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jan cornelis kamphorst
Hanze University, j.c.kamphorst@pl.hanze.nl

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Introduction

Cooperating with other professionals is an increasingly important goal in higher vocational programs. The segregation of professionals' work according to disciplines, institutions or departments is diminishing. Instead, their work setting has become more and more multidisciplinary, which demands different skills and competencies to those required by the monodisiplinary contexts from the past. To address practical problems, professionals must collaborate with others, and cross the boundaries of their professions and backgrounds of study. The importance of multidisciplinary cooperation is emphasised in the European Qualifications Framework for Lifelong Learning (European Communities 2008). According to the Dublin descriptors (the descriptors for levels of higher education agreed upon by the members of the European Union, to which this framework refers), a professional with a bachelor's degree "can communicate information, ideas, problems and solutions to both specialist and non-specialist audiences" (Bologna Working Group 2005, p. 66).

The present study was conducted at two research centers of Hanze University in Groningen, the Netherlands, a university of applied sciences. This university emphasises the importance of multidisciplinary learning environments, also called "hybrid learning configurations" (HLCs), in which school-based learning and work experience are connected by interweaving learning and work processes (Cremers 2016). In HLCs, students are provided "opportunities for transboundary learning and knowledge creation in order to adress complex real-life problems" (Cremers 2016, p. 15). Important features of HLCs are the provision of authentic and complex problems that enable self-directed learning, authentic learning, the emergence of a strong link between the worlds of work and learning and knowledge creation across boundaries (Newell, 2001; Van Merriënboer, Kirschner & Kester 2003). The research centers, where students, lecturers, researchers and professionals from different fields of work are expected to merge knowledge, skills and perspectives, are very suitable for designing HLCs, and thus for the emergence of multidisciplinary cooperation (Bakker & Akkerman 2014). Students in the final (fourth) year of their bachelor's degree program are encouraged to cross the borders of their specific discipline, and facilitated in cooperating in teams with their peers, senior researchers and representatives of professions (similar, related or even dissimilar to their own intended profession).

Our university has further elaborated upon the concept of HLCs, and put it into practice in the form of innovative workplaces. An innovative workplace is "a social practice, in which partners of education, research, business, (local) government and public organizations work together on complex issues, which ask for solutions based on knowledge which transcends the borders of traditional structures, sectors, disciplines and forms of learning" (Cremers et al. 2016). The IWP Workgroup (2016) listed five dimensions on which innovative workplaces can be distinguished: (1) the degree of complexity of the issues that are addressed (simple to highly complex); (2) how one or more disciplines are involved in the research (mono- or multidisciplinary, for instance); (3) the learning objective (individual or group learning and co-creation); (4) diversity of partners (combination of two or more partners from education, research, professional practice, communities and business); and (5) the positioning and organisation (as a unit of the university, a partnership in which the university is one of the partners, or a public-private cooperation in or with an autonomous organisation).

The focus of the present study was on the degree of students' cooperation in innovative workplaces (dimension 2). We distinguished between multidisciplinary, interdisciplinary and transdisciplinary cooperation. *Multidisciplinary* cooperation occurs when professionals from

several disciplines are involved in a project, but maintain their distinct disciplinary perspectives (Cremers 2016; Fortuin 2015; Kamphorst & Nauta 2015). For example, when IT professionals develop software for nurses, both groups exchange information from their respective disciplines to make the software suitable for use in health-care settings. However, their cooperation is restricted to exchange of information from the different disciplines. Multidisciplinary cooperation is distinct from interdisciplinary and transdisciplinary cooperation. *Interdisciplinarity* occurs when professionals intensively interact, "resulting in integrating data, methods, tools, concepts and theories" (Fortuin 2015). An example would be when a psychologist and a nutritionist design an intervention to promote healthy eating. *Transdisciplinarity* goes one step further: professionals from different disciplines integrate their disciplinary knowledge and skills with non-academic knowledge (Fortuin 2015). Professionals cross the boundaries of their own discipline, and take up the distinct perspectives of colleagues. For example, this has occurred in a Hanze University project that is aimed at the neutral use of energy resources, and in which researchers cooperate with companies, civilians, researchers and local authorites. For the current study, we assumed that multidisciplinary cooperation is a necessary condition for inter- or trandisiplinary cooperation.

The context of this study was as follows. All students in the fourth year of their bachelor program can choose to do their graduation assignment, a capstone project during the final semester of their bachelor's degree program, at a research center. Ideally, the students conduct practice-oriented research that aligns with the requirements they need to meet to graduate, the research agenda of the research center and the demands of an external party. Most of the time, the external party is the owner of a practical problem. The student is required to translate this practical problem into a research problem and research questions. Students from different programs of study are organised into thematic groups, which are intended to facilitate or promote the students' cooperation, regardless of their different backgrounds, through sharing ideas, providing information or feedback and motivating and stimulating each other.

