battle distraction. To conclude, students cope with procrastination in various ways. Creating study groups, developing fixed working patterns, and breaking down the task at hand are among the most common. Amongst other things, students state that a study program might invest in creating awareness of procrastination, accommodating group work, and creating enough separated physical spaces for study and relaxation to mitigate the effects of procrastination. This study will inform the design of a procrastination intervention program.

Paper Session 3-15: Continuing and Lifelong Learning

Time: Wednesday, 13/Sept/2023: 4:00pm - 5:00pm · Location: EQ-112 Flat Room
Session Chair: Keith Martin Sunderland

TOWARDS BUILDING A FRAMEWORK FOR CONTINUING ENGINEERING EDUCATION IN HIGHER EDUCATION INSTITUTIONS: A COMPARATIVE STUDY

Gomez Puente, Sonia M.¹; Nørgaard, Bente²; Smith, Christopher³; Caratozzolo Martelliti, Patricia Olga⁴; Heiss, Hans-Ulrich⁵; Urenda Moris, Matias⁶; Schrey, Katriina⁷; Myllymäki, H-R⁷; Hadzilacos, Rigas⁸

¹Eindhoven University of Technology, Netherlands, The; ²Aalborg University, Denmark; ³Glasgow Caledonian University, Scotland; ⁴Tecnologico Monterrey, Mexico; ⁵TU Berlin, Germany; ⁶Uppsala University, Sweden; ⁷Aalto University, Finland; ⁸EPFL, Switzerland

Continuing engineering education (CEE) is becoming an attractive notion of continuously enhancing and upgrading the engineering skills required by the Fourth Industrial Revolution. Current developments in science and technology and the challenges to address the United Nations Sustainable Development Goals (UN SDGs) of the 2030 Agenda require updating theoretical knowledge, skills, and specific practical work. Even though higher education institutions (HEIs) can provide CEE or CPD (Continuing Professional Development) within or external degree programs, CEE focuses on training engineers as lifelong learners to meet societal and industrial needs. A comparative study was conducted among eight universities to analyse the strategies used to provide CEE services at an institutional level. This study aims to investigate approaches and practices in CEE offerings to learn lessons and adjust CEE programs and policies in the HEIs involved in this research. The study followed an adapted version of a Comparative Case Study (CSS) as a suitable framework to map the CEE strategies and approaches of the participating universities. Preliminary results indicated differences in the organisational structures, e.g., traditional courses within existing programs. At the same time, other institutions provide flexible mechanisms such as short courses, modules, or micro-credential activities leading to qualifications. Similarities are found in institutional policies aiming at developing postgraduate programs aligned to industry demands. This study reflects the importance of learning programs as resources provided by HEIs applying a framework for engineering education and the engineers' further professional development.

European and national strategies supporting the implementation and development of continuing engineering education at Scandinavian universities

Lybecker Korning, Ida Marie; Nørgaard, Bente

Aalborg University, Denmark

Lifelong learning (LLL) and continuing engineering education (CEE) have been on the EU's agenda for almost three decades. It was formally initiated by the European Year of LLL in 1996 and since then reinforced with several initiatives targeted at LLL until the current initiative the European Year of Skills 2023 which aims to promote a mindset of reskilling and upskilling with the goal of meeting the needs of the European labor market. In 1996, however, some universities were already developing diverse CEE activities and acting in collaboration with external stakeholders such as the local industry. Many of these activities, however, have over the years been initiated by passionate university staff or based on personal relationships. The CEE activities have for most universities been an unregulated area and sideline activities, and at some institutions, it is organized in private units associated with the university. This is even though the individual Scandinavian countries have national policies of education, and each university has more or less explicit vision and strategies for CE activities.

This research will aim at answering the question: How European initiatives and Scandinavian national strategies support the implementation and development of CEE and further try looking into the crystal ball to see what actors in CEE believe will be the future of CEE in the Scandinavian countries. The study will document the current state of the initiatives and strategies and based on 20 interviews from 10 Scandinavian universities analyze what actors of CEE believes will be the future of CEE.

Transnational collaboration on lifelong learning between higher engineering education institutions: A university perspective

Bennedsen, Jens¹; Øien, Geir Egil Dahle²

¹Aarhus University, Denmark; ²Norwegian University of Science and Technology, Norway

Lifelong learning (LLL) is in focus in all European countries. Workforce upskilling and reskilling are seen as central elements in ensuring national competitiveness.

Universities are main players in this effort but often find it difficult to find sustainable models for LLL activities, in terms of e.g., economy, student intake, and academic resources. Collaboration between universities can be one possible way forward to overcome such obstacles, and given the enhanced post-Covid digitalization is also increasingly made possible, even across borders. However, many universities also find such collaboration challenging, e.g., due to outdated legislation, lacking financial predictability, lacking academic capacity, or other factors. Studies done by the authors indicate that universities' perspectives are seldom present in the literature when barriers and enablers for LLL participation are analysed. This motivates us to particularly consider a university perspective here.

This paper analyses responses to a questionnaire sent to 28 Nordic and Baltic universities, collecting information about successes, opportunities, and barriers for formal (i.e., ECTS-awarding) university-level LLL with professional content within engineering and technology. The respondents were management representatives representing an institutional view and having good knowledge of the institution's LLL offer (e.g., further education centre managers and LLL coordinators). 19 institutions answered, mostly with free text. Our analysis is done following constructivist grounded theory using an open and focused coding approach. The main aim is to identify the main barriers and success factors seen by the universities for upscaling LLL activities, and subsequently to suggest strategies for alleviating barriers and facilitating success factors.

The Relationship between Vocational & Higher Education: Time for a Re-Charge?

Silverstone, Benjamin; Clark, Robin; Andrews, Jane

University of Warwick, United Kingdom

In both the UK and EU there is a growing awareness of the need for Higher and Further Education (HEIs / FEIs) institutions to work together to provide high quality engineering courses able to meet the needs of an increasingly technical and knowledge-based economy[1],[2]. This paper focuses on learning and teaching in one particular engineering area, that of 'electrification', it reflects upon moves to create a regional multi-level educational strategy built upon the development of expertise at partner FEIs.

As one of the UK's leading Engineering Education providers at tertiary level, WMG is leading this boundary-crossing project. An Action Research approach has been developed that transcends organisational competitiveness by creating a multi-level approach to the provision of electrification skills amongst the population of the West Midlands.

Four different project objectives have been developed:

1. Analyse stakeholder need from the perspective of employers, students and colleges.

2. Analyse extant provision per FEI in terms of physical and human resources
3. Identify any gaps in provision of training available within the region.
4. Develop a plan for the establishment of Centres of Excellence across the region.

This paper critically discusses the need for synergising provision within what is very much a Quasi Market[3]. It argues that rather than compete with each other, FEIs need to be working together, and in partnership with HE, create high quality, industry driven and cohesive regional provision. In an emerging field such as 'electrification' (of transport and in terms of new battery technologies), the need for regional focus and expert leadership has become increasingly important.

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Paper Session 3-16: Engagement with Industry and Innovation 3

Time: Wednesday, 13/Sept/2023: 4:00pm - 5:00pm · Location: EQ-208 Flat Room
Session Chair: Janusz Szpytko

Job Competency; experiential learning for engineering students

Goold, Eileen¹; Roland vanOostveen, Roland²

¹Technological University Dublin, Ireland; ²Ontario Tech University, Canada

This study investigates engineering education in the context of career focused education. Often the technical and mathematical sciences on which engineering courses are built do not explain the landscape of practice. The main objective of this study is to capture the knowledge and meaning an undergraduate student constructs from the social interactions and experiences in an authentic workplace and the student's responses to real-world contexts.

A single case using purposeful sampling is employed to investigate the phenomena of transitioning from engineering education to practice with one intern as the context. The intern is an information-rich case and his story provides a detailed insight into the complexity of a student's first encounter with engineering practice.

This study highlights the conflict between engineering practice and engineering education and the corresponding emotional transition for graduate engineers. In particular, this study gives an intern's perspective of transitioning from education into practice and his emotional journey of self-learning, adapting to new situations, focusing on clients' requirements and finding his place on the engineering team. The intern's story supports the advocacy to reshape university engineering education so that students' values, practices and expectations align better with practice.

