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Develop An Interdisciplinary Course Using The Twente Interdisciplinarity Toolbox

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Develop an Interdisciplinary Course using the Interdisciplinarity Toolbox

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1. Background: Overview of the Workshop

The ability to engage in interdisciplinary research and problem-solving are essential skills for contemporary engineers, however designing and delivering effective learning opportunities to reach these ideals, is often not straightforward [1]. Educators are often faced with a plethora of challenges, and interdisciplinary courses often do not run as smoothly as disciplinary ones. In this workshop, the primary goal was to stimulate participants to consider a few common design scenarios modeled on real-life cases and to apply some of the main design concepts and questions employed by a new online platform the Twente Toolbox which aims to assist instructors with interdisciplinary course design. Participants were asked to make certain design choices in response to the cases within teams. The toolbox, funded by the Netherlands Initiative for Education Research (NRO) and developed by researchers at the University of Twente (interdisciplinary-education.utwente.nl) maps out different interdisciplinary course design structures, skill targets and learning goals. These are linked to specific in-class student tasks and assessment tools, which help students achieve those learning goals. In the session, participants were directed to relevant sections within the toolbox that would help inform design decisions of participants.

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2. Motivation

Many of us are not fully aware of the scope of alternative course design options and learning tasks that now exist for interdisciplinary education [2]. For example while many interdisciplinary project-based course designs favor open-ended problems for students, student project groups consisting of members from different disciplines and an assessment which puts weight on integration of methods, none of these are strictly necessary for interdisciplinary education and in certain circumstances taking other alternatives may be more fruitful for students. By introducing participants to these design choices participants could become more familiar with choices open to them. The Twente Toolbox - interdisciplinary-education.utwente.nl - both outlines such design choices, and provides the conceptual resources needed to understand them, but also links choices to families of appropriate student tasks. The workshop was thus designed to provide an entry point into the toolbox material and structure, from which participants could go further and begin to apply to other material the toolbox provides.

The toolbox is web-based platform accessible through a browser. The platform is structured around a database linking learning outcomes (in the form of skill targets) to specific tools (students tasks) and to course-design options, such as whether to structure a project task as open-ended or more closed. Tools are drawn from published articles and those developed at the University of Twente. The links are based on tool-designers' own assessments of the relevant learning outcomes (as reported for instance in their papers). Categorisations of skills into families are based on existing educational literature. All concepts and tasks are explained so that users also acquire knowledge while using the tool and the means to use a task easily. In addition, the toolbox provides different guided entry points into the information to help instructors gain access to the most relevant tasks and avoid information overload. For instance instructors can access specific tasks by selecting intended learning outcomes they would most wish to focus on in a course design.

At the same time part of the value of toolbox should be its ability bring together collected knowledge on interdisciplinary education as it exists, but also to introduce novel or little known design options and alternatives. We anticipate many of these will not have be countenanced by many educators and would provoke reflection and dialogue in workshops (including on the broader purposes of interdisciplinary education). At the same time, since the toolbox is open to further design itself, participants have the chance now and in the future to provide their own input on what might be missing, inadequately explained or unaccounted for.

3. Workshop Design

Workshop participants were initially presented with a short introduction which explained the central concepts from the toolbox they would be working with. These concepts were described as follows:

> **Mixed or mono-disciplinary**: do you want groups of students mixed up by discipline or should students stay in disciplinary groups?
>
> **Integrated or multidisciplinary solutions:** do you want students to achieve integrated solutions – solutions which create novel approaches or require students to step out their disciplines – or is the emphasis on them applying their own disciplinary methods (in an

interdisciplinary setting).

Open or closed problems: should the problem be open-ended or should the students apply certain methods, or achieve certain types of solutions for the project-task .

Workshop participants were then split into group of around five to consider a case by answering the following questions.

- Should the grouping of students for the project-task be mono-disciplinary (split into disciplinary groups) or mixed (inter-disciplinary) and why?
- Should a solution to the project-task be integrated or is a multidisciplinary result fine and why?
- Should the project-task be open or closed-structured (or something in between) and why?

Four different cases were spread out amongst the groups. We give the cases here. Each differ, some substantially, in terms of students involved and the institutional objectives of the course, which prompts instructors to reflect on what the purpose of interdisciplinary education should be in such a case and how it should be structured in way to both benefit students but also meet those institutional objectives.

Case 1:

In order for your faculty to reach the interdisciplinary course targets set by the University, your programme director has requested that your well-established 2nd year Industrial Design Engineering course (15 ECs) ***incorporate 2 other disciplines****; Mechanical Engineering and Industrial Engineering Management. The new extended cohort will now consist of 500 students with a 2:2:1 ratio, i.e. IDE 200, ME 200, IEM 100 students. The original course aimed to train students in real-world and practical aspects of designing a consumer product with sub-modules on product-market relations, graphic design and computational modelling of products.*

Lectures & tutorials fed a team project accounting for 50% of the final score. The project was "sponsored" by an industrial partner who simulated a real product conundrum that students had to solve. The course will carry-on as project-based - structured around a project-task – but you have the license to change how the project task is structured and supported with the new types of students on-board as well.

Case 2:

You have been asked to revamp an established course with a project component. The current context is a single discipline of students within a technical medicine programme which was set-up to be interdisciplinary from the start. Technical medicine students are trained in aspects of traditional medicine, clinical practices, but also aspects of engineering relevant to medical equipment design. Technical medicine students as professionals should mediate between traditional medical doctors, and medical instrument operators, and propose technical-based diagnoses and solutions. The goals of this particular course are to instruct students on anatomy, physiology and pathophysiology of the cardiorespiratory system; as well relevant measurement and imaging techniques of use in clinical cardiology, and the principles underlying their design. Students should then apply their new knowledge to the project to solve clinically relevant technical medical problems, in order to make a diagnosis and to propose therapy in a peer consultation. The hope is that students can integrate medical and technical (engineering) knowledge with clinical planning in their projects and students will be assessed on their ability to do so. The project-task can be designed as you see fit in a way for students to

illustrate these abilities.