Once each students is matched with a graduation research assignment, they start writing a research proposal. After the graduation research proposal is approved by a lecturer from the program of study, the research centre (a lecturer-researcher) and the external party, the student can start working on the research assignment.

For good understanding of the context, it is important to note that other dimensions of the innovative workplace are less evident for students at a research centre. Student research is only occasionally part of the professional research group's larger commercial research, and thus the thematic groups of junior researchers do not typically participate in the networks of researchers at the research centre; moreover, generally speaking, the students at each research centre are from a limited range of programs of study (dimension 4). Furthermore, the students are assessed on their individual performance in conducting research (dimension 3). They must provide evidence to the lecturers at their program of study of how they conducted their research, and show that their work is the result of their individual effort. In other parts of the curriculum, such as first- and second-year projects and third-year minors and internships, there is more emphasis on the assessment of cooperation. However, this doesn't mean students no longer need to provide evidence of their cooperative competence during their fourth-year research assignment. (We will come back to this issue in the final section of this paper.) The degree of the research problems' complexity (dimension 1) can differ, however. Preferably, research problems addressed in graduation assignments are authentic, based on a realistic situation in professional practice, and sufficiently complex. This depends on the problems the external partners have brought to the research centre, and also whether these problems fit in with, or are more at the fringes of, the centre's research

agenda. When a problem is too simple, the research centre can decide not to accept it for professional or student research.

Research goal, central problem and research questions

From the perspectives of learning and professions, innovative workplaces offer attractive solutions for the development of multidisciplinary cooperation by bachelor's programs and allied research centres. However, in practice several problems may arise that thwart this goal. We distinguished between characteristics of students and of learning environments as conditions for multidisciplinary cooperation (cf. Spelt et al. 2009).

Students differ in curiosity, respect and openness towards other disciplines. They also vary in patience, diligence and self-regulation with regard to integrating and processing insights from other disciplines (Spelt et al. 2009). Furthermore, students have different social and educational experiences, which affect their mono- or multidisciplinary attitudes and preferences. In a study by Plumb and Sobek (2007), teachers indicated that the extent of student teams' multidisciplinary cooperation differed according to attributes such as interpersonal communication and cooperation, understanding and communicating disciplinary tradeoffs and empathy for diverse perspectives.

The conditions of the learning environments – in this case, the innovative workplaces provided by bachelor's programs in collaboration with research centres – can also differ. Factors that affect multidisciplinary cooperation include such aspects as tutors' time for mentoring students, the way multidisciplinary cooperation is addressed, the orientation of the program of study towards mono- or multidisciplinary perspectives, the pedagogy aimed at active learning and achieving cooperation, the assessment of multidisciplinary attitudes and skills and the graduation requirements (Spelt et al. 2009). Some programs of study seem to be strictly monodisciplinary, while others are, by nature, more multidisciplinary and more inclined towards boundary-crossing.

The general problem addressed by this study was that, although study programs in Dutch higher vocational institutions are based on the same European framework, in which multidisciplinarity is an important objective, competence regarding multidisciplinary cooperation is not an obvious or necessary outcome of the bachelor-level education provided at these institutions. This also seemed to apply to Hanze University. The innovative workplaces, in which programs of study, researchers and practitioners work together, are designed to improve opportunities for students to cross boundaries. However, there were signals from the programs as well as the research centres that innovative workplaces were not guaranteeing the emergence of multidisciplinary cooperation among students. The goal we wanted to achieve with this study was twofold. First, we aimed to develop an instrument for measuring the occurrence of multidisciplinary cooperation among students working on an assignment at a research centre. Second, we sought to conduct empirical research on the conditions for the realisation of multidisciplinary cooperation.

From this general problem, we derived the following research questions for this study: (1) Do students who are working at a research centre experience multidisciplinary cooperation? (2) Does their graduation research assignment encourage students to practice multidisciplinary cooperation? (3) Which factors enable or hinder graduate students' multidisciplinary cooperation in a thematic group at a research centre? We expected that the answers to these questions might provide information for research centres and study programs to improve the construction of or adjust their

innovative workplaces and the ways they address multidisciplinary cooperation in these environments.

Research design: Data collection, instruments and analyses

The data for this study was collected among fourth-year students from different programs of study who were working on their graduation assignment at two research centres (Table 1). Economic and engineering bachelor's degree programs can range from more monodisciplinary to more multidisciplinary. The Facility Management program of study is generally perceived as an economic discipline, but the program distinguishes itself from other economic programs by including aspects of applied psychology and related domains such as civil engineering, human technology and architecture (Mobach 2013). The Built Environment program of study uses knowledge and skills from a variety of disciplines (Oostra, 2013). Likewise, the Human Technology program profiles itself as being at the intersection of engineering and human behavior, and less as a monodisciplinary engineering program. Table 1 shows the distinction between eco-social and tech-social, in addition to the economic, engineering and social programs of study.