Equal partnership between engineering education and industry – A needs analysis

Verdegaal, S ophie; Den Hertog, Janina; Visscher-Voerman, Irene

Saxion University of Applied Sciences, Netherlands, The

One of the aims of the TALENTS-project is to create (interdisciplinary) learning communities in which engineering professionals, students, teachers, and researchers can learn together and collaborate as equal partners, within the context of authentic challenges, starting from their individual learning goals. To what extent are partners willing to participate in this partnership and under which conditions do they consider it to have added value? We conducted individual interviews with engineering students (N=11), teachers (N=12) and professionals (N=10) about what they require to participate in the learning community, employing epistemic, spatial, instrumental, temporal, and social elements of learning environments. We also inquired which resources participants were willing to invest. Data were summarized on group level in a within-group matrix, following these elements. Next, we employed a cross-group analysis, focusing on commonalities and differences. The most striking results were found in the epistemic, social, and instrumental elements. Respondents have similar needs when it comes to improving dialogue to formulate a challenge. However, professionals prefer to have more influence on formulating this challenge and its output, whereas teachers wish to focus on students' development. Students wish to co-create with partners and they place importance on matching students with a challenge that aligns with their educational background and personal interest. To create an environment based on equality, students need traditional roles of teachers, clients, and students to be less apparent. Ultimately, almost all respondents are willing to co-operate as equal partners in the learning community because they can see it leads to added value.

Engineering students reflect on work-life relevant learning

Bj rn, Camilla; Edstr m, Kristina; Kann, Viggo

KTH Royal Institute of Technology, Sweden

As engineering education is a professional education, it should prepare students for working life. The question is to what extent the educational programmes succeed in doing this. This study investigates this matter from a student perspective, guided by the questions: What competencies do the students view as work-life relevant? How do students reflect on their opportunities to learn these competencies? The context of the study is the five-year Master of Science in Engineering programme in Computer Engineering at [University]. It contains a programme-integrated course, with four seminars in each year of the programme. During their fourth year, as an assignment in this course, the students reflected on their own readiness for working life. This study is a thematic analysis of 38 such written reflections, each of 500-1000 words. We find that students expressed an elaborate view of what constitutes work-life relevant competencies. They readily identify learning experiences in the programme where they have developed such competencies, for instance through projects. They also show an understanding that there are limitations in the ability of the university environment to achieve fully authentic learning experiences. Many students see it as their own responsibility and necessity to complement their education with other opportunities for work-life relevant learning, such as hobby projects or internships. Others seem relaxed about any gap they may have in their work-life preparation and expect to learn on their first job.

Entrepreneurship Education: creating a positive adrenaline

Bordonau, Josep¹; Bolibar, Oier²; Filba-Martinez, Alber³; Nicol s-Apruzzese, Joan¹; Busquets-Monge, Sergio¹

¹UPC-BarcelonaTech, Barcelona, Spain; ²Business Advisor, Barcelona, Spain; ³UPC-BarcelonaTech & Catalonia Institute for Energy Research, Barcelona, Spain

A method to develop Entrepreneurship Education in any regular Engineering course is presented. The method is based in a team of students working on the description of the idea for the development of a real start-up using a structured approach trained by a business advisor and by the teacher. The team analyses the problem, the potential market, the solution, the development and the financing challenges of the start-up. The team works the Case development along an Engineering Course related with the technology of the start-up. The dedication of each student to the Case development is 25 hours, working along the different phases of the analysis and synthesis, mentored by the business advisor and the teacher. The added value of the experience is based on: first, the preparation and development of a 1 hour interview of the student team with one of the founders of the company, usually the CEO; second, a weekly validation of the technological value proposition with the business advisor, as part of the analysis. Along with the interview, the student team will consolidate their findings and debate with the CEO about their own ideas, being a process full of positive adrenaline and creating a very significant engagement along the whole course. The approach has been tested in two academic years, working 4 cases with the collaboration of 4 start-ups of EIT InnoEnergy. The results of the surveys demonstrate the validity and engagement level of the approach.

Paper Session 3-17: Engineering Skills 4

Time: Wednesday, 13/Sept/2023: 4:00pm - 5:00pm · Location: EQ-117 Tiered Room
Session Chair: Helena Kovacs

Validity of Student Professional Practice Competency Claims

Lowe, David; Kadi, Anthony

The University of Sydney

The University of Sydney has introduced a program of engaging engineering students throughout their degree program in diverse forms of self-selected exposure to, and engagement with, professional practice. To gain recognition of completed activities students are required to submit "claims" that include identification of the core competencies that were developed and demonstrated during the activity, along with a detailed reflection on their learning. Given that the claims are highly individualised and often unsupervised, assessment is predominantly limited to evaluation of the reflections along with evidence of the activity.

A key question in the program relates to the validity of the assertions made by student regarding the competencies that have been demonstrated. In this paper we report on an analysis that compares student claims regarding competencies that were developed with the language contained within their reflections, and the extent to which those reflections focused on the competencies specifically being claimed.

The results suggest that for claims related to some competencies, such as team skills, the student reflections do indeed tend to include a stronger focus on that competency. Conversely, for other competencies, such as understanding of the underpinning sciences and engineering fundamentals, the reflections are much less clearly connected to the competency. This may be the result of greater diversity of understanding, but we also consider the possibility that it may relate to less clarity by students regarding the language used in reflecting on these competencies, and the implications of this for the development of their understanding.

Soft Skills of Engineering Students

Barakat, Nael¹; Shekh-Abed, Aziz²

¹University of Texas at Tyler, USA; ²Ruppin Academic Center, Israel

Soft skills are a combination of personal qualities and interpersonal abilities that enable individuals to work effectively with others, communicate clearly, and collectively solve problems. Soft skills are required for effective problem-solving and decision-making. Soft skills, such as communication, teamwork, and empathy, are essential for developing a collaborative culture that encourages high order thinking and building relationships. By developing these soft skills, engineering students can improve their chances of success both in their academic pursuits and in their future careers.

The goal of the study was to evaluate soft skills among engineering students, to provide insight to educators that can help in designing better activities which integrate both skillsets holistically and efficiently. 92 Students were asked to fill out anonymous Likert-like questionnaire about their self-reported soft skills. The findings indicate no significant differences between students based on extrinsic factors (gender, campus, department and class), which may lead to both theoretical and educational implications. These findings can be utilized to formulate recommendations for combine soft skills into the engineering curriculum.

Multicultural Online Collaborative Learning: Students' Engagement in Design Thinking Framework

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¹Ritsumeikan University / Shiga, Japan; ²Universitas Negeri Jakarta / Jakarta, Indonesia.; ³Universiti Teknologi Malaysia / Johor Bahru, Malaysia; ⁴King Mongkut's University of Technology Thonburi / Bangkok, Thailand

This paper presents a collaborative learning course in which students from four universities in different Asian countries work in mixed teams to learn how to develop user-centered products and solve problems in a hands-on way using the Design Thinking framework. For the past three years, the courses were conducted entirely online.

Cooperation and collaboration among diverse people from different backgrounds is essential to solving the social problems facing the world today. Like many universities, we have been actively sending our students abroad to provide opportunities to experience diverse cultures and values, but the pandemic has made it very difficult to travel abroad for the past three years, forcing universities to shift from face-to-face classes to online classes. The pandemic has made it extremely difficult to travel abroad for the past three years, and universities have been forced to shift from face-to-face classes to online classes. During this time, four Asian universities, to which the authors belong, have jointly launched an online problem-solving collaborative learning course aimed at supporting students to "No one will be left behind," as stated in the SDGs.

The structure of the course, profiles of participating students, improvements to the course, student evaluations, and challenges found are described.

Exploring the impact of Problem-based learning on student learning outcomes: Findings from the PBL South Asia project

Jurelionis, Andrius¹; Stankeviciute, Gintare¹; Dhital, Avinash²; van Andel, Ellen³; Sundman, Julia²; Stasiuliene, Laura¹; Acharya, Shakuntala⁴; Subra, Riina²

¹Kaunas University of Technology, Lithuania; ²Aalto University, Finland; ³Delft University of Technology, Netherlands; ⁴Indian Institute of Technology Guwahati, India

Problem-based learning (PBL) is reported to have a profound impact on developing skills for industry-readiness in graduates. This paper presents the results of surveys conducted among students, mentors, and administrative staff in Nepal, Bhutan, and India, regarding the impact of implementing PBL methodology on multidisciplinary projects in engineering. The surveys were carried out under the Erasmus+ funded project, "Strengthening Problem-based learning in South Asian Universities" (PBL South Asia), which aimed to address quality education (SDG 4), sustainable cities and communities (SDG 11), and employability in the region by enhancing students' skills, such as practical experience, communication skills, teamwork abilities, as well as academic knowledge. As a result, South Asian higher education institutions have introduced PBL courses in their curriculum.

The surveys were designed to evaluate how specific skills, developed through learning outcomes, were perceived by different stakeholder groups. Several methods were used for the assessment – open questions with tracking the keywords that the respondents use, as well as "EntreComp" framework which looks into how students assess their abilities to be curious and open, think sustainably, behave ethically, and cope with uncertainty and ambiguity.