Case 3:

Your university is worried that its students are too siloed in their current disciplines and are not learning to interact which is not preparing them well for the real-world. Most student do not readily have contact with students outside their programme. You have been tasked with designing a novel 3rd year elective course (15 ECs) that can attract students from all programmes within the university. The cohort will be diverse, including engineers, designers and social science students (max 50). The course should be project-based - structured around a project-task – but you have the license to decide how the project task is structured and supported.

Case 4:

Three different groups at a university require instruction on stochastic programming (optimization with uncertainty). Stochastic programming problems is used widely in scheduling and queuing problems. The groups are applied mathematics, civil engineering and industrial and engineering management. As a rational step they have decided to share the course. Courses at this university generally include a project and it is assumed that this course too will have a substantial project component along with instruction. The principal focus is ensuring that all students walk out of the course with adequate stochastic programming skills. You are asked to think about how that project should be designed and what support elements (tasks) to include. It is important to note that although each group needs stochastic programming skills their foci are different. Civil engineers are mostly interested in traffic management type problems; industrial and management engineers in scheduling and supply chain management; and the applied mathematics in more complex nonlinear problems. Programmes want to ensure that the groups acquire and practice these skills.

Participants were advised that they could browse the toolbox (through a link provided: interdisciplinary-education.utwente.nl) if they need some deeper explanations regarding the main concepts. After 40 minutes the groups reconvened for a group based discussion in which group was asked to pitch their solutions to the problem for their case.

As a last action the participants were introduced to the content and various functions of the toolbox platform and shown how they could use it to deeper their designs for their particular cases by attaching skills targets (when formulating learning outcomes) and student tasks. Attention was given to a decision-tree tool on the home page which asks the same questions asked of participants in the workshop and, given their choice, directs users towards relevant students tasks. Finally participants were also asked to provide any feedback they might have on the toolbox when using it in the future.

4. Results of the Workshop

For this workshop there were eight groups in total of, on average, five participants. The cases and questions provoked intense discussion over 40 minutes. Groups thoroughly and genuinely engaged with the case studies presented in the hopes of putting forward sensible design strategies. Groups were able to give a reasoned answer to all the questions, and often went beyond those questions to consider how they might structure their course more generally and plan support to students. We found that the groups mapped their answers to the questions we provided to their case well, rather than relying on any canonical view of how interdisciplinary

education should be structured. Groups doing case 2 for instance generally saw the situation as one in which students would not be grouped across disciplines for projects, but within their discipline. Those doing case 4 perceived that the project task should not be widely open-ended but needed to be well-structured so as to support other educational goals. Those doing case 3 however recognized a more canonical interdisciplinary type situation and proposed a mixed groups with open-ended integrated problem-solving. They then proceed to bring their own experiences to bear on how to structure such courses and provide student support. This was some demonstration of the fact that many instructors do have typical experience with case 3 type designs. For the other cases educators were less certain but not unwilling to engage with student support issues.

As such participants acknowledged the value of critically considering such a set of questions at the beginning of an interdisciplinary course design process and the need to adapt designs to fit different situations. They also acknowledged, through exposure to different cases, the need to think actively about the best model or design which allows for each discipline involved to have a meaningful contribution (rather than necessarily leave that always to the students themselves to figure out). They acknowledged that different students from different disciplines can face challenges in this regard (for example social science students engaging with technical students). Following the workshop some participants expressed the view, in personal conversation with our team, that the workshop had substantially opened up their consideration of what could matter in interdisciplinary design situations and how important it was not to automatically rely on any one format.

Further seeing the variety of possibilities helped some groups go beyond the specific course level. Some for instance started to discuss interdisciplinarity at the curriculum level seeing a role for beginning with structured problems and more homogeneous groups earlier in a degree, and moving towards more open-ended problems and mixed groups later in the degree once students were more experienced and grounded in their disciplines. In general groups were reflective on what could be achieved in an interdisciplinary problem-solving context – particularly with respect to integration; and to recognize a tension between requiring students to create novel solutions going beyond disciplinary boundaries, but also to create sophisticated well-grounded solutions. There is a need to be realistic about what students can achieve in interdisciplinary courses.

5. Conclusions

In this workshop we introduced participants to the some of conceptual framework and overarching design questions used by Twente Toolbox to assist instructors and others in interdisciplinary course design. Participants demonstrated to us that they could use these concepts and questions from the Toolbox to make informed design decisions to suit different kinds of cases. This was some endorsement of the Toolbox's goals and structure. We hope the dedicated engagement of the participants in our workshop will help spread the use of the Toolbox across the SEFI community.

6. Significance for Engineering Education

Interdisciplinarity is fundamental in many modern engineering programmes, yet remains difficult to set-up effectively given the many different kinds of situations it might be required. If engineering education is to move forward on interdisciplinary education it is important we develop a diverse understanding of what options are available for training interdisciplinarity, and the various goals one could have for an interdisciplinary course. The Twente Toolbox attempts to provide these. The workshop itself provided an introduction to the content and organization

of the Toolbox and a hands-on opportunity to apply these features of the Toolbox to a real-world case. Through broader use of the Toolbox we hope to see in the future the development of novel interdisciplinary course designs.

7. References

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