Table 1. Distribution of the participants (N =71) among different types of programs

	Research centre and year of data collection		
Program of study	Built Environment 2015	Built Environment 2016	Energy 2016
Economic	13	5	6
Eco-social	9	9	1
Engineering	9	1	3
Tech-social	2	2	8
Social	1	2	0
	34	19	18

In each of the two research centres, students were organised in thematic groups; for example, Health Space Design, Work Space Design and Climate & Environment at the Research Center for Built Environment, and Sustainable Building, Sustainable Households and Sustainable Mobility at the Research Center for Energy. Because of the multidisciplinary character of their themes (technical, business, communication, legal perspectives), the thematic groups were open to students of different degree programs (Energy Research Centre, 2017). Student research was also linked to the work of researchers and professors in research circles, to some extent; however, the link generally seemed to be rather loose.

The data for this study was collected among these 71 students during one-hour group sessions. Data was collected in two ways. Quantitative data was gathered using a structured questionnaire, with students given the option of adding explanations for their answers. Qualitative data was gathered using focus-group discussions. The two methods were combined in one session per focus group. The 14 focus groups were each made up of members of one thematic group, with two to eight members per focus group. The size of the thematic groups varied, and the participation rate for all focus groups was higher than 50 percent. Both types of data addressed the three research questions and provided complementary results. In particular, the focus-group discussions provided explanations and gave more insights into the outcomes from the questionnaire.

In each of the 14 sessions, the students first completed a semi-structured questionnaire. The questionnaire consisted of 12 five-point Likert-type items on cooperation, 13 Likert-type items on characteristics of the graduation assignment, and eight yes/no items about factors promoting and hindering *multidisciplinary cooperation (*MC here and in the results section), with students given the option to give comments. The session then continued with a focus-group discussion. The participants were asked to choose from seven partially overlapping questions (Box 1).

- To what degree do junior workers experience MC at this research centre? Are you cooperating with colleagues? Does the research assignment or do contextual factors influence the degree of multidisciplinary cooperation?
- Can you give examples of cooperation with colleagues at this research centre? Is it really multidisciplinary cooperation?
- Does MC result in cross-boundary knowledge or skills, which you would not acquire in other settings?
- How could students' MC improve at this research centre?
- Is the degree of MC an issue in the final assessment of the result of your (graduation) assignment by the research centre or your program of study?
- Which factors actually promote or impede MC at this research centre?
- Were you aware of the possible multidisciplinary setting at this research centre when you decided to apply for a graduation assignment here, and did this affect decisions regarding your study; for example, choosing a minor or certain subjects?

Box 1. Focus-group discussion questions

In most discussions, subjects related to MC were sufficiently addressed after two or three questions. Discussions took place in a very good atmosphere: students appreciated answering the evaluative questions and exchanging ideas about the multidisciplinary character of their work in the research centres. Their open attitude contributed to the quality of the study. Participants exchanged their ideas concerning MC with their peers, interacting with them as colleagues. This revealed that they experienced MC as a relevant issue. The discussions also provided evidence of the need for peer feedback on this subject. Each focus-group discussion was chaired by an educational researcher. Senior researchers at the research centre who supervised the groups also attended the sessions and facilitated the discussions. The managers of the two research centres and the students agreed that the anonymised data could be used for this paper. The study was conducted in conformance to the research guidelines of the Dutch Association of Universities of Applied Sciences.

For the Likert-type items from the questionnaire, we conducted two factor and reliability analyses using SPSS. The outcome of the first factor analysis, on the 12 information exchange items, indicated the existence of two scales: "Tendency towards MC regarding Information Exchange" (or IE, seven items, Cronbach's alpha of .76) and "Feedback regarding Research Approach" (or RA, three items, Cronbach's alpha of .89). Two items did not fit in a scale. The scale items are presented with one or two asterisks in Table 2. In the Results section we have used these scales to give a first impression of the extent to which students in the 14 thematic groups exchanged information (the IE score) and provided feedback to each other (the RA score). Further, these scale scores were used to explore differences related to program of study, research centre and year of data collection. The 13 graduation assignment items did not constitute a scale. We calculated frequencies for the eight factors promoting or hindering MC. Individual responses on this final question were used as input for the focus-group discussion.

During the focus-group discussions, both the educational researcher and the senior researcher took minutes. The minutes were analysed for broad key concepts, such as "multidisciplinary orientation", "learning environment of the program of study", "student attitudes and behaviour", "culture and organisation of the research centre", "composition of the thematic group" and "characteristics of MC". The qualitative data from this analysis was then merged into four themes (see the section "Results of the focus-group discussions").

Results

Sharing of information and feedback

With regard to the first research question, students were asked about how and to what extent they asked advice and feedback and shared information with peers in their thematic group about preparing for and completing the graduation assignment. Conversely, they were also asked about their perceptions regarding how and to what extent their peers communicated with them. Table 2 gives the results concerning these two perspectives – "my colleagues and I" and "my colleagues and me". The items for these two perspectives are directly parallel in most cases.