Results of the survey showed that student participants have identified teamwork and collaboration, and communication and presentation skills as those most associated with PBL methodology. Among the self-assessed improvement in abilities, students have indicated their increased abilities to assess the needs of different stakeholders, combine different contexts, setting up strategies, which are consistent with earlier findings on critical thinking and problem-solving skills.

Paper Session 3-18: Teaching Technical and Digital Skills

Time: Wednesday, 13/Sept/2023: 4:00pm - 5:00pm · Location: EQ-118 Tiered Room
Session Chair: Henning Meyer

HELP – Home Electronics Laboratory Platform –Development and Evaluation

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In response to the COVID pandemic, many of our undergraduate students were supplied with custom development kits to undertake their electronic laboratory activities at home. Following our return to on-campus teaching we plan to combine on-campus laboratory sessions with at-home experiments taking advantage of both on-campus and at-home experimental work while avoiding some of the limitations experienced during remote teaching. The goal is to embed active learning as a key part of a long-term strategy to enable students to better manage their own learning and to maximise the analytical engagement with lecturers in a hybrid blend of on-campus and remote activities.

In this paper we report on three generations of the at home laboratory kit developed by the authors institute and partners in the Erasmus+ project “Home Electronics Laboratory Platform (HELP)”. The HELP kit comprises of a portable signal generator & measurement instrument and a custom electronic board, which includes several functional blocks alongside the usual breadboard for assembling circuits with discrete components. The motivation for the design of each generation is introduced and the desired functionality and its implementation are described.

The impact and user experience with the kits has been assessed through student surveys and staff focus groups in the HELP consortium partners. The main themes associated with take-home electronics laboratories have also been explored in a workshop with HELP partners and contributors from other universities across Europe and the USA. This work is summarised and future potential technical and pedagogical developments are outlined.

Nine years of systematic CAD course development: what did we learn?

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Computer-aided Design (CAD) has its role in the curriculums of mechanical engineering degree programs. The tools learned during CAD course help students to conceptualize and visualize their own designs and thus help them to be better engineers. During the years 2014–2022 a multi-CAD course with several hundreds of students from different disciplines, such as mechanical and civil engineering, was carried out. During each course implementation student feedback was systematically to collect to both help to get a better view of students learning as well as to get means to measure the success of different learning tools and methods tests.

The tools introduced included automatically graded quizzes and developing an own CAD model assessment system. These tools enabled to transfer teaching assistants' workload from assessment to guiding and supporting students. Additional surveys, starting and mid-term, were developed to better understanding the starting level of students and how they study during the course. All this development was helpful during the distant teaching times in the years 2020–2022, and the course was successfully transferred into full online teaching. Some practicalities from those times are taken to the everyday practicalities of the CAD course teaching.

INSTRUCTIONAL CONSIDERATIONS FOR VIRTUAL REALITY IN ENGINEERING TRAINING AND EDUCATION: PRELIMINARY RESEARCH RESULTS

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Due to the potential of technology to improve the teaching and learning process, virtual reality has been steadily incorporated into every aspect of human civilization.

The study examines the most effective ways to use VR, utilizing the Oculus Quest 2 system, to raise the standard of modern training and improve the educational experience. The technical and educational points of view will both be taken into account.

More than 25 undergraduate students representing various profiles from engineering education comprised the research sample. The data was gathered in two stages: written questionnaires and short semi-structured interviews related to Oculus Quest 2 training sessions in which participants were exposed to live on board the International Space Station (ISS), including experiments and missions performed on the station.

The results of the brief interviews and questionnaires used in this study showed that every participant was very eager to work with and engage in virtual reality experiences in engineering education. Additionally, despite some students reporting small difficulties or challenges, they gave virtual reality glasses an overall user rating of very satisfactory.

The majority of participants responded positively to idea of future training and support programs incorporating VR equipment because they started to feel that the training sessions increased their motivation and passion for learning while also promoting the growth of their digital reality skills. Overall, the research's findings support the recommendation that digital reality be used more frequently in higher education programs because they demonstrate the tremendous value and advantages it can have.

What do engineers do with what they know: Observing specialized technical knowledge in practice

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¹University of Johannesburg, South Africa; ²University of Cape Town, South Africa

The gap between engineering education and practice has been subject to considerable research attention. We look at studies of engineering practice with a view to informing education. Our interest is in identifying technical knowledge and how it is used in practice, as well as what kind of technical knowledge is used but not taught. This paper seeks to systematically review the existing literature on engineering practice, drawing from and adding to a prior data set developed by Andrea Mazzurco and colleagues, who found that there was a gap in studies of specialised technical knowledge in practice. Investigating their dataset we found that rather than being absent, studies of practice have tended to background knowledge, by focusing on professional skills and attributes and obscuring the role of specialised technical engineering knowledge. In engineering education and practice, surveys of ‘what graduates need’ tend to separate out graduate attributes from specialised engineering knowledge; however, detailed, qualitative studies show the extent to which these graduate attributes are intertwined with specialised knowledge. This paper focuses on research studies that include an observational component. In total, 24 papers were analysed with a view to answering the research question: what do observational studies of engineering practice tell us about specialised engineering knowledge? We examine how knowledge was constructed by the authors, usually as socially mediated and embodied; but also at how knowledge was used by participants, generally as foundational to reasoning but in tacit ways.

Paper Session 4-01: Virtual and Remote Education Post Covid 3

Time: Thursday, 14/Sept/2023: 9:00am - 10:00am · Location: EQ-002 Lecture Hall
Session Chair: Joseph Little

Rethinking the Nature of Experimental Learning: Moving Beyond Conventional Laboratory Experiences

Lowe, David

The University of Sydney, Australia

Laboratory experimentation is an important educational tool across many disciplines, providing a mechanism for students to enhance their understanding of the relationships between theoretical models and physical reality. However, whilst laboratories are used extensively, the existing approaches to experimental learning have evolved little in the last 100 years, the intended learning outcomes are often poorly articulated and the connection between the learning outcomes and the student experiences is unclear. These limitations have meant that the development of laboratory experiences has tended to be driven by a combination of history, the capability of physical laboratory environments, and technological opportunity (e.g. the feasibility of rich simulations or remotely accessed laboratories) rather than pedagogic considerations or a deeper understanding of the role of experimentation within the educational process. Indeed many "new" laboratory innovations tend to only be technologically-enhanced versions of conventional experiences rather than leveraging the affordances of new technologies. In this paper we explore the nature of experimental learning and the extent to which we can achieve improved educational outcomes by a reconceptualization of the nature of this form of learning.

Learning Through Screens During COVID-19 Crisis: Foresee Tomorrow's Education by Analyzing Yesterday's Setbacks and Barriers

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This paper aims to enrich the state of the art on engineering and management learning and education by shedding light on the barriers encountered during the COVID-19 crisis due to the imposed digital transformation. Our research question is: what were the barriers encountered in remote and hybrid learning during pandemic experiences and what lessons can be drawn for higher education in the context of Problem-Based Learning (PBL)? This paper aims to enrich the debate on how digitalization impacted the learning and teaching experience in teaching modules traditionally achieved face-to-face.

To investigate our research question, we adopted an abductive, quantitative, and qualitative approach through a case study methodology. Based on our literature review we proposed a five-fold barriers taxonomy: (a) technical, (b) anthropologic, (c) epistemic, (d) didactic, and (e) financial barriers faced during the technology-intensive learning experience. These barriers have been audited in the context of a French engineering school. The analysis of the barriers confirmed by the field study made it possible to highlight three must-do actions: (A) develop the ability to learn, (B) develop agility, and (C) empower teachers and students. These actions aim to ensure better quality and resilience of the future learning process in the post-covid world.

Experience with remote laboratories for on-campus engineering degrees

Reid, David P.; Drysdale, Timothy D.

The University of Edinburgh, United Kingdom

Remote laboratories extend the teaching and learning opportunities available for on-campus courses, by increasing the overall capacity for practical work and enabling new types of activities. We present three case studies from different types of usage within the School of Engineering at the University of Edinburgh over the last three academic years. Each case study provides an overview of the experimental hardware and user interface, the learning context and reflections on their development from our perspective as providers of the system. The case studies include a spinning disk lab that allowed students to complete assessed coursework during the Covid-19 pandemic; a pendulum lab that provided large cohorts of students access to lab equipment in a traditional classroom setting with in-person peer-to-peer and peer-to-staff interactions, but with remote equipment; and a truss lab that was used to provide live lecture demonstrations and real-world data for tutorial questions. Our remote laboratories have been successfully used under both pandemic and post-pandemic conditions, with ongoing usage growing. The software and hardware is open-source so as to enable adoption by a wider community of users.

