

PREREQUISITES FOR INTERDISCIPLINARY LEARNING: ORGANISATION AND STAFF

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ABSTRACT

Today, most universities are organized in disciplinary departments where discipline based programme coordinators design curricula and learning is mainly based on disciplinary approaches. The emerging view is that to solve the more complex societal problems, more interdisciplinary approaches are required. In our study at the Delft University of Technology (TU Delft), we investigated what the prerequisites are for the design and delivery of interdisciplinary courses in a discipline-based university. We have interviewed 18 staff members involved in interdisciplinary courses and analyzed their experiences, thoughts, and needs in interdisciplinary course design and delivery. Results indicate that several competencies and experiences for staff members are necessary, such as open-mindedness, stepping out of the spotlight, and having worked in the industry. Furthermore, the disciplinary structure at TU Delft is currently felt to hamper interfaculty collaboration.

KEYWORDS

Interdisciplinary, requirements, learning, course development, Standards 9, 10

INTRODUCTION

Currently, most learning at universities is based on disciplinary learning approaches, although a shift to more interdisciplinary education has taken place over the years. Disciplinary education, however, is not sufficient anymore to solve the more complex societal problems of today (Holzer, Gillet, Laperrouze, Maitre, & Tormey, 2018). Complex problems need multiple perspectives and integrated approaches to be taken into account to broaden the problem-solution space and to realize new innovative solutions (Thomson Klein, et al., 2014). To meet these requirements, universities strive to strengthen their educational programs with interdisciplinary courses and programs. (Holzer, Gillet, Laperrouze, Maitre, & Tormey, 2018). Kans analyzed the meaning of interdisciplinary in the CDIO context, which varied between different actors (Kans & Gustafsson, 2016). We define interdisciplinary courses as those that enable students to define problem statements, translate and synthesize theories, methods of at least two different disciplines to come to an integrated result, and innovative solution.

Like most universities, TU Delft is a typical example of a Dutch technical university organized along disciplinary boundaries, wherein disciplinary departments, scientific staff work with their own epistemologies, methodologies, vocabulary, and curricula, which are designed by

discipline-based program coordinators. Staff members are usually dedicated to and appraised on the education programs and courses within their own disciplines and are rarely involved in interdisciplinary education. Equally, individuals are judged on their disciplinary research standards, and contributions to collaborative research are less valued.

At the same time, according to its vision, TU Delft “*stimulates diversification of the portfolio by strengthening educational programs with interdisciplinary courses and programs*” (Mulder, Baller, & Kos, 2017). Indeed, TU Delft is providing interdisciplinary courses to its Bachelor and Master students.

The disciplinary foundations of universities make working interdisciplinary and collaborating across disciplines a real challenge across the academic system (Thompson Klein & Falk-Krzesinski, 2017). Disciplinarity poses organizational, structural, and pedagogical challenges to the interdisciplinary design of education (Holley, 2009) (Gantogtokh, Kathleen, & Quinlan, 2017).

Facilitation of interdisciplinarity consists of elements like infrastructure and institutional support such as instruction rooms, incentives, professional development of teachers, allocated time and budget for curriculum or course development, the involvement of departments (Larsen, et al., 2011). Although most of these support elements do exist in disciplinary institutes, they may not per se stimulate the interdisciplinary course endeavors, as they do not necessarily break down the disciplinary boundaries or sustain interactions across disciplines amongst Staff (Carr, Loucks, & Blöschl, 2018), limiting the development and execution of interdisciplinary learning programs (Thompson Klein & Falk-Krzesinski, 2017), (Lattuca, Knight, Kyoung, & Novoselich, 2017) (Frodeman & Mitcham, 2007).

In a previous quantitative study, we have investigated the perception of interdisciplinarity by program and course responsible coordinators. To investigate the perception, we have used the framework for interdisciplinary engineering education developed by the 4TU Centre for Engineering Education (Klaassen R. G., 2018). The framework focuses on the constructive alignment of the courses: the alignment between the educational vision, turning this into pedagogical approaches, and facilitated by support structures.

