Emerging professional skills: Insights and methods

SEFI 2022 Engineering Skills SIG Workshop Report

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ABSTRACT

In this workshop run by the Engineering skills SIG, attendees were given the opportunity to learn about emerging professional competencies, and strategies to overcome teaching barriers.The workshop format was “world cafe” with several tables for small groups to informally discuss these strategies within a time limit. Each table focussed on an emerging skill and/or scenario and participants each visited several tables. The session was informed by the engineering skills survey taken by SEFI 2021 conference attendees. It gave us views on new competencies, barriers to teaching them, and illustrations of good practice. Obstacles to teaching them include motivation, legitimacy, overloaded curriculums, student resistance, resource constraints, and pedagogical understandings.Ideally skills should be learned by students in contexts where they’re used. While many technical competencies are primarily developed in engineering practice, professional/soft abilities are often not. As a result, there ought to be some opportunity for the student to transfer, adapt and (re)learn them in an engineering degree. This report summarises the conference workshop outputs with sections for each table. Each section acknowledges the hosts/authors, a summary of the discussion, and any materials presented. Readers may find this paper useful when facilitating related discussions.

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1 INNOVATION AND ENTREPRENEURIAL MINDSET (RAFAELLA MANZINI, UNIVERSITA' CARLO CATTANEO - LIUC)

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1.1 What is innovation?

- Good definition: Oslo Manual (ch. 3.2, 3.3, 3.4, https://www.oecd.org/science/oslo-manual-2018-9789264304604-en.htm) and the Frascati Manual (ch 2.2-2.5, https://www.oecd.org/sti/inno/frascati-manual.htm).
- Innovation is creating value from ideas. What value? Both economic and social value.

1.2 What do we mean with “innovation skills” and “entreprenerial mindset”?

- Innovation skills: ability to contribute to transform ideas into value, with an
- entrepreneurial mindset: taking care of the idea, until it deploys its economic and/or social value.

1.3 Do we really need to teach these skills to engineering students? Aren’t they already skilled, in their specific technical area? Some provocative statements

- Engineers are highly creative, in their technical field of expertise
- Engineers are problem solvers, so they are naturally ready for innovation
- Engineers do not need to have innovation and entrepreneurship skills:

1.4 What do we really need to teach to engineering students?

- Innovation is a process, it is not only a matter of creativity and technical competences.
- The focus should be on value generation, something which is not always “natural” among engineers:

1.5 How to help students developing innovation skills and an entrepreneurial mindset

- Project – based and challenge based approaches are the most suitable;
- Case-based learning can be helpful, but it isn’t enough;
- Internships can greatly help;
- Leverage on the specialized technical knowledge and expertise of students
- Make engineering students aware of their limitations
- Create groups with mixed competences and background

1.6 References

The innovation supermarket, where you can find resources for teaching innovation management: https://www.johnbessant.org/innovationsupermarket

Hagvall Svensson, O., Adawi, T., Lundqvist, M., & Williams Middleton, K. (2020). Entrepreneurial engineering pedagogy: models, tradeoffs and discourses. *European Journal of Engineering Education*, *45*(5), 691-710.

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Belkhir, L., Fleisig, R. V., & Potter, D. K. (2018). Effective learning of innovation by engineering students in a multi-disciplinary context. *The International journal of engineering education*, *34*(4), 1223-1235.

Keiding, V. (2019). Teaching innovation to engineer students: a proposal for an operational process model. In *Proceedings of the 47th SEFI Annual Conference European for Engineering Education (SEFI)*.

2 COMMUNICATIONS (NATALIE WINT, SWANSEA, AND JENNIFER GRIFFITHS, UCL)

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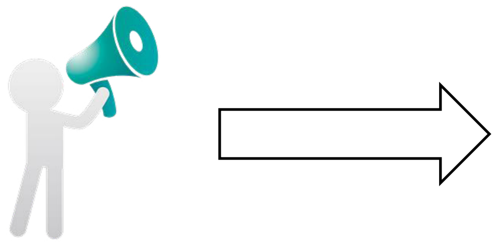
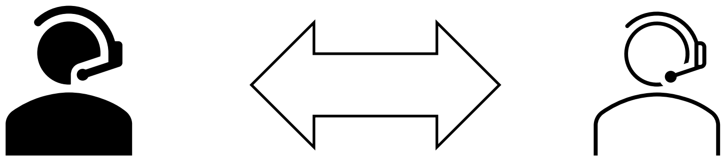
2.1 Models of Communication