Paper Session 4-02: Health and Well Being

Time: Thursday, 14/Sept/2023: 9:00am - 10:00am · Location: EQ-116 Flat Room
Session Chair: Sharon Feeney

Delivery of mental health training across a College of Engineering

Wilson, Sarah; Blaber, Isabelle; Hancock, Joshua; Pitcher, Gabriella; Hammer, Joseph
University of Kentucky, United States of America

Mental health is of significant concern across College and University campuses. Within engineering, students have identified that they would be more likely to seek mental healthcare if referred by a student or faculty member. Therefore, this research to practice study aimed to encourage students to become advocates and referral agents for students in mental health distress. To accomplish this, engineering-specific mental health and wellness training was developed through the integration of quotes and data from engineering students, personalizing the training to the engineering experience. To reach nearly all engineering students (over 2,500 students), the 15-minute training was delivered in over 60 courses. The courses were selected such that nearly all students in all years of study received the training, and preference was given to courses taught by faculty who would: 1) Support integration of the training into their course, 2) Encourage a positive narrative around prioritizing mental health, and 3) Represent the demographics of students and faculty within each program. Three graduate students from Counseling Psychology were hired to schedule and deliver the training. Pre- and post-test data found that students' perceived knowledge about mental health resources and signs of a mental health concern increased. There was no change in intention to seek help. Moving forward, the training will be offered to all students on a yearly basis to 1) provide students with an up-to-date list of mental health resources on campus and 2) remind students of the importance of advocating for themselves and their peers.

Moving Constructive Alignment beyond the Curriculum: Embedding Mental Health and Wellbeing into the UK Engineering Student Experience

Palmer, India; Knowles, Nicky; Andrews, Jane; Clark, Robin; Cooke, Gill; Knowles, Graeme
University of Warwick, United Kingdom

This paper addresses the question of how the Engineering Curriculum can be better designed so as to improve the mental health of university engineering students. Since the end of the Pandemic, the UK has seen an increase in the numbers of young people aged 18-25 self-reporting mental health problems (Young Minds, 2023). Taking a wider perspective, there has been a rise of 450% in the numbers of young people informing UCAS that they have a mental health problem over the last decade (NUS, 2022). Engineering Education has the lowest rate of self-declared mental health problems on application, with 1.4% of engineering students giving prior notice of mental health challenges compared with 3.7% of all applicants (UCAS, 2023).

In acknowledging that lower pre-reporting rates of mental health challenges are unlikely to reflect lower rates of mental illness or unwellness amongst our students, one of the driving principles of this project is to address the higher-than-average rates of attrition and failure amongst engineering students. Furthermore, in planning how the curriculum might be further enhanced so as to promote mental health, the need to develop 'authentic' engineering education experiences (Chang et al., 2010) is acknowledged to be central to student success.

In sum, in discussing the importance of embedding mental health into the engineering curriculum, this paper contributes to academic debates around the engineering student experience. It argues that there is a real need to extend the concept of constructive alignment beyond the curriculum and across all aspects of the student learning journey.

How to develop teachers' well-being?

Séllei, Beatrix; Lógó, Emma
Budapest University of Technology and Economics, Hungary

The well-being of teachers is one key to students' and education's success. As an innovative solution, we hold a training program for educators using design thinking based on the "Designing Your Life" program that can be familiar with engineering educators' mindsets. We adopted it for the Hungarian circumstances and made one pilot program and one real program with the self-applying teachers at the Budapest University of Technology and Economics. We surveyed teachers' well-being with the PERMA Profiler at the beginning of the program and one month after the program in both samples and had in total of 41 answers (n=23). Based on the results, such programs can help to enhance teachers' well-being, and in this way, universities can offer a better emotional climate and prevent teachers' and students' burnout.

Automatically scored, multiple-attempt, recurring weekly exams in a physics course: Can they improve student wellbeing and learning outcomes?

Suhonen, Sami
Tampere University of Applied Sciences, Finland

This paper describes the arrangements and assessment methods employed in an engineering physics online course offered by Tampere University of Applied Sciences. The grading process involves the use of automatically assessed weekly online exams in Moodle. The exams contained mostly numerical questions, but also conceptual questions, force diagrams, and multiple-choice questions. Students were allowed to attempt each exam three times, and their best score was recorded. The questions and initial values were randomized for each try to reduce possibilities for trial-and-error method and copying from peers. By completing the week exams with enough points, the students were able to pass the course with low grades. The main idea was to make the course completion more flexible and time and place independent and reduce exam stress. It also reduced teachers' workload in relation to assessment and retakes. Most students took more than one attempt in the exams, and the majority of students who initially scored low points showed improvement in subsequent attempts. According to student feedback, vast majority of students agreed that this exam arrangement worked well and that retakes reduced stress, was flexible and improve their learning experience and outcomes. Almost no one would like to change back to one-attempt exam checked by the instructor.

Paper Session 4-03: Innovative in T&L 7 - Teaching Skills

Time: Thursday, 14/Sept/2023: 9:00am - 10:00am · Location: EQ-211 Flat Room
Session Chair: Michael Carr

Development and evaluation of a teaching concept that focuses on increasing modeling competence in Technical Mechanics (TM)

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Engineering students often learn by retracing pre-calculated given solutions of tasks and try to understand this problem-solving way. This reconstruction is not always successful in solving new types of problem via modified tasks (Rossow, 2008).

Every mechanical exercise follows the same solution methodology (Müller-Slany, 2018). Applying this basic problem-solving structure correctly is a Pre-condition for solution's reflection and is therefore essential for teaching.

To improve these competencies a strategy training is implemented in exercise-settings in Technical Mechanics (TM).

By solving in separated model steps pre-structured exercises with differences in depth of structure and always visualizing these steps, the awareness and applying of each step should be increased. This research approach aims to investigate the effects of explicit strategy training on the problem-solving skills of engineering students in TM in an experimental design. Research Questions are: what influence does the strategy training have on the knowledge and recognition of the model? What influence does this training have on correct application of this methodology? What influence does this application have on the correct solution of tasks?

As part of a quantitative analysis a self-constructed test for measuring the modeling recognition in Multiple Choice format as well as a competence test to evaluate the application of the problem-solving model were implemented and tested. First results of the research design and the intervention itself are presented.

Flash Observations for Improved Teaching Quality Among Graduate Teaching Assistants in Engineering Education

Plumb, Sarah; Bates, Joanna; Lazari, Panos; Di Benedetti, Matteo

University of Sheffield, United Kingdom

To maintain high quality, when teaching practical activities at scale, sufficient Graduate Teaching Assistants (GTAs) must be employed. However, their pedagogical skills are inconsistent.

This research is a pilot study to test the reliability and validity of research methods which will be scaled up in their application to the primary research to identify GTA pedagogical skills requiring further training. In the primary study, staff and GTA perspectives will be collected using surveys, and the emerging deficient skills will be further investigated using novel twenty-minute "flash" skills-based teaching observations of GTAs. Observation time will be split among the GTAs, and the focus will be on using one of the single skills identified in the surveys by GTAs across the lab rather than how an individual uses it.

This paper documents a pilot study conducted to trial a selection of three bespoke observation forms based on asking questions (i.e., the observed skills). Reflections by four observers after eighteen observations indicated that twenty minutes was sufficient time to get a fair assessment of how the observed skill was being used. The format allowed researchers to give individual feedback to GTAs who requested it and provide insight regarding the use of that skill in the lab.

The researchers identified two critical factors for the successful launch of the primary study; assessing the lab settings - to avoid significant interference with the teaching - and identifying when in the session GTAs are expected to use the observed skill- ensuring that the short observation is timed effectively.

Improving Teaching Quality in Higher Education: A Practitioner's Guide to Using Formative Teaching Analysis Poll

Johannsen, Thies; Meyer, Henning

TU Berlin, Germany

Teaching Analysis Poll (TAP) has become an increasingly popular tool for evaluating teaching quality and enhancing learning outcomes in higher education. It requires, however, additional human resources. This paper presents a modified version for easy implementation: Formative Teaching Analysis Poll (FTAP). It can be used by individual educators and is nonetheless an effective practical method for practitioners in higher education to improve their teaching quality and enhance learning experiences of their students.

We provide an overview of the underlying methodology of FTAP, its benefits, and how it can be effectively implemented in higher education. FTAP involves collecting formative feedback from students on various aspects of teaching and learning methods, formats, and quality. It may include instructional methods, course design, and student engagement. The collected data is then analysed to identify areas of improvement and to inform teaching practice.

The paper highlights the benefits of FTAP for educators, including the provision of valuable feedback and means to implement it into an ongoing course. FTAP not only contributes to enhance teaching performances but is a powerful instrument to involve students and learners in the design and creation of a learning environment based on their needs. Illustrated with a case example, we show how by actively engaging in the learning process students reflect on their individual needs and take ownership for their education. In conclusion, this paper provides practitioners in higher education with an experience based, practical guide to evaluate their pedagogical and didactical approach, improve teaching quality, and enhance student learning experiences.