The Framework

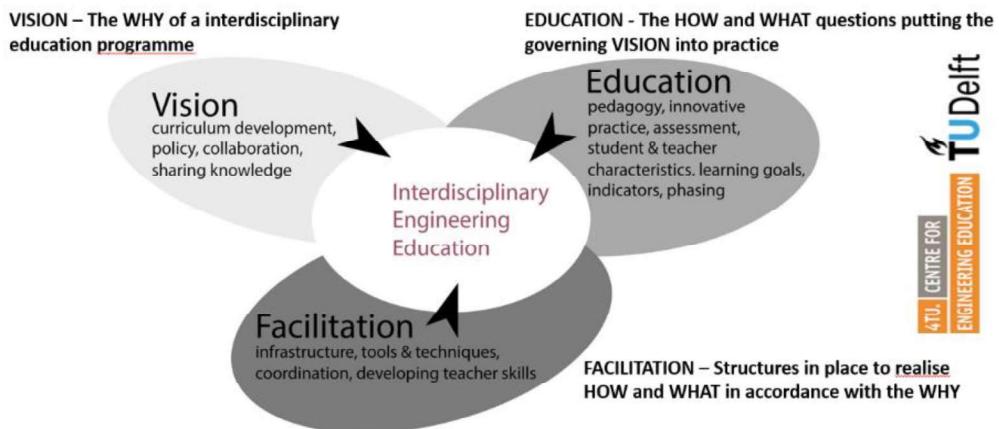


Figure 1. Framework for Interdisciplinary Engineering Education (4TU Centre for Engineering Education).

In this paper, we looked specifically at perceptions of the facilitation component as a follow-up study to the perceptions of visions, skills knowledge, and assessment of interdisciplinary learning (Klaassen, De Fouw, Van der Tang, & Rooij, 2019). The facilitation of interdisciplinary education is defined as the facilitation needed to realize interdisciplinary education. The aim of this study is to establish what we can learn from the interdisciplinary practices at TU Delft to make interdisciplinarity work. The key research question is: "What support (staff/organization) do the program and course responsible coordinators and teachers need in order to design and deliver interdisciplinary courses and break down the disciplinary barriers?"

METHODS

A total of 18 individuals from TU Delft (14 course responsible coordinators and four educational directors of seven of the eight TU Delft faculties; all coordinators were also teachers) were interviewed about their experiences and perceptions with their interdisciplinary minor and master programmes¹. This group was chosen since they determine the requirements of a program. As it was not always clear from the course descriptions whether the courses were indeed interdisciplinary, a snowball technique was used to find our respondents.

The conducted qualitative interviews were semi-structured, using a predetermined set of open questions in line with the 4TU Framework, but diversions and new ideas or thoughts of the interviewee were also allowed. All interviews were audio-recorded and transcribed and analyzed according to a three-step analysis process of data reduction of excerpts into predetermined content codes, data display in thematic subcategories of indicators, and data interpretation. The interview transcripts were divided into excerpts, each of which was coded by three raters independently. All interviews were coded based on 11 indicators, which were established on the basis of the aforementioned study (Klaassen R. G., 2018). The excerpts that were coded with the indicator 'Prerequisites of Staff and Organisation' are analyzed and discussed in this article.

In order to determine the reliability of this coding method, the inter-rater reliability was calculated, which is the degree of agreement among a number of raters. The Fleiss' kappa (κ) was used as a measure of reliability; this is often used for analyses with three or more raters. The higher the Fleiss' kappa, the higher the agreement among raters, and therefore, the higher the reliability (Fleiss, 1971). The average Fleiss' kappa for the indicator 'Prerequisites of Staff and Organisation' over the 18 interviews were found to be 0.720, which means that there is a substantial agreement of the three raters (Landis & Koch, 1977). In those 18 interviews, the indicator 'Prerequisites Staff and Organisation' was applied 635 times.

RESULTS

The results section focusses first on requirements for staff, then on Organisation (Figure 2).

Staff

What is done on the level of staffing to realize the interdisciplinary content/coordination of the different courses and or programs?



Figure 2. Structure of results section.

Knowledge

According to our interviewees, those individuals involved in interdisciplinary course design and delivery should at least have a profound knowledge in one specific discipline or domain. In addition, most of them suggest that it is best if they are so-called “T-shaped,” having in-depth knowledge of their own discipline and having many “hooks” to communicate about and integrate knowledge from other disciplines (Gero, 2014) (Brown, 2005) (Frank, 2000). Some of the interviewees refer to this as being system integrators. These should see the link between the different disciplines.

“You need several persons who have this vertical expertise pole. But at the same time, they should also have many hooks on their wide horizontal pole in order to communicate with the outside world.”
“First of all, you should have content knowledge of the case study at hand. You do not need to know all ins and outs of it, because then you are an expert. You should be a system integrator. You should know where the disciplines come from and what is more or less going on in that area of expertise.”

There is one interviewee who specified in more detail the required knowledge of coaches, who facilitate the interdisciplinary teams. They should be process-focused, not content-focused-stating:

“The coaches have completed the course xxx. That does not mean that they have the knowledge of the technology they are coaching. I have come to realize that I do not mind they do not know anything about the technology. I really want them to only play the role of coach. The students should do the content. That is what I call guiding the process. They should make sure that the student can perform optimally. We teach the coaches how to do this.”