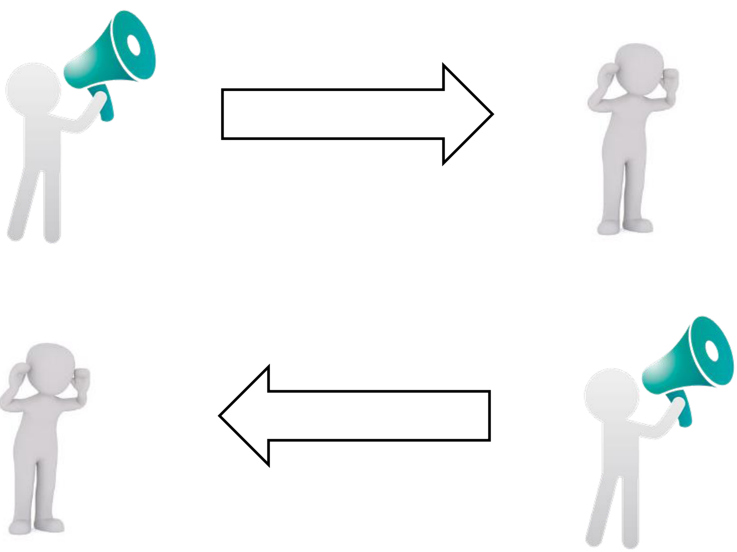
- **Linear models (e.g., Aristotle's, Lasswell's, Shannon-Weaver, Berlo's SMCR)–** only looks at one-way communication.



- **Interactive models (e.g., Osgood Schramm, Westley and Maclean) –** looks at two-way communication.



- **Transactional models (e.g., Eugene White's, Barnlund's, Dance's Helical) –** looks at two-way communication where the message gets more complex as the communication event (e.g., conversation) progresses.



2.2 Communication across disciplines

Students must communicate with people from different disciplines or cultures. They will face challenges in doing so and should therefore be aware of how to address them.

- People from different backgrounds often attach different meanings to the same word.
- People bring different perspectives to bear on what they hear and infer a different meaning than was intended. Students are therefore more likely to transcend their disciplinary perspective if they are self-aware of the set of largely subconscious assumptions.

Michael O'Rourke et al., *Enhancing Communication and Collaboration in Interdisciplinary Research,* Sage, July 2013.

2.3 Inclusive communication

Dusek J, Ferrier E, Goodner R, Sarang-Sieminski A, Waranyuwat A, Wood A. Proactive Inclusion of Neurodiverse Learning Styles in Project-Based Learning: A Call for Action. ASEE Annual Conference and Exhibition. 2018.

Sarang-Sieminski, A., Waranyuwat, A.,Ferrier, E., Wood, A., and Faas, D. (2019) "Work in Progress: Bridging the gap between accommodations letters and emerging classroom practices," Presented at CoNECD, Paper ID#24891, April 14-17, 2019.

2.4 Other references

Andersen, A. (2004) Preparing engineering students to work in a global environment to co-operate, to communicate and to compete, European Journal of Engineering Education, 29:4, 549-558, DOI: 10.1080/03043790410001711243

Lappalainen, P. (2009) Communication as part of the engineering skills set, European Journal of Engineering Education, 34:2, 123-129, DOI: 10.1080/03043790902752038

Paretti, M.C. (2008), Teaching Communication in Capstone Design: The Role of the Instructor in Situated Learning. Journal of Engineering Education, 97: 491-503. https://doi.org/10.1002/j.2168-9830.2008.tb00995.x

Ravesteijn, W., De Graaff, E. & Kroesen, O. (2006) Engineering the future: the social necessity of communicative engineers, European Journal of Engineering Education, 31:1,63-71, DOI: 10.1080/03043790500429005

Trevelyan, J. (2009). Engineering Education Requires a Better Model of Engineering Practice. 2009 Research in Engineering Education Symposium, REES 2009.

3 INTER- AND TRANSDISCIPLINARITY (HOSTS: THIES JOHANNSEN, TU-BERLIN, ANN-KRISTIN WINKENS, RWTH AACHEN)

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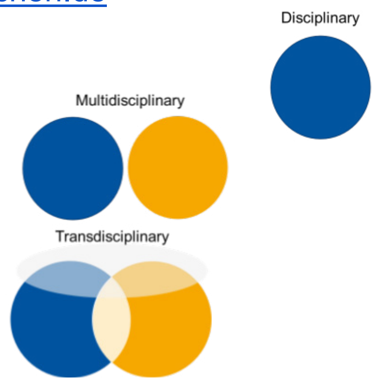
3.1 What is inter- and transdisciplinarity?

Multidisciplinarity is a sum of disciplinary perspectives.

Interdisciplinarity is a transformative process of mutual cooperation among disciplines.

Transdisciplinarity is a transformative process of mutual cooperation among stakeholders from different fields – including non-academics.



(cf. "What is transdisciplinarity" SEFI@work SIG Skills, 10 December 2021)

3.2 How can inter- and transdisciplinarity be implemented in HE teaching?

Problem- and project-based Learning

Problem-based learning begins with identifying and structuring a problem and exploring its limits (Brassler/Dettmers 2017: 5). This includes dealing with relevant terms and concepts as well as critical source work. It is a student centered learning concept that addresses complex learning (Hadgraft/Kolmos 2020: 5).