Teach as you Preach: Teacher Training for STEM-Educators at DTU

Rattleff, Pernille; Sass, Ditte Strunge

Technical University of Denmark, Denmark

At technical universities today, we are training students for jobs that do not yet exist, to use technologies that have not been invented, to solve problems, we do not even know are problems yet. To succeed, we must create sustainable learning processes allowing our students to construct proper conceptual understanding and be able to retrieve, transfer, and apply knowledge, skills, and competences in new complex settings.

To facilitate such learning processes, higher education institutions must train excellent teachers. This paper presents the framework for STEM teacher training at the Technical University of Denmark. A framework that claims exactly to train excellent teachers by practicing what we preach: Employing a student-centred approach focusing on student motivation with active learning and constructive alignment to ensure conceptual understanding.

Rather than presenting long theoretical lectures to the participants of our teaching training programme, we – from day one – ask them to engage in a range of carefully planned activities designed to scaffold the construction of sustainable knowledge, skills, and competences that can be activated in unknown future contexts. Exactly as we wish for them to do with their own students.

Paper Session 4-04: Climate Change and Sustainability 6

Time: Thursday, 14/Sept/2023: 9:00am - 10:00am · Location: EQ-203 Flat Room

Session Chair: Emanuela Tilley

A theory-based teaching concept to embed Sustainability in the Engineering Curriculum

Block, Brit-Maren; Guerne, Marie Gillian

Leuphana University Lüneburg, Germany

The implementation of sustainable development and the responsible use of the resources are among the key objectives of our time. To meet the challenges, young professionals with a growing set of skills are needed. Higher education is crucial in fostering the skills graduates need to become agents of change for sustainable development. Therefore, new teaching and learning approaches are needed in the engineering curriculum that link technical and sustainability-oriented topics.

Studies show that there is a particular lack in the design and implementation of engineering courses that address sustainability-oriented issues and contribute to the promotion of the new required competencies. This practice paper addresses this gap, in which the authors present a teaching example for sustainable engineering education.

The article presents the implementation process of a research-based concept in WiSe 22-23. The aim of the master module is to expand and strengthen students' competencies in the field of sustainability. Various didactic teaching and learning methods were used, such as the flipped classroom approach, game-based learning and interactive learning. Thus, an attempt was made to combine learning aspects from education, sustainability and engineering and thus to ensure more sustainability in the engineering curriculum. The article provides an overview of the structure and the most important components of the module. The knowledge gained will contribute to the evidence-based implementation of sustainability in the engineering sciences. The presented results and findings should serve as a basis for discussion for the community and contribute to the further development of sustainable technical education.

THE ART OF REPAIRING - OR HOW TO TEACH ENGINEERING STUDENTS SUSTAINABLE DESIGN PRINCIPLES

Kühne, Stefan; Forbrig, Christian; Marckwardt, Anja; Kober, Julian; Rappsilber, Juri; Oberschmidt, Dirk

Technische Universität Berlin, Germany

Project-based learning bridges the gap between theoretical training and practical applications. The motivation of students to participate is increased especially by working out real-life problems. To provide this kind of practical learning experience, we are establishing a repair project for broken, otherwise discarded, lab equipment. It will not only help to reduce waste and save money by repairing research equipment, but will also encourage interdisciplinary collaboration and innovation. Providing a space to learn about the underlying functional properties of various often highly specialized lab instruments, students identify malfunctions, deepen understanding of vulnerable designs, and discuss and perform strategies for repairing them under guidance, while collecting credit points. Through gaining a deep understanding of how these instruments work, students may even invent new strategies to realize similar tasks or add new features. This project builds on the findings from a 2021 pilot study. We discovered that by offering a repair project, students were able to gain a deeper understanding of theoretical concepts, improve their self-confidence as well as their motivation in learning, and increase their awareness of sustainable design. In the following, we are presenting the transformation of the pilot study into a current course concept. With weekly mini-evaluations we are monitoring students' learning success towards their learning goals and share the results.

Engineering for One Planet: Resources for infusing sustainability and leadership competencies across all engineering disciplines

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¹The Lemelson Foundation; ²Alula Consulting; ³ABET

Engineering for One Planet (EOP) is an initiative to transform engineering education and equip all future engineers across all disciplines with the fundamental skills and principles of social and environmental sustainability.

Catalyzed by The Lemelson Foundation and VentureWell in collaboration with hundreds of sustainability advocates across sectors, the EOP initiative envisions a world in which all engineers play a critical role in ensuring that the solutions of today do not become the problems of tomorrow, restoring and regenerating our environment, and improving lives for all.

EOP is accelerating curricular transformation by supporting faculty change efforts and fostering cross-sector collaboration for systems change. Experts from academia, civil society and government co-developed the EOP Framework in 2020, including core and advanced sustainability and leadership learning outcomes, and five universities pilot-tested it for two years. Revised in 2022, the EOP Framework also maps to ABET Student Outcomes in Criterion 3. In 2023, EOP launched companion teaching guides with step-by-step guidance and free teaching resources for integrating learning outcomes from the EOP Framework.

To date, hundreds of faculty have used the EOP Framework to generate curricular changes in diverse engineering disciplines and programs, impacting hundreds of courses and thousands of students. EOP makes its teaching tools available for free and is designed for flexible adoption and adaptation to encourage rapid expansion of sustainability into engineering education.

This presentation will enable participants to learn about the resources available through EOP, gain ideas from successful curricular change approaches and get involved in EOP's growing global community.

Addressing the Challenges of Climate Change and Sustainability

Dornick, Sahra

Technische Universität Berlin

The issues of climate change and sustainability are urgent and critical concerns of our time. The rise of climate disasters, such as floods, droughts, forest fires, and hurricanes, poses a threat to the survival of humans, animals, and plants. Despite scientists having warned about the impending dangers of high CO₂ emissions, particularly from the global North for many years, there has been no political or technical solution in sight.

Engineers are known for being problem-solvers, but what happens when the problem is complex and the consequences of technical interventions are hard to predict? In my paper, I propose measures to sensitize engineers to the complexity of climate change and sustainability. Based on the method of focused ethnography, I draw on Feminist teaching methods, my extensive teaching experience in the field of transdisciplinary gender research in science and technology studies, and my observations during the international "Winter school of ENHANCE on gender and diversity in science, technology and society" at Technische Universität Berlin in 2023.

The paper concentrates on the content and pedagogical approaches that can be used to convey the complexity of the issue while fostering the development of critically reflective knowledge. By incorporating these measures, engineers can be better equipped to tackle the challenges posed by climate change and sustainability in a more holistic and thoughtful manner.

Paper Session 4-05: Teaching Professional Skills

Time: Thursday, 14/Sept/2023: 9:00am - 10:00am · Location: EQ-204 Flat Room

Session Chair: David Kennedy

COMICIR- COMMERCIALIZATION OF INNOVATIVE CHALLENGES FROM INDUSTRY AND RESEARCH (PRACTICE)

Norrman, Charlotte; Moshfegh, Ali; Engzell, Jeanette

Linköping University, Sweden

At Linköping university, a model to facilitate impact and bridge the gap between research, education, and business creation, has been developed. It is named "ComICIR", which stands for Commercialization of Innovative Challenges from Industry and Research. The model allows researchers, firms, and students to work in a co-creation process that are built on the following five steps: (1) research validation, (2) idea generation, (3) idea validation, (4) idea evaluation and, (5) innovation strategy. In the paper, we describe the model and analyse how challenges and ideas could be developed and experientially based pedagogical approaches could be adjusted in order to benefit the regional ecosystem of research, education and industry and contribute to reaching increased impact of innovative ideas and ventures. Our main finding is that CBL is beneficial but requires close cooperation between teachers and innovation support actors. Flexibility is needed to fit the purpose of the course as well as the needs of the challenge providers. Hence, challenges need to be categorized and qualified to take into account the aim and scope of the challenge as well as its degree of development as this affects how the challenges should be written and treated to get the best outcome.

Re/upskilling the agricultural labour force: Micro-credentials as innovative LLL strategy

Vidric, Vladana¹; Paulus, Christina¹; Grebner, Simon³; Treiber, Maximilian³; Mayr, Martin¹; Mandler, Andreas²

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Industry 4.0 had a strong impact on globalization by changing the workforce and increasing access to new skills and knowledge. According to the World Economic Forum by 2025, 50% of all employees will need reskilling due to adopting new technology. Industry 5.0 addresses long term prospects such as sustainability, resilience and human-centricity regarding efficiency and productivity. Agriculture is the most exposed economic sector to climate change with cascade effects on agro ecosystems. Innovations in the agricultural sector are inevitable to ensure food security and social and environmental sustainability.