Table 2 shows that students communicated about their research assignments somewhere between "sometimes" (= 2) and "frequently" (= 3). The item that was rated lowest concerned "asking for advice", with means of 2.6 for "my colleagues and me" and 2.5 for "my colleagues and I". The item with the highest mean, 3.2, refers to learning a lot from the feedback provided by colleagues. Noticeably, the students experienced the feedback and information they received as more stimulating than the feedback and information they gave to others.

Table 2. Sharing of information and feedback by students (N=71)

My colleagues and me	Statistics			My colleagues and I
I ask my colleagues for [general] advice about how to do my graduation assignment.*	2.6 .79 2 1-4	*M* *SD* Mode Range	2.5 .81 2 1-4	My colleagues ask me for [general] advice about how they can do their graduation assignment.*
I approach my colleagues for [specific] information which I can apply in my graduation assignment.	2.8 .99 3 1-5	M SD Mode Range	2.6 .97 2 1-5	My colleagues approach me for [specific] information they can use for their graduation assignment.
I ask my colleagues how they tackle their graduation assignment.*	2.8 .80 3 1-5	*M* *SD* Mode Range	2.7 .88 3 1-5	Colleagues ask me how I tackle my graduation assignment.*
I learn a lot about how my colleagues approach their graduation assignment.**	2.8 .88 3 1-5	*M* *SD* Mode Range	2.8 .78 3 1-4	Colleagues find my advice and information useful for their personal approach to their graduation assignment.*
I profit from the information provided by my colleagues when working on my graduation assignment.**	2.9 .81 3 1-4	*M* *SD* Mode Range	2.5 .73 2 1-4	Colleagues profit from the information I provide to them when working on their graduation assignment.*

My colleagues and me	Statistics			My colleagues and I
I learn a lot from the feedback provided by colleagues.**	3.2 .93 4 1-5	*M* *SD* Mode Range	2.6 .97 2 1-5	Colleagues appreciate the feedback I provide to them.*

Notes: Response scale: 1 = never, 2 = sometimes, 3 = frequently, 4 = often, 5 = always. * Items from the scale Tendency Towards MC Regarding Information Exchange (IE). ** Items from the scale Feedback Regarding Research Approach (RA). The IE and RA scores were used for further analysis. Two items did not fall under either of these factors.

Students' opinions about the graduation assignments

To answer the second research question, which concerned the characteristics of the graduation assignment related to MC, the students were asked to give their opinion about 13 aspects. The results for this question are presented in Table 3.

Table 3. Students' opinions about the graduation assignment (N=71).

Proposition	*M*	*SD*	Mode	Range
The content of my graduation assignment is a consistent and well-defined whole.	3.2	1.0	4	1-5
My graduation assignment is a logical continuation of other parts of my program of study (e.g., subjects or minor).	3.6	0.9	3	1-5
By doing this graduation assignment, I encounter new knowledge and insights that are worthwhile to share with colleagues (e.g., through social media, publication, presentations or workshops).	3.7	0.8	4	2-5
To complete my graduation assignment I have to go more deeply into some subject matters than I have been used to during my studies so far.	3.8	0.9	4	1-5
My graduation assignment requires a broad orientation transcending my own field of study.	3.8	1.0	4	2-5
By doing this graduation assignment, I will deliver a professional product that accurately represents what I can do within my field of study.	3.8	0.9	4	2-5
I find it interesting to share ideas about my graduation assignment with people from different fields of study.	3.9	0.8	4	2-5
My graduation assignment is derived from a practical problem.	4.1	0.8	4	2-5
My graduation assignment is part of a bigger project.	4.1	1.1	5	2-5
By doing this graduation assignment I will deliver a product (advice, design, procedure) that contributes to solving practical problems.	4.1	0.8	4	2-5
My graduation assignment is complex enough to be challenging.	4.3	0.6	4	3-5
I am expected to think independently about how to conduct my graduation assignment.	4.3	0.7	4	2-5
The product of my graduation assignment is relevant for different stakeholders (e.g., professionals, researchers, interest groups).	4.4	0.6	4	3-5

Note: Response scale: 1 = completely disagree, 2 = disagree, 3 = neutral, 4 = agree, 5 = completely agree)

Table 3 shows that students had, on average, positive opinions about the multidisciplinary aspects of their graduation assignment. They agreed least with the proposition that their assignment was a consistent, well-defined entity, but the mean score was still above a neutral rating. Other scores were between "neutral" and "agree" or between "agree" and "completely agree".

Factors enabling or hindering performance

Concerning the third research question, respondents were asked to indicate whether eight factors promoted or impeded MC during completion of the graduation assignment. Table 4 gives the results for this question.