- Brassler, Mirjam/Dettmers, Jan (2017): How to Enhance Interdisciplinary Competence—Interdisciplinary Problem-Based Learning versus Interdisciplinary Project-Based Learning. In: *Interdisciplinary Journal of Problem-Based Learning* 11 (2). DOI: 10.7771/1541-5015.1686.
- Hadgraft, R. G., and Kolmos, A. (2020). Emerging learning environments in engineering education. Australasian Journal of Engineering Education, 25(1), 3–16. doi:10.1080/22054952.2020.1713522

3.3 Case-based Learning

Case learning aims to develop professional intellectual and behavioral skills through a topic-specific and problem-oriented interpretation of real-life experiences (Lynn 1999: 3). Case teaching is an inductive method that builds a bridge between theoretical-declarative and practical-functional knowledge (Biggs/Tang 2011: 163). Students gain application-oriented knowledge and develop practice-relevant competencies in the theory-based and guided examination of a case.

- Biggs, John Burville/Tang, Catherine So-kum (2011): Teaching for quality learning at university. What the student does. 4th ed. Maidenhead: McGraw-Hill/Society for Research into Higher Education/Open University Press.
- Lynn, Laurence E. (1999): Teaching and Learning with Cases. A Guidebook. New York: Chatham House Publishers.

3.4 Best practices

Blue Engineering

Blue Engineering is an international and innovative workshop-style course provided by Technische Universität Berlin. It focuses on ecological and social responsibility. The course facilitates creative, interdisciplinary and sometimes heated debates on the issues posed by technology in society and in nature.

- Baier, André (2019): Education for sustainable development within the engineering sciences - design of learning outcomes and a subsequent course evaluation. TU Berlin, Berlin. http://dx.doi.org/10.14279/depositonce-8844.

Engineering for Impact

Engineering for Impact – Responsible Innovations is an interdisciplinary project- and problem-based course that introduces students to methods and tools of how science can make an impact. Students work in groups to develop a technology-based application concept for a self-selected societal challenge.

- Johannsen, Thies (2021): Integrated Classroom Learning. How to Create an Activating and Safe Environment for Online Learning in Knowledge Exchange and Innovation Education for Engineering Students. In: Jan von der Veen, Natascha van Hattum-Janssen, Hannu-Matti Järvinen, Tinne de Laet und Ineke ten Dam (Hg.): Blended Learning in Engineering Education: challenging, enlightening – and lasting? SEFI 49th Annual Conference. Berlin, 13.-16.09.2021, S. 936–950.

Project “Leonardo”

Project “Leonardo” aims to enhance and promote interdisciplinary discourses within RWTH Aachen University. In doing so, various courses are offered from usually two lecturers from different scientific disciplines that focus on social challenges. The aim is to discuss a central topic in an interdisciplinary manner under academic supervision and to bring together both students and lecturers from different disciplines.

- Winkens, A., Böschen, S., and Leicht-Scholten, C. (2021). Interdisciplinary Teaching at RWTH Aachen University: Project "Leonardo". Paper presented at the The European Conference on Education 2021, London, United Kingdom (online).

3.5 Workshop discussion

- It is important to define terms.
- There are overlaps with other relevant skills.
- Different knowledge and different understandings may be a challenge (cf. silos); results in barriers to collaborate with teachers/educators from different disciplines.
- There is generally a lack of recognition for the process, and a focus on results.
- To enhance collaboration skills interdisciplinary thesis in groups may be an effective approach; also, it raises awareness among students.
- There is usually a conflict between depth and breadth: either deep dives or broad, inter- or transdisciplinary understanding of a problem.
- How to approach inter- and transdisciplinarity? It is useful to make experiences first and then reflect them methodologically: have students make experiences rather than explaining methods theoretically.

- Usually there are deficits in institutions in regard to inter- and transdisciplinarity whereas individuals are very competent. Raises the question of institutional support.
- It may help to have testimonials from professionals that inter- and transdisciplinarity are meaningful in professional careers.
- Collaborating with industry may result in conflict of interest regarding research and commercialisation.
- A very relevant barrier is motivation of stakeholders, be it academics, students or external partners.

4 SYSTEM COMPLEXITY (YOLANDE BERBERS, KU LEUVEN)

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4.1 What do you think System Complexity is, how would you define it, what does it include? Why is this skill important for engineers?

- Most attendees agreed that system complexity is to see non-obvious connections between things, while understanding why they behave a certain way, which gives insight into “a system is more than the parts”.

4.2 How is it taught at your institution?

- Many attendees didn’t identify a standalone teaching of this. However, in aerospace curriculum (TU-Delft) system engineering is part of the curriculum, there is a specific course on this
- Most agreed that system complexity is learned when students work on different parts of a system, and have them then integrate all these parts. Typically these are done in challenge based learning projects e.g. a Solar Car. These problems are typically “wicked”. Students should learn to model first before building, and make their reasoning explicit: ““build down the complexity to build it up” (Twente).

4.3 How is it assessed?

- A lot of visualization is necessary to understand the complexity of the system.