The interviewees indicated that those involved should have a common understanding of the jargon used and a common frame of reference towards the problem solutions. They should see the bigger picture and be able to apply their knowledge in other domains. If the teachers are too focused on their own discipline, they tend to forget the other disciplines, to work together, and to integrate knowledge were possible.

Competences

Many different competencies (attitude, skills, and experience) were mentioned by the interviewees necessary for working interdisciplinary. An overview of these is shown in Table 1.

They should be enthusiastic, have an open mind to societal context, have wider interests than only technology, should not mind stepping out of the spotlight, share responsibility, and credits. They need to be able to take a step back. They should not pose their own discipline at the foreground and be interested in and trust other disciplines (rely on their input). They should be convinced that their work is for the total sector and not only their own domain.

"We (ref: teacher) also have the same constraints in that we have our own disciplinary backgrounds. We see things and talk about things in our own languages. But I think we have been successful at stepping back, stepping out of the spotlight and letting the students debate about how to proceed forward in their multidisciplinary interfaculty groups."

Their mentality should be open: openness to other disciplines and to mentally learn and grow. They should not be afraid to talk to and work with other disciplines and other teachers. A networking attitude is important to link with colleagues from other disciplines.

Table 1. Attitude, Skills and Experience overview

Attitude	Skills	Experience
Enthusiastic, open to learn	Awareness of disciplinary boundaries	In industry/business
Open-minded towards societal context and other disciplines	Networking skills	Prior experience with multi/interdisciplinary group work.
Share responsibility and credits	Approach student at the appropriate level of knowledge	University Teaching Qualification
Stepping out of the spotlight	Strong communicators/collaborators	In one specific discipline
Interests wider than technology only	Facilitation skills	T-shaped
Rely on upon and trust other disciplinary input	Team dynamics	Dealing with different opinions

For optimal interaction with the students and to facilitate integration, they should be able to relate to the students' knowledge level and approach them at the required level. They should be able to teach students from different backgrounds, ways of thinking, and levels of knowledge. They should be strong communicators in order to do so.

"I think it has to be someone who's very conscious of the student background. Because often, if you've come through a certain education path, you know a bachelor standard is this, a master standard is this, and a Ph.D. standard is this.... But of course, they know almost nothing about certain subjects."

"So it has to be someone who realizes what is taught where and to quite carefully introduce things....., you can go quite fast through a lot of things. They're relatively mature students. But you have to go back to the beginning of a lot of things. And I think if it's given to anyone who doesn't have a kind of skill in that, then it's very difficult. Students get lost quite quickly".

They should be able to facilitate multidisciplinary teams, know when to steer and when to let loose, and also know about team dynamics.

“.. and our students have not yet worked in teams. Therefore there is also an aspect of teamwork. Therefore we also need to show them what it is to work in a team. They will do a teamwork game like Belbin role play”.

Experience

In order to appreciate the challenges in interdisciplinarity, most interviewees find it important that the staff has worked in or has experience with the industry /business, providing an interdisciplinary background. The lecturer should have dealt with multidisciplinary groups, have experience in working with other disciplines, and in dealing with different opinions.

“It should be someone who has a good connection with the business. Who knows many people in the industry because otherwise you cannot get all project up and running. But one also needs to have a feeling for how one works at a company. We have, for instance, started up two new companies from our own department. You should know what is going on in a company.”

“I think it is obvious (to have business experience), but I have worked half of my career in the business. Then you look at it differently. But, you do have individuals here with only a full academic career, and they may not have that skill available.”

Organization

What is done at the level of the organization to realize the interdisciplinary content/ coordination of the different courses and or programs? Firstly, requirements for the design and subsequently for policies are provided.

Design: Professional development of teachers: training, informal learning and learning on the job

According to the interviewees, the teaching staff should have the University Teaching Qualification, which is obligatory for all teaching staff at TU Delft (Vereniging van Universiteiten, 2018). Interviewees also suggest that teachers need to be trained in interdisciplinarity, as most of them do not know how to design/deliver interdisciplinary education. No such formal training exists at TU Delft. Some teachers train themselves (informal learning), by talking to experienced interdisciplinary teachers and read students' end-reports to get familiar with the integration of knowledge and ways of working.

“I think it is not that easy to do this kind of course. I think that the teachers, too, need to be trained in how to teach a very mixed group and in how to content-wise combine knowledge from different disciplines.”