Table 4. Factors that promote or hinder MC during the graduation assignment

	Promoted	Hindered
The graduation assignment	85%	18%
Cooperation with my group of junior colleagues	78%	7%
Lecturer's coaching of the group of junior colleagues	76%	11%
The social climate and physical environment of the research centre	72%	16%
The professional field	68%	14%
The program of study (e.g., counseling by lecturers, the schedule, time reserved for doing subjects, competition with other subjects)	67%	43%
The composition of the group of junior colleagues	58%	15%
The size of the group of junior colleagues	49%	8%

Note: Factors can be, and in fact sometimes are, experienced as stimulating and hindering at the same time. As a result, the percentages per factor may not add up to 100%. The answers provided by the respondents formed the starting point for the focus-group discussion.

Table 4 shows that students experienced most factors as promoting MC during their graduation assignment; there was no single dominant factor. They perceived MC to be positively affected by factors such as the [type of] assignment, [characteristics of] the group of colleagues, the coaching of the thematic group, the program of study, [characteristics of] the professional field, and the environment of the research centre in which they worked on their assignment. In contrast, the respondents asserted that a few of these factors had a detrimental influence on MC. The factor that emerged most strongly was [the characteristics of] the program of study: 43% of the respondents identified the program as an obstacle to MC. The second important thwarting factor was the graduation assignment itself: nearly one out of five respondents (18%) identified this factor as inhibitory for MC.

Further analysis of the quantitative data

In addition to the results reported above, we were interested in differences in MC relative to the program of study and the research centre, and whether there had been changes over two years. For this additional analysis we used the two scale scores for "Tendency Towards MC Regarding Information Exchange" (IE) and "Feedback Regarding Research Approach" (RA) (see the section "Research design: Data collection, instruments and analyses").

The results showed that students with a tech-social background had a relatively high IE score (*M*=2.99, *SD*=0.63), indicating that they tended to engage in more MC regarding Information Exchange. Also, students in the tech-social as well as the eco-social domains scored higher on RA (*M*=3.06, *SD*=0.80; *M*=3.16, *SD*=0.55). This could indicate that students from a program of study that claims to be highly multidisciplinary (see the section "Research design: Data collection, instruments and analyses") were more inclined towards MC with regard to IE and RA. The students from the social domain had the lowest scores on IE and RA (*M*=1.93, *SD*=0.71 and *M*=2.56, *SD*=1.07, respectively). However, the differences between programs for both scores were not found to be statistically significant ($F = 1.700$, $df = 4$, $p = .162$ for IE and $F = 0.747$, $df = 4$, $p = .564$ for RA).

Analysis of the means for IE and RA for the two research centres showed that students at the Energy Center had a higher score on IE (*M*=2.99, *SD*=0.52) as well as RA (*M*=3.28, *SD*=0.77) than students at Built Environment (*M* =2.64, *SD*=0.65 for IE and *M*=2.90, *SD*=0.63 for RA). The differences were found to be significant ($F = 4.159$, $df = 1$, $p = 0.046$ for IE and $F = 4.189$, $df = 1$, $p = 0.045$ for RA).

Based on the results of the first part of the study in 2015, the Center for Built Environment made changes in the design and organisation of the graduation assignment in 2016, which may have influenced students' perceptions. The results of the third analysis showed slightly higher scores for IE and RA in 2016. However, the differences between 2015 and 2016 were not found to be statistically significant.

Results of the focus-group discussions

Each focus-group discussion was reported and shared with the senior researcher of the thematic group. In this paper we present a selection of the results under four headings: program of study, students, research centre and graduation assignment.

Program of study

The participants in the focus groups reported that the curricula of the programs of study addressed MC differently. Law and Business Management paid relatively little attention to MC. On the other hand, the participants noted that Communication Systems was distinguished by a wide range of subjects in the curriculum, derived from several disciplines. The same applied to the program Built Environment. Clients of Built Environment professionals usually dealt with a broader approach than only an engineering framework. Students' comments included: "The program stimulates MC by demanding that students address this issue in their graduation assignment plan" (Built Environment) and "The facility manager is, by definition, a professional who combines several disciplines" (Facility Management).

Participants noticed differences in the degree of complexity and inclusion of different disciplinary perspectives in assignments provided by their programs of study. Some found that assignments in the first year had already prepared them for MC. The Minor, a project in which third-year students from different programs explicitly cross boundaries, was also a good preparation for dealing with MC aspects during the graduation assignment. Other students (Law and Social Work*)* perceived their program of study as strictly monodisciplinary.

The participants in the discussion also mentioned that the procedures, assignments, assessment criteria and deadlines with regard to graduation differed across programs of study. “If you are lucky and your graduation proposal is approved soon, you can start [almost immediately] with your graduation assignment”, while others had a delay of several months. This affected working together with others. The workload during the graduation assignment became too high for some students who had not yet completed all the third-year subjects. These differences affected the possibilities for MC with other students.

The students frequently complained that it seemed that their colleagues in the thematic groups spoke in different research languages, due to different textbooks on research in their respective programs of study. They suggested a refresher course on research methodology at the start of their work on the assignment. Others replied to this suggestion by saying that there had been such a course, but this was attended by only a few students (probably due to the aforementioned workload).