This paper presents Erasmus+ projects that highlight the importance of future engineering education in the agricultural sector considering change drivers and challenges (e.g., climate change, labour market needs, digitalization, pedagogical approaches, micro-credentials). The goal is to provide holistic competence-based education that helps learners develop sustainability skills for responsible action. Therefore, we combine the innovative pedagogic approaches with substantial content, to allow up/reskilling in a short period of time. We consider opportunities and limitations and how comprehensive engineering courses must be designed to be effective. We present (compare) innovative learning approaches in the realm of agricultural engineering and evaluate the efficiency of short courses (6 ECTS), micro credentials.

Analysing the experiences of several courses conducted at different European universities in past years, we can conclude that if the right pedagogic methods are paired with substantial content, up/reskilling is possible in short period of time (6ECTS). Main beneficiaries are farmers, life-long learners, partners of the project, associated partners, and students living in rural areas.

Formulation of the FIRIS-P Professional Core-Competency framework for Flexible Academic Curricula: The Biomedical Engineering Program

Buitenweg, Jan R.

University of Twente, Netherlands, The

Introduction – How to formulate the goals of an academic educational program in such a way that they reflect the identity of the profession, but at the same time allow the flexibility required for self-responsible and self-directed individual study paths that can initiate lifelong learning and successful interdisciplinary collaboration after graduation? Here, we present a novel competency framework that (1) reflects the identity and academic level of the interdisciplinary Biomedical Engineering (BME) profession, (2) permits the alignment of program intended learning outcomes that accommodate the content of the different specialisation tracks of the BME program and (3) guides students and staff by improved curriculum mapping and optimization. **Methods** – We collected input from teaching staff members who are actively practicing their BME profession in the interdisciplinary ecosystem around our university. Using their feedback, we iteratively formulated a set of core competencies that characterize the work and role of the BME professional. We obtained preliminary face-validity by performing curriculum mappings from several courses from BME-tracks and by asking feedback from students. **Results** – The iterations resulted in the FIRIS-P competency framework including five successive core professional competencies of which specified subcompetencies carry the BME identity: (1) Fundamental competencies, (2) Instrumental competencies, (3) Reasoning competencies, (4) Interventional competencies, and (5) Societal competencies. These core professional competencies are completed and supported by transferable Personal competencies. **Discussion** - Preliminary validation indicates that the FIRIS-P framework carries all three characteristics mentioned above, warranting future evaluation of its merits for education of lifelong learning BME professionals.

Communicating complexity to prepare for complexity

Lilledahl, Magnus

Norwegian University of Science and Technology, Norway

A trend in higher education is a stronger focus on the content of a study program as a whole rather than the individual courses that make up the program. The Norwegian university of science and technology (NTNU) has recently completed a large project, The future of technology studies (FTS), that attempt to describe how study programs should prepare students for a technological career in a rapidly evolving society. A central recommendation from the project is the necessity of an integrated, program-driven curriculum. This is especially true for sustainability. Hence, there is a need for a useful description of the content at the program level. However, a typical description of the learning outcomes of a study program is very brief, often just a set of bullet points that is in no way sufficient to describe the complexity of a study program.

Two study programs in physics and mathematics at NTNU are in the process of revising the study program following the recommendations of FTS. We found that the current framework for documenting the content of the study program is not sufficient. We are proposing a new scheme where the content is documented in a master document. Some new features of the master document that are typically not part of conventional program descriptions are: Specific target audience, not only what but also what not, and why and why not, using a natural language, and maintaining complete revision history.

Paper Session 4-06: Engineering Skills 2 - Self Reflection

Time: Thursday, 14/Sept/2023: 9:00am - 10:00am · Location: EQ-112 Flat Room

Session Chair: Tinne De Laet

PROFESSIONALISING SCIENCE AND ENGINEERING TEACHERS IN GUIDING AND ASSESSING REFLECTION

Mittendorff, Kariene; Eshuis, Elise; Daggenvoorde-Baarslag, Heleen

Saxion, Netherlands, The

The current knowledge society of the 21st century requires students, among other things, to have the ability to think reflectively. Various studies show however that educational programs and teachers, from engineering programs in particular, experience difficulties in integrating the development of students' reflection skills in their curricula. This gave rise to a multi-year project on improving reflection in engineering educational programs. We worked with teacher teams of 6 programs to improve their curricula and teacher practices regarding reflection. Part of the project were training sessions for teachers focused on guiding and assessing reflection activities of their students.

This paper presents a study that was conducted in relation to this training to gain insight into: 1) teachers' guidance and assessment skills and 2) the contribution of the training to any changes in these skills. A selection of teachers of the participating teams were interviewed before and after the training (N = 8). To gain insight into teachers' guiding skills, we designed video vignettes that depict multiple authentic, prototypical situations. Text excerpts of written reflection reports were used to unravel teachers thoughts and approaches regarding assessing students' reflections. The interview protocol aimed to elicit teaching interventions and actions regarding guidance and assessment of students' reflections and teachers rationales and thoughts behind these interventions and actions. Data-analyses are currently being finalized. Preliminary results indicate minor differences in teachers' guiding and assessment skills before and after the training; their skill repertoire seems expanded and questions they ask their students aimed at deeper reflection.

Improving communication procedures by means of videorecorded proposals

Aguilar, Marta; Olivella, Jordi

Univesitat Politècnica de Catalunya, Spain

There is an agreement regarding the importance of communication in the promotion processes of all types of technical or entrepreneurial initiatives. Communication skills have to make it possible to obtain the maximum interaction with the agents involved and facilitate the commitment of these agents to a project. In this context, communicators' erroneous perception of their own abilities and of how they are transmitting the information is a significant drawback that calls for improvement. Video-recording someone when speaking creates an impact on them given that the possibility of seeing themselves implies a significant change in the learning process.

This technique has been applied as part of the teaching activities in the energy engineering master at the Universitat Politècnica de Catalunya and InnoEnergy.

In the experience developed, the students follow a first block in which they analyse a technological opportunity and subsequently detail a proposal to develop this opportunity. Starting from some basic instructions, they prepare an oral presentation to deliver their proposal. This presentation is video-recorded. These recordings are the starting point of a second block of the course. In this block, some concepts and ideas on communication are presented. The different concepts make it easier to understand one's limitations and errors one may have incurred. Finally, a new proposal presentation based on the analysis and improvement of the previous presentation carried out is delivered.

We conclude that these procedures can lay the ground for novel guidelines in the area of communication skills for technological innovation projects promotion.

Can Students' Self-Efficacy Beliefs Explain Academic Motivation and Career Intentions?

Wimmer, Anna-Kathrin

Ludwigs-Maximilians-Universität Munich, Germany

In our technologized and increasingly complex world, jobs in STEM make a crucial contribution to innovation and sustainability. However, there are still many vacancies in this field. To tackle the shortage of professionals, it is even more important to successfully prepare qualified young people for engineering careers and foster competences that promote innovative and creative solutions. In addition to cognitive abilities, research has shown how self-efficacy, which describes confidence in one's own abilities to successfully overcome obstacles, can influence students' motivation, interest and therefore academic and vocational training success. Studies show that people with a strong belief in their own competence have greater persistence in completing and problem-solving tasks. Hence, this paper discusses how the students' own perception of self-efficacy can influence their interest in the subject, academic retention, and subsequent career intentions and success. To gain further empirical insights, data from the mixed-methods study "digiMINT" will be collected using narrative interviews with female pupils, STEM students and employees, as well as industry representatives. The aim is to understand conditions of engineering education and jobs, and additionally the perception of self-efficacy as a predictive factor of career intentions. Furthermore, it will be evaluated how self-efficacy can be cultivated as a valuable skill in engineering education and teaching additionally to cognitive skills. In long term, promoting a positive experience for students' own self-efficacy could support a sustainable integration into the labor market and equip future engineers with an interdisciplinary which is particularly relevant for complex tasks in an increasingly complex world.

Paper Session 4-07: EDI 7 - Recruitment and Student Experiences

Time: Thursday, 14/Sept/2023: 9:00am - 10:00am · Location: EQ-208 Flat Room
Session Chair: Michelle Therese Looby

A new approach to encourage the next generation of female engineers in Spain: a young and fresh podcast to attract more girls to the field: “Clau, quiero ser ingeniera”

Olea, Marta; Jiménez Leube, Francisco Javier; Rebollo, Claudia

Universidad Politécnica de Madrid, Spain

The underrepresentation of women in STEM fields is a complex issue with multiple factors that remain unclear. At Universidad Politécnica de Madrid (UPM), we have dedicated years to devising strategies aimed at attracting more girls to this domain. As the coordinating institution of the EELISA alliance, where we endeavor to define the European engineer, we confront gender inequality as one of the foremost challenges. To address this need, a 4th year student at UPM conceived an initiative: a podcast with three primary objectives. Firstly, it aims to highlight the accomplishments of female engineers who can serve as role models for girls. Secondly, it seeks to spark the interest of girls in pursuing STEM careers. Lastly, it aims to increase the visibility of current female engineering students. The student discusses engineering in a captivating manner, revealing the fascinating world of STEM. This informal conversation between two women resonates with girls, allowing them to envision themselves undertaking similar paths in the future. The content is readily accessible through popular social networks and platforms such as Instagram, TikTok, YouTube, and Spotify, which are frequented by young people daily. This ongoing project has the potential to significantly contribute to the rise in the number of girls applying to study engineering in Spain.