“It should be taught to people how to integrate and how to approach this. That should be handled in a more structural way at a university. However, the university is disciplinarily focussed, so who will take the lead and who will pay?”

Others use training on the job. Some interviewees experiment with different educational approaches and learn during their own course how to integrate and deal with complexity. Over time they become more secure in dealing with interdisciplinarity, and they tend to see better the importance of having a wider picture.

The interviewees suggested sharing the learnings and experiences amongst interdisciplinary teachers and novices, to improve the overall knowledge level. Suggested topics for

development were: difficulties encountered and solved, jargon and language issues, dealing with complexity and integration.

Design: Course design

Most interviewees said that improved interdisciplinary courses/curricula would be delivered when teachers with different disciplinary backgrounds design them together. This ensures alignment in program, vocabulary, methods, and approaches, minimize overlap, and increases the coherence of the program. The way they work together could also be improved. Co-teaching, for instance, would help teachers to get more insight into the other disciplines and get vocabulary usage aligned.

".. We should define much more together what kind of students we want to educate and deliver. We need to exchange much more information between different courses in order to get a shared view on what courses we deliver as well. I think that if we do this much more frequently, that the meaning of interdisciplinarity will become clearer, also for new teachers."

For the design of an interdisciplinary course, the commitment of important, impactful professors across disciplines is key. They should also be fully aligned with their interdisciplinary views. If these views differ, it is difficult to design such a course.

The alignment of interdisciplinary views is also an issue in graduation committees in an interdisciplinary program; in addition to the chair being a professor, there are two supervisors from two different disciplines. The student needs to satisfy them all.

Equally, some interdisciplinary programs/courses have some mono-disciplinary courses included. When their content is changed due to, e.g., curriculum redesign, the interdisciplinary course is also affected and needs to be realigned with the mono-disciplinary course, which usually causes lots of problems.

Policies: appraisal

The appraisal system in TU Delft is linked to the staffs' contribution to research, not to education. Their main priority is, therefore, their research.

Teachers are not motivated per se in joining an interdisciplinary course as there is no direct incentive, such as a link with their own disciplinary research. It is time-consuming, and there is no reward because the results cannot be used for their own research and articles. Papers based on interdisciplinary topics prove to be more difficult to publish.

Furthermore, course codes are frequently not linked to their own faculty, so it is unclear what they actually contribute to their faculty. A teacher of an interdisciplinary minor course states:

*"... So there is really no reward for you?
No nothing, no, no reward, no appreciation, really totally nothing".*

So what is in it for them?

Policies: Quality through availability of teachers and budget

A common issue for all interviewees is the availability of teachers for interdisciplinary courses for different reasons. As interdisciplinarity is not in the veins of a disciplinary institute such as

TU Delft, tutors who would like to get involved are absorbed by their own departmental obligations and have no time. Also, little budget is available for interdisciplinary work, and sometimes teachers leave the university without replacement. Searching for an alternative teacher from a different faculty and discipline is difficult and takes time. He/she may have different views on the course and the integration of disciplines. This may result in a drop in the quality of the course.

“.. because we needed to continuously chase people and once in a while a teacher does not want to continue, and then you need to find an alternative. And at a certain point in time, it becomes a kind of a mess, a kind of collection of certain courses, with little connection and integration”.

What could help to attract teachers is when the organizational structure is clear and visible. They feel more rewarded when their contribution is visible to others. An interviewee suggested that only well-established research groups should deliver teachers. In these groups, more individuals are available to teach, there is a shared vision on education, and thereby the availability of a teacher and continuity of the course is ensured.

Usually, new lecturers are appointed through departments. They are appointed for educational tasks within the departmental, disciplinary programs and not for interdisciplinary programs. This is seen as a missed chance to improve the number and quality of lecturers who have experience in interdisciplinarity.

“Well, that is a bit tricky in my role as education director. I do not appoint people. That runs through the departments or institutes. We have an open vacancy for a tenure track, and someone will be recruited who can teach within the programs our department provides. But, as education director, I am not involved in what we actually need for our programs”. So there is a mismatch.”

There is a tendency to allocate more budget to research than to education, which hinders the development of improved educational, interdisciplinary programs.

“.... And, by the way, education dangles a bit. Despite the fact that they all say that education is also important. But meanwhile, the most budget goes to the research-driven faculties.”

Besides this, more students are admitted to the university, but no more budget is provided for course design, improvement, and facilitation.

Policies: Quality through team-teaching, planning, and evaluation

It is important to have an educational expert in the team, focusing on course design. Correct learning objectives will be delivered, the course is constructively aligned, and integration takes place.