Students

Generally, students were aware of and positive about the necessity for MC. At the same time, many students found it difficult to combine independent work and cooperation. Students indicated that they preferred to work on their thesis rather than meet with others to exchange ideas about how they could include alternative disciplinary points of view, especially when they were running short of time. They realised that the way they worked was affected by the requirements of their program of study. They were also inclined to stay in their comfort zone by working at home or in the familiar program's study rooms, where they could meet their fellow students, rather than in the office space at the research centre. Thus, the possibilities for MC were easily reduced.

Some students were inclined towards strategic behavior: “When you exchange ideas about how to tackle a problem with fellow students, the chance that they adopt your idea and get the credit for that, you are not doing yourself a favor.” Students wanted to be recognised and rewarded for what they did and created. A Law student put it even more straightforwardly: “I concentrate on my assignment. I am not communicating with other students, I just want to finish this assignment as soon as possible, in order to graduate on time within the nominal four years of study.”

In other focus groups, students mentioned that organising feedback for each other in frequent meetings further strengthened their cooperation and contributed to the quality of their final products, as well as to their motivation and perseverance in their tasks.

Research centre

The focus groups mentioned that the research centre was pivotal for fostering MC. Important factors we distinguished were (a) the culture of the research centre, (b) the research circles around professors, consisting of senior researchers, lecturer-researchers, representatives of the profession and student researchers, and (c) the organisation of students in thematic groups.

According to the participants in the focus groups, both research centres in this study were characterised by an open culture. Exchange of information was organised in weekly meetings, at fixed times, for all participants at the research centre, or in lectures provided by professors, senior researchers or external guests. At the end of the year or semester, all students presented their final products (for example, thesis, designs or prototypes) in workshops and poster sessions. Students noticed that, in practice, they were less involved in general information-exchange activities and consultation rounds on strategy and the research agenda of the centre, because they preferred to

focus on their assignments and not to pay attention to side activities, due to the short period of time allowed for completing the graduation assignments.

In the focus groups the students mentioned that they did not feel that they were really involved in the research conducted in the research circles and that they had fewer contacts with senior or lecturer researchers than desired. They reported that they occasionally noticed that these organisational units were important for the research program of the center and that the research themes could be linked to their own research; those who noticed this experienced their contribution to the research as rather fragmented.

Instead, the participants noticed that the thematic groups they all belonged to were involved in and supportive of their research. A major factor in this regard was the positive role of senior researchers and lecturer-researchers, who were all to some degree involved in guiding junior researchers. Participants mentioned elements such as listening to problems during the conduct of research ("only listening already helps"), giving suggestions for how to deal with practical problems, protecting the design of the study and reminding them of the relevance of the study or the structure of the thesis. Frequent meetings with the researcher who filled the role of counselor and gave feedback were perceived as key.

Participants from thematic groups signaled the existence of an "island culture", despite the fact that both research centers explicitly and increasingly addressed the composition of the thematic groups. This influenced their inclination to stick to a limited interpretation of their graduation assignment, not seek out too much MC with their colleagues and only do what was necessary to fulfill the requirements for graduation. Participants at the Built Environment Research Centre offered suggestions to better facilitate MC, such as listing the names and expertise of junior researchers in a central place and designating one room at the center for meetings. At the Energy Research Centre, participants experienced the positive effects of these measures on MC. However, at this center there was no central place for drinking coffee and informal consultations.

Graduation assignment and MC

In line with the results of the questionnaire, the participants experienced the type of assignment they received as promoting work with others on the graduation assignment. In most cases, the assignment was challenging, with enough possibilities for the students to include multiple perspectives. Some students complained that they were forced to choose a less attractive assignment, because their preferred assignments had already been awarded to other students. This affected the level of satisfaction with their assignment and the degree of MC. Sometimes, lack of specific knowledge made good execution of the assignment difficult. For example, a Facility Management student who completed an assignment in the field of care for mentally disabled people mentioned that he did not know how to address certain issues in his work.

The focus groups proposed several actions to improve the match between students and assignments, such as an application procedure for each assignment, more time for orientation about the assignment, more explicit communication about procedures and better management of expectations by the program of study as well as the research centre.

Discussion

The current study was conducted among fourth-year students who were grouped together in innovative workplaces at two of our university's research centers. The students' prime objective in this setting was to work on their individual graduation assignment and achieve assessment success. They were also encouraged to cooperate with others, in line with how they had been taught in earlier stages of their study. Thus, it was expected that they would, to some degree, share ideas, provide feedback to some degree, and motivate and stimulate each other. The signals from several study programs that multidisciplinary cooperation among students was not always guaranteed constituted an incentive for us to conduct this study. The results appeared to be transferable to and useful for similar innovative workplaces in our university. The message of this study for other higher-education research institutions could be that students are only prepared to cooperate when particular conditions related to characteristics of the program of study, students, the research unit and assignments are fulfilled. However, as we found that conditions such as characteristics of programs of study, students, research units and graduation assignments are likely to vary across research units and programs of study, it cannot be assumed that cooperation occurs always and everywhere in the same way.