[1] European Engineering Learning Innovation and Science Alliance (**EELISA**) is the first alliance of Higher Education Institutions from different countries in Europe meant to define and implement a common model of *European engineer* rooted in society. <https://eelisa.eu>

Professional identity of female engineering graduates: an exploration of identity status through life history research

van Hattum-Janssen, Natascha¹; Endedijk, Maaik D.²

¹Saxion University of Applied Sciences, the Netherlands; ²University of Twente, the Netherlands

The number of students entering engineering programmes is too low to meet the need for engineering graduates. Still, many leave for jobs outside the technical sector right after graduation. Professional identity is a concept that helps to explain why they stay in or leave the technical sector (Cech 2014). It is the result of the process of professional socialisation. This study uses life history research to understand the professional socialisation of engineering graduates from kindergarten age until a few years after graduation. An analysis of the life experiences of male and female engineering graduates shows differences in how they describe moments of choice, reflecting different professional identity statuses of male and female graduates.

Experiences and career choices of female engineering undergraduates in China

Liu, Zeyi¹; Inês, Direito¹; Xu, Yuwei²

¹University College London, United Kingdom; ²University of Nottingham, United Kingdom

It is a global issue that the ‘pipeline’ leading to STEM occupations begins to ‘leak’ after graduation from STEM subjects, and the leakage tends to be much more severe for women. This study adds to current discussions on the underrepresentation of women in STEM fields, emphasizing the roles of gender and family engineering social capital in the career choices of female engineering students in China. The study follows an explanatory mixed-methods research design including a survey and interviews. The survey was completed by 508 Chinese engineering undergraduates at Chinese universities and created a quantitative descriptive landscape that situates the qualitative element of the study. Semi-structured interviews were conducted with 24 female engineering newly graduates to explain the underneath complexities of the quantitative discourse. Descriptive analysis of the survey data shows that women students, on average, tend to report higher engineering agency and more positive university experiences, but a weaker desire to pursue an engineering profession than men. This inconsistency can be partly explained by the qualitative finding that the hegemony of Confucianism shapes the specific gender norms towards engineering profession in China. Qualitative data also suggest that it is the “craze for Master’s degrees” in China that drives a number of women participants to take an MSc in engineering with the intention to work outside this field. However, having a family member working in engineering tends to provide overarching guidance for female engineering undergraduates to continue with an engineering profession.

What do we know about our first-year engineering students' backgrounds and experiences?

Buskes, Gavin; Rios, Shannon

The University of Melbourne, Australia

Students entering university come from a wide variety of backgrounds and experiences, with differing levels of knowledge and exposure to professional skills. However, university entry criteria typically focus on academic ability in particular subject areas such as maths and physics, but little information is known about students’ attitudes and abilities in a variety of other, important domains such as attitude towards engineering, communication skills and level of interaction with peers. Self-concept, a cognitive evaluation that an individual makes and customarily maintains with respect to themselves concerning their ability in a general or a specific area of knowledge, can be used to evaluate students’ perception of their attitudes and abilities across these previously unmeasured domains for academics to better understand the composition of the first-year student cohort.

In this paper, results of surveying approximately 350 first-year engineering students’ self-concept across several distinct domains are reported. Exploratory factor analysis was performed on the resulting data, yielding 8 composite factors comprising of a mix of the original domains. While students strongly associated academic ability with perceived skill in mathematics, there was a surprising pair of engineering factors that emerged – one that captures ‘engineering affect’ and one that captures students’ perceived relationship between engineering and creativity. It was also found that self-concept in peer interaction and communication skills were lowest out of the 8 identified factors. The results will be used to develop activities and programs to suit students’ needs, particularly in terms of improving peer interaction and communication skills.

Paper Session 4-08: Engineering Skills 3 - Sustainability

Time: Thursday, 14/Sept/2023: 9:00am - 10:00am · Location: EQ-117 Tiered Room
Session Chair: Keith Martin Sunderland

EXPLORING THE FABRICATION LAB CONCEPT FOR LEARNING SUSTAINABLE CO-INNOVATION IN INDUSTRIAL ENGINEERING EDUCATION – AN ACTION RESEARCH CASE FROM AUSTRIA

Erol, Selim; Grano, Alice

University of Applied Sciences Wiener Neustadt, Austria

According to recent studies, cooperative innovation between universities and industry, especially with small and medium firms, is not as frequent as expected. Case-studies of regional innovation systems have shown that open access to state-of-the-art research infrastructure, services, skills and activities are needed to achieve long-term innovation partnerships. Co-innovation requires particular skills beyond technical knowledge, which are not always addressed in engineering curricula at university. Fab labs are a concept that potentially fosters students in the acquisition of such skills. In this paper, we describe our experiences in designing, building and running a fab lab as a new element for industrial engineering education at our university in Austria.

Teaching Sustainable Logistics as a Project-Based Learning Course

Deckert, Carsten; Mohya, Ahmed

Hochschule Düsseldorf University of Applied Sciences, Germany

Sustainable logistics combines the task of the 6R of logistics (right product, right place, right time, right condition, right cost) with social and environmental sustainability, especially low emissions and low resource consumption. This means that a problem that is already challenging, namely planning, executing and controlling logistical processes, gets even more complex and requires aspects of systems thinking to incorporate environmental and social impacts. Classical approaches of teaching, e.g. lectures with presentations and short exercises on closed problems, do not do justice to the complexity and intricacies of the topic sustainability. In such a context, project-based learning (PBL) where students do group work on open-ended problems with real-world complexity seems to be a more adequate means to teach the subject.

The paper describes a PBL course in which students worked on projects to conceptualize micro-depots for parcel delivery in different areas of Düsseldorf. A micro-depot is a temporary storage location in a city from which parcels can be delivered by cargo bikes. The aim was to locate the micro-depot, design the delivery routes, check the feasibility and calculate the reduction of greenhouse gases and other emissions. The course was taught in cooperation with a partner from the courier, express and parcel delivery industry. The paper describes the experiences with the course and gives recommendations for a successful implementation of PBL in courses on sustainability.

Shaping a sustainable future through integrating sustainability, creativity and entrepreneurship in engineering education at Aalto University

Dziobczanski, Paulo Roberto Nicoletti; Kähkönen, Elina; Mitts, Håkan

Aalto University, Finland

To address complex societal challenges, such as the climate crisis, engineering students and professionals must be equipped with the skills to tackle these issues. Aalto University has acknowledged this need in its "Shaping a sustainable future" strategy. To effectively solve complex sustainability challenges, the strategy defines three cross-cutting themes as tools: *Solutions for sustainability*, *Radical creativity*, and *Entrepreneurial mindset*.

To support the strategy implementation, a "Shaping a sustainable future in education"-project was established in 2021. The project team is known as the Aalto Co-Educator team. This paper reports on the team's learnings from collaboration with the teaching faculty in preparing Aalto University students to tackle complex challenges.

The Aalto Co-Educator team provide support for the strategy by working with teaching staff to identify meaningful connections between the cross-cutting themes and education, and in this way implementing the defined strategy goals in programmes and courses. In practice, this happens on three levels:

- (1) programme development, where the team supports programme heads and staff in curriculum development;
- (2) course development, where the team supports teachers in planning and implementing their courses and;
- (3) competence development, where the team supports teaching staff through pedagogical training.

This paper is intended as a resource for engineering educators seeking guidance on integrating sustainability, creativity, and entrepreneurship into their educational activities. By implementing the practices developed by Aalto Co-Educator team, engineering educators can better prepare students to shape a sustainable future while equipping them with the skills necessary to tackle the most pressing challenges of our time.

Embedding competencies in sustainability and authentic learning experiences in Food Science Education through a study program-driven approach

Jakobsen, Anita Nordeng; Hoel, Sunniva; Jensen, Ida-Johanne

NTNU - Norwegian University of Science and Technology, Norway

The food sector is experiencing a substantial shift towards Industry 4.0 regarding technological solutions to ensure efficient and sustainable food production. To face the required changes and be able to influence and change existing systems, future candidates must have solid capabilities in their respective subject areas as well as generic skills such as critical thinking, reflection, communication, and teamwork skills.