“And then ask lots of questions about the more education part. So what the learning objectives were and how things fitted with the learning objectives. And I think having someone asking those questions helps. Because everyone who works at the university understands those things, and that helps translate a lot of the jargon and the specifics to a course to say the slightly more abstract learning objectives.”

A few interviewees specifically mentioned that in the team, one person was responsible for project management without any contribution to the content, guaranteeing, in combination with an educational expert, a well-designed course delivered on time.

As different faculties take part in course design, all stakeholders should be involved for input and commitment. Therefore a steering group was appointed with relevant representatives from the disciplines/faculties having a say in the course design. A curriculum committee specifically looked at the integration of the different disciplines in the course.

At the moment, at TU Delft, there is only a small “timeslot” in which interdisciplinary master courses can run across all faculties, which limits the delivery of the interdisciplinary course. It is recommended to reserve a specific timeslot in the masters’ program, equal across all faculties, enabling easier logistics and stimulating students to select the interdisciplinary course. This would allow one overarching course code and one administrative point, centrally organized allocating ECTS, time, and budget fairly across different faculties. Interviewees equally recommend a centrally directed course evaluation system. Currently, course evaluations are still organized per faculty, evaluating their own courses. Evaluation of interdisciplinary courses is, therefore, more difficult.

DISCUSSION

In this paper, we have looked at “What support (staff/organization) do the program and course responsible coordinators and teachers need to design and deliver interdisciplinary courses and break down the disciplinary barriers?”

With respect to staffing, we have been able to derive a clear profile of the potential interdisciplinary teacher and his/her professional competencies. Most interviewees would appreciate stimulation of staff professionalization for interdisciplinary teaching, for interdisciplinary course development and delivery. One methodology already used is working in interdisciplinary teacher teams consisting of content experts, educational experts, and representatives from different faculties. Ideally, these should be valued in the appraisal system and in budget allocations to these courses. With respect to the particular additional disciplinary knowledge required for a particular teacher in an interdisciplinary environment, our results show that a T-shaped teacher is recommended.

With respect to the organisation, we argue that the current disciplinary structure of TU Delft is felt to hamper interfaculty collaboration in terms of budget, appraisal, quality assurance, and evaluation. Alignment of the different faculty defined systems and processes is one of the first steps to remove some hurdles to interdisciplinarity at TU Delft. Interviewees also felt that the organization of interdisciplinarity at TU Delft would benefit from a more centralized, less departmental approach. Working in interdisciplinary teams should be more valued by the organization in terms of appraisal, allotted time, and budgets. Non-departmental budgets should be available for these interdisciplinary programs and courses. Overall, our findings are in line with earlier studies reported in this area (Gero, 2014) (Brown, 2005) (Frank, 2000) (Kans, Haralanova, & Khoshaba, 2014).

The development of one TU Delft shared vision on interdisciplinary education is recommended since this will lead to a clear organization and course structures. This is in alignment with our earlier research in which it became apparent (Klaassen, De Fouw, Van der Tang, & Rooij, 2019) that these visions vary amongst teachers and faculties, also within one course, which hinders constructively aligned program development.

Thus, alignment of the different faculty defined systems and processes is one of the first steps to improve interdisciplinarity at TU Delft.

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BIOGRAPHICAL INFORMATION

Nanneke J. de Fouw is currently a senior researcher for 4TU-CEE at TU Delft. She holds a Ph.D. in Medical Biology (University of Utrecht). She has more than 25 years' experience in leading and facilitating multidisciplinary teams at major multinational FMCG companies in product innovation and learning. She holds certifications in Belbin, MBTI, and Prince 2, and is a certified IAF facilitator. Her interests are in the development of young professionals in their interdisciplinary environment.

Renate G. Klaassen, Dr., is a program coordinator and researcher, working at the 4 TU Centre for Engineering Education at TU Delft. Areas of research interest pertain to content, language integrated learning in higher education, interdisciplinary learning, engineering roles for the Future of Higher Engineering Education, and conceptual understanding in engineering education. In the recent past, she has been heavily involved in educational advising on the innovation of the BSc in Aerospace Engineering and various other curriculum reforms at TU Delft. Consultancy activities include assessment (policy, quality, and professionalization), internationalization of university education, and design education.

Youandi van der Tang is a Master student in Aerospace Engineering, with a specialization in Spaceflight, Space Exploration. Currently, he is organizing the Massive Open Online Course: "Hyperloop: The Future of Transportation." As a Teaching Assistant, he works as a data analyst in research into interdisciplinarity of university programs, under the supervision of R. Klaassen. He has vast experience in working interdisciplinary as he was a member of the interdisciplinary development team "Hyperloop Pod Competition" 2019.

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