This finding concurs with the literature on student cooperation, which also shows a large variety of different university settings in which students are enabled to cooperate and learn with and from each other, and that cooperation leads to multiple learning outcomes. For example, Adams (1998) and Schulz (2000) showed that working together in a non-majors' science laboratory in two North American colleges increased chemistry students' curiosity, confidence and satisfaction and resulted in better understanding and analytical skills. Needle, Corbo, Wong, Greenfelder, Raths and Fulop (2007) reported about the students at an arts and science college who collaborated in a multidisciplinary setting on the microscopic digital imaging of the adult zebrafish brain. Students "broke down academic barriers in different disciplines", and "emerged not only as independent, self-regulated learners, but also as more imaginative and integrative thinkers". Similarly, Reichelt-Brushett and Smith (2012) found that scientist from a science and management school and artists from a school for arts and social sciences who cooperated in a workshop also discovered the boundaries of their own disciplines and exchanged tools and practices. Thus, each research unit and each program of study must invent how cooperation can be designed and which outcomes are desired.

This study had several limitations. It was exploratory, due to the fact that, to date, only a few studies have been conducted in the field of multidisciplinary education (Lattuca 2004; Spelt et al. 2009). For practical reasons, the focus of this study was on multidisciplinary cooperation. We assumed that the occurrence of interdisciplinary or transdisciplinary cooperation implies the occurrence of multidisciplinary cooperation. It could be beneficial in a follow-up study to explicitly address different degrees of boundary-crossing. Also, more attention could be paid to the learning process in multidisciplinary groups (Spelt et al., 2009). Furthermore, the empirical basis of the scales (Tendency Towards MC Regarding Information Exchange and Feedback Regarding Research Approach) may need more confirmation and validation before they can be used in other educational practices.

In contrast, according to the comments of the lecturer-researchers, the results of the present study provided a good opportunity for programs of study and research centres to improve multidisciplinary cooperation, such as by paying more attention to the embedding of the graduation assignment in the program of study and the profession, better organisation of the

thematic groups and better guidance and training of students with regard to research issues. The students appreciated the focus-group discussions as a means of peer feedback. Instead of talking about the content of their graduation assignments, they exchanged experiences and ideas about multidisciplinary cooperation. Some participants mentioned that this was the first time they had been invited to step aside and look at their work and how they cooperated with others.

Conclusions

The competence of multidisciplinary cooperation is intended to be an important learning outcome in universities of applied sciences. We conclude, however, that multidisciplinary cooperation is not realised as much as might be expected or desired (e.g., Cuypers-Henderson & Overdieck 2016). The results from the questionnaire and the focus-group discussions point in the same direction. With an average score slightly less than 3 on a scale of 1 to 5, students practice multidisciplinary cooperation somewhere between “sometimes” and “frequently”, but not “often” or “always”. They are inclined to exchange general information about how they work on their assignment and about research issues. However, students show considerable variety in their attitudes and behaviours towards multidisciplinary cooperation. Factors that contribute to these differences are related to the program of study, the students, the research center and the graduation assignment.

Programs of study differ in orientation on the continuum between monodisciplinarity (e.g., Law) and multidisciplinarity (e.g., Facility Management), and this affects the narrow or broad interpretation of cooperation in the respective curricula (Cuypers-Henderson & Overdieck 2016; Spelt et al. 2009) and the research language used. Differences between programs of study in procedures, time tables, deadlines and workload also thwart cooperation. Furthermore, the results of this study indicate that multidisciplinary cooperation is encouraged, but that programs of study and research centres where students can do their graduation assignment lack criteria to assess this competence.

Students are aware of the possibilities that an innovative workplace at a research center offers for multidisciplinary cooperation, but they experience a tension between working independently and working with others. Another obstacle is time management, especially when it comes to multidisciplinary cooperation during more-complex and multifaceted assignments. Furthermore, students tend to stay in their comfort zone, preferring the familiar and safe environment of their school or their private homes to the offices in the research center. Students also have a tendency towards strategic behaviour, meaning they do not share ideas or outcomes with fellow students. Sometimes, students organise feedback in their thematic group. This self-organised peer feedback supports their motivation and perseverance, and leads to better results on the graduation assignment. An important condition for self-organisation was the match between individual members of the groups.

Research centers influence the degree of cooperation between students. Students found that an open culture, with exchange of information about research issues, as well as good facilities, such as a good place for meeting each other and lists with names and available expertise, encouraged their cooperation with others. Although research circles should have a positive impact on the degree to which students cooperate, in practice they did not function optimally and were not perceived as an impetus for students’ cooperation. The results of this study show that thematic groups, formed separately from the research circles, were better organised in several respects.