At NTNU, a program-driven approach for embedding sustainability and authentic learning experiences in the bachelor program of Food Science, technology and sustainability was conducted. Thematic groups of staff members developed learning outcomes and learning- and assessment methods to ensure coherence in the study program. Sustainability learning outcomes are built into all program-specific courses. Case- and laboratory-based learning, problem-based learning, projects, and peer-review assessments have been included systematically, in addition to a mandatory internship period, to create authentic learning experiences and stimulate the development of generic skills. A significant action was establishing a course introducing sustainable food production in the first semester.

Data from an external periodic evaluation of the study program, national student surveys, and NTNU's candidate survey demonstrate a well-designed study program with high overall satisfaction among the enrolled students. Compared to other natural and technical science study programs, the program scored higher on most parameters related to contact with working life. Furthermore, the majority of the candidates reported that they had developed sustainability competencies during their studies.

Paper Session 4-09: Engineering Students - Self Development 2

Time: Thursday, 14/Sept/2023: 9:00am - 10:00am · Location: EQ-118 Tiered Room
Session Chair: Greet Langie

Exploring the link between spatial and communication skills in engineering students

Lynch, John William; Sorby, Sheryl; Murphy, TJ; Vinnakota, Manjeera; Shannon, Kelsey

University of Cincinnati, United States of America

Industry leaders rarely remark that the technical skills of engineering students are lacking; however, they frequently indicate that new engineers should be better prepared in communication skills, particularly written communication skills. Despite consistently cited poor written communication skills of our students, their visualization ability, or spatial skills, are typically excellent. Prior research has explored the importance of spatial skills for success in engineering and has demonstrated that spatial ability is a significant predictor for graduating from STEM fields. More importantly, spatial skills are malleable and trainable, so engineers with lower visualization skills can be trained to improve their chances of success in engineering. This research explores if these two phenomena are linked. In other words, is there a negative correlation between these two types of skills for engineering students? Do our students struggle to write about things that are inherently spatial? Data for this study was collected from first-year engineering students at a large university in the U.S. An online survey was administered that consisted of two validated spatial visualization tests, a verbal analogy task, and questions regarding students' perceived communication ability. Student scores on the spatial visualization tests are compared with their perceived ability to communicate and their verbal analogy scores. Results from this study will contribute to exploring the link between spatial and technical communication skills. Results can also inform the development of an intervention aimed at improving the written technical communication skills of our engineering students by helping them learn to write about spatial phenomena.

Engagement in technical student-run organizations: How do this effect the students' well-being and what does it mean to the future of education?

Sivertsen, Ingrid Berg

NTNU Norwegian University of Science and Technology, Norway

Loneliness among Norwegian students has never been higher than after the Covid-19 pandemic (Lervåg et al. 2022). In recent surveys, over 50% of Norwegian students report they felt troubled by loneliness (Lervåg 2022, Tekna 2022). One article written by a student representative implies that loneliness may be counteracted if engineering students participate in student organizations, and that the universities needs to facilitate for that (Nitschke 2022). Engineering students worldwide engage in student-run organizations (SRO) where they design, develop, and build technical solutions (Li et al. 2023, Dol 2016). At the Norwegian University of Science and Technology (NTNU) those student organizations are referred to as *technical student-run organizations* (TSRO). This study investigates what it means to be a part of a TSRO. The following three questions are asked: 1) How does it affect the students experienced well-being? 2) How does it shape their views on education? 3) What do they think are the benefits from participating in a TSRO? This study makes use of in-depth interviews, think-out-loud protocols, and the UCLA loneliness scale. Eleven engineering students from NTNU have been respondents for this study. They are all associated with different TSROs at NTNU. This study might give new insight to important factors of the student well-being after the COVID-19 pandemic, and how the COVID-19 pandemic has impacted our students' psychological conditions. Is there a potential in the TSROs that has not yet been unleashed?

An embedded intervention to support the development of student feedback literacy

Coppens, Kurt¹; Van den Broeck, Lynn¹; Winstone, Naomi²; Langie, Greet¹

¹KU Leuven, De Nayer Campus, Leuven Engineering & Science Education Centre (LESEC), Faculty of Engineering Technology, Engineering Technology Education Research (ETHER), Sint-Katelijne-Waver, Belgium; ²Surrey Institute of Education, University of Surrey Guildford, UK

Feedback literacy is an emerging concept. It is seen as an individual competency that facilitates taking an active role in contemporary feedback processes. As such, it is a valuable skill not only in the classroom, but also in students' future professional lives. This paper reports on a qualitative study of a learning intervention embedded in a lab series, aimed at developing first-year engineering students' feedback literacy. The intervention consists of a short e-learning module, a one-hour workshop, and two peer feedback assignments. The design of this interventional study is based on the comparison of an experimental group with a control group. Both groups participated in focus group discussions after the intervention (n=55). Findings were complemented by data from reflection logs collected at the end of the semester describing students' most important feedback experience (n=42). The results suggest that the learning intervention contributed to the understanding of the key concepts and principles of feedback literacy. Moreover, students in the intervention group appear to value their peers better and recognise their valuable contribution in the feedback process. Although students realise that easily applicable feedback, such as minor corrections, make a limited contribution to their learning, they still often prefer it because of the minimal time effort required. Based on the findings, the paper concludes with recommendations for both individual courses and entire programmes, such as encouraging reflection, and supporting students in storing and revisiting feedback.

A CULTURAL-HISTORICAL ACTIVITY THEORY APPROACH TO STUDYING THE DEVELOPMENT OF STUDENTS' DIGITAL AGENCY IN HIGHER EDUCATION

Ganduri, Lilian^{1,2}; Collier-Reed, Brandon¹; Shaw, Corrinne¹

¹University of Cape Town, South Africa; ²Cape Peninsula University of Technology

Researching classroom practice requires theoretical resources that can explain the variety inherent in such an activity as well as the dynamic nature of classroom practice. Cultural-Historical Activity Theory (CHAT) offers the possibility of accounts of social, cultural, and historical aspects of the context and of how students adapt and transform in these contexts. This conceptual paper engages with the relevance and utility of CHAT for researching student practices in a course as an activity system. It draws on part of a Ph.D. research study that explores first-year engineering students' access and engagement with technological resources for learning. A key concept in the study is the development of the ability to control and adapt to technology, known as digital agency. The research question addressed in this paper is "How does CHAT reliably build theory of the complexity inherent in the development of digital agency among first-year engineering students learning at a university?" Some of the challenges in the application of CHAT for researching in this context are identified, such as describing practice as an activity system and identifying the object of the activity system. In addition, the value of CHAT for such studies is explained including the contribution it makes in the identification of contradictions and tensions that cause change and development in the activity system. These findings offer insight as to the usefulness of CHAT for engineering educators and scholars understanding their practice or researching learning and teaching in the classroom.

Plenary 4: Plenary Keynote by Professor Ed Byrne - Contemporary Landscape, Drivers and Developments in Engineering Education for Sustainability

Time: Thursday, 14/Sept/2023: 10:00am - 11:00am · *Location:* EQ-010 Performance Hall & EQ-002 Lecture Hall

Contemporary Landscape, Drivers and Developments in Engineering Education for Sustainability

Byrne, Edmond

University College Cork

Edmond Byrne is Chair Professor of Process and Chemical Engineering at University College Cork. He is programme director on the BE(Hons)/ME in Process & Chemical Engineering. The programme won the Sustainability Teaching Award (2016) from the Institution of Chemical Engineers (IChemE). His research interests include engineering education for sustainable development, for which he has published widely, and transdisciplinary approaches to sustainability transformation, on which he has co-edited two books (Transdisciplinary Perspectives on Transitions to Sustainability, Routledge, 2017; Metaphor, Sustainability, Transformation; Transdisciplinary Perspectives, Routledge, 2021). He chaired the 10th Engineering Education for Sustainable Development conference (EESD2021), hosted at University College Cork in 2021.

Contemporary Landscape, Drivers and Developments in Engineering Education for Sustainability

The 'landscape' around sustainability education in engineering has continued to evolve. Engineering education for sustainability largely emerged originally out of environmental engineering imperatives, though more recent developments have considerably broadened the scope of 'sustainability' teaching in professional engineering programmes. This has implications for associated curriculum developments as well as having pedagogical implications. Principal drivers for these developments emanate from the evolving requirements of professional engineering bodies internationally. These drivers have been supported and supplemented by an enhanced sense of urgency in the wake of the impacts of an unsustainable societal construct (e.g. the consequences of accelerated climate change, biodiversity loss, energy and food imperatives, etc.), as well as broader drivers such as around university policy, industry expectations for graduate attributes, and evolving societal imperatives. Having reflected on the above, some specific examples of how engineering education for sustainability may be incorporated into the curriculum are considered.

2023 Draft Book