However, students also experienced fragmentation and loose connection with their fellows in these groups, at the expense of multidisciplinary cooperation.

Finally, the quality of the graduation assignment affected the degree of multidisciplinary cooperation. The higher the challenge offered by the assignment, the more students were inclined to multidisciplinary cooperation. However, an assignment that is too complex, combined with a demand for specific knowledge or skills, may be detrimental for multidisciplinary cooperation, unless students have learned how to cooperate across disciplines in previous stages of their study and are encouraged to show cooperative behaviour.

REFERENCES

Adams, D L 1998. What works in the non-majors' science laboratory – some practical advice on how to build a workable and meaningful introductory science laboratory. *Journal of College Science Teaching*, 28(2), pp. 103-108.

Bakker, A & Akkerman, S F 2014. Leren door boundary crossing tussen school en werk [Learning by boundary crossing between school and work]. *Pedagogische Studiën*, 91(1*)*, pp. 8-23.

Bologna Working Group 2005. *Framework for Qualifications of the European Higher Education Area*. Report. Danish Ministry of Science, Technology and Innovation, Copenhagen.

Bulthuis, P 2013. Het ZelCommodel, grip op competentieniveaus. De samenhang tussen zelfstandigheid en complexiteit [The ZelCommodel, grip on competence levels. The relationship between autonomy and complexity]. *Examens*, 2(5), pp. 5-10.

Cremers, P H M 2016. *Designing hybrid learning configurations at the interface between school and workplace*. PhD thesis. Wageningen University, Wageningen.

Cremers, P H M, Wals, A E J, Wesselink R, & Mulder M 2017. Utilizing design principles for hybrid learning configurations by interprofessional design teams. *Instructional Science*, 45(2), pp. 289-309. doi:10.1007/s11251-016-9398-5.

Cuypers-Henderson, M & Overdieck, A 2016. Van multidisciplinair samenwerken naar boundary crossing [From multidisciplinary cooperation to boundary crossing]. *Onderwijsinnovatie*, 18(3), pp. 35-37.

Energy Research Centre 2017. Bachelor programes. Viewed at https://www.hanze.nl/eng/research/strategic-themes/energy/education/.

European Communities 2008. *European Qualifications Framework for Lifelong Learning*. European Communities, Luxembourg.

Fortuin, KPJ 2015. *Heuristic principles to teach and learn boundary crossing skills in environmental science education*. PhD thesis. Wageningen University, Wageningen.

IWP Workgroup 2016. *Innovatieplaatsen in ontwikkeling* [Innovative Work Places in development]. Hanze University, Gronigen.

Kamphorst, J C & Nauta, J 2015. *Multidisciplinair werken van juniormedewerkers in Kenniscentrum Noorderruimte. Onderzoeksverslag* [Multidisciplinary cooperation by junior researchers in Research Center Built Environment. Research report]. Hanze University, Groningen.

Mobach, M 2013. Inaugural professoral address Facility Management. Hanze University of Applied Sciences, Groningen. Viewed at https://www.hanze.nl/eng/research/centre-for-applied-research/built-environment-noorderruimte.

Needle, A, Corbo, C, Wong, D, Greenfelder, G, Raths, L & Fulop, Z 2007. Combining art and science in "arts and sciences" education. *College Teaching*, 55(3), pp. 114-119.

Newell, W H 2001. A theory of interdisciplinary studies. *Issues in Integrative Studies*, 19(1), pp. 1-25.

Oostra, M A R 2013. *Local energy initiatives*. Inaugural professoral address Spatial Transformations. Hanze University of Applied Sciences, Groningen. Viewed at https://www.hanze.nl/eng/research/centre-for-applied-research/built-environment-noorderruimte.

Plumb, C & Sobek, D 2007. *Measuring student ability to work on multidisciplinary teams: building and testing a rubric*. Paper presented at 2007 annual conference and exposition of the American Society for Engineering Education, Honolulu, Hawaii.

Reichelt-Brushett, A J & Smith, J 2012. Connecting silos – inviting art and science interactions. *Leonardo – Art, Science and Technology*, 45(5), pp. 484-485.

Schulz, E 2000. A chemistry course with a laboratory for non-science majors. *Journal of Chemical Education*, 77(8), pp. 1001-1006.

Spelt, E J, Biemans, H J A, Tobi, H, Luning, P A & Mulder, M 2009. Teaching and learning in interdisciplinary higher education: a systematic review. *Educational Psychology Review*, 21(4), pp. 365-378.

Van Merriënboer, J J G 2009. Cognitive load theory in health professional education: design principles and strategies. *Medical Education*, 44(1), pp. 85-93.

Van Merriënboer, J J G, Kirschner, P A & Kester, L 2003. Taking the load off a learner's mind: instructional design for complex learning. *Educational Psychologist*, 38(1), pp. 5-13.