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The role of space in interdisciplinary collaboration in design education

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Abstract The growing interest in the collaborative design education for innovation has mainly been concerned with students and learning outcomes. We know less about the collaboration between the tutors who teach interdisciplinary design courses. Addressing this gap, this article explores the effect of space on the interdisciplinary collaboration between faculty members from the fields of industrial design, architecture, engineering and business administration, who come together to design and conduct an extra-curricular educational activity, Interdisciplinary Design Studio (IDS) at METU. The empirical basis of this study comes from the interviews with the faculty members and the participant observation notes generated during the IDS meetings. The findings show that the effect of space on collaboration becomes evident over three issues, (1) the participation of tutors, (2) the commonality of their expectations from a design project, and (3) the interaction not only between students and tutors, but also among tutors as an interdisciplinary team.

Keywords Design education · Engineering education · Space · Collaboration · Interdisciplinarity · Design factory

Introduction

The increasing interest in achieving innovation through the collaboration among design, engineering, and business has resulted in the initiation of various interdisciplinary courses and programmes (Richter and Paretti 2009; Fixson 2009; Eppinger and Kressy 2002). This

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interest is triggered by the observation that professionals who do not experience interdisciplinary cooperation during undergraduate education find it challenging to work with other disciplines (Itkonen et al. 2009). Since neither designers nor engineers have an opportunity to familiarize themselves with the educational and professional perspectives of each other at university, they enter professional life without being prepared for dealing with the challenges that may occur due to the differences in these perspectives (Yim et al. 2014; Rasoulifar et al. 2014).

Within the growing literature that presents the evaluation of the interdisciplinary design courses from the perspectives of the tutors and the students, the main tendency in these studies is to focus on the student experiences and/or learning outcomes. Even when the tutors are mentioned, this is usually done to reflect on their role in the course or in the research (see for example Lee 2014; Andersen 2001; Busseri and Palmer 2000; Wodehouse and Maclachlan 2014). Thus, we do not know much about the collaboration between the tutors who teach interdisciplinary design courses. This paper addresses this gap by examining the collaborative work among the faculty members who came together in the case of the Interdisciplinary Design Studio (IDS) at Middle East Technical University Design Factory (METU DF) in 2015.

METU DF is an interdisciplinary research and education centre for innovative product development and rapid-prototyping, which was recently established with support from the Ministry of Development of Turkey. The main goal of METU DF is to offer an inspiring and encouraging environment for interdisciplinary collaboration, where both academics and students from various disciplines work together using the space and production infrastructure provided. IDS is an extra-curricular educational activity offered by METU DF, which brings students from different disciplines together in interdisciplinary teams to develop innovative products. It was designed by an interdisciplinary team of faculty members, from the Faculty of Engineering, Faculty of Architecture, and Faculty of Economic and Administrative Sciences. The first IDS was carried out in 2015 fall and lasted for four weeks. The faculty members were also the tutors of the IDS, and participated in the IDS by directly teaching through the seminars and workshops, and providing feedback on the projects in the mentorship sessions. The authors of this article, who are among the members of this tutor team, had an additional role in this process: to carry out a research project on the interdisciplinary collaboration in the IDS. Thus, this article is based on intense and rich empirical data, generated through the interviews with the 16 tutors who participated in the IDS, as well as our observations during the whole process.

Acknowledging that interdisciplinary collaboration for innovation is a broad subject topic to investigate with all dimensions, in this paper we choose to focus on its relationship with space. Space is a valuable topic of research, particularly for the case of the IDS, since the DF building was not ready to use yet when the IDS began. The lack of a dedicated and specifically-designed space enabled us to see the ways in which space can be influential on people's approach towards interdisciplinary collaboration, which would not be easy to capture otherwise. This article begins with the review of the existing studies on the relationship between space and collaboration. Next, we outline the methodological approach that guides our research design. Then, we present our findings regarding the effect of the (lack of a shared, independent and working) space on the interdisciplinary collaboration of the IDS tutors, in three sections, which are pulled together to offer conclusions in the final part of the article.

Interdisciplinary collaboration and space

Interdisciplinary work has become more prominent than ever in recent years in the scientific arena (NSB 2010; NRS 2004; Glänzel 2001). In order to address complex problems humanity is facing, such as energy, climate change, and water, researchers from different disciplines are needed to work together as these problems do not neatly fit into the disciplinary boxes the academic system created (Nature 2015; Klein 2009). Within the existing studies on interdisciplinary collaboration, the relationship between physical environment and collaborative work has been placed considerable attention. Particularly labs, buildings, and campuses have been taken as fruitful contexts to investigate (Klein 2009; Vinokur-Kaplan 1995; Lehrer 2012). Although the literature is scattered in different fields from design and architecture to organization studies to science of team science, its review foregrounds four issues regarding interdisciplinary collaboration, which are interaction, proximity, creativity and flexibility.

Interaction between the workers who share the same building is suggested to be influenced by the design of the workspace. As Sa (2007, p. 24) indicates, buildings have the potential to foster new forms of collaboration and to 'increase the chance of serendipitous encounters among researchers who would otherwise be unlikely to interact.' One of the very first buildings that catalyzed interdisciplinary research had been the famous building 20 of the MIT, until it was demolished in 1998. The building's layout led to chance encounters in the corridors, flexible partition helped creating new and innovative lab spaces, and most importantly, the unusual mix of different departments from sciences to engineering to humanities located in one building facilitated many interdisciplinary engagements (Lehrer 2012; Harris and Holley 2008). Another early example is the Salk Institute designed by Louis Kahn, in which in order to promote collaboration there were no walls separating the labs from each other (Sternberg and Wilson 2006; Bourgeois 2013). This approach to building design has inspired the new interdisciplinary centres especially in biomedicine and biotechnology.

The second issue, which is closely related to interaction is the proximity among collaborators. It has been demonstrated that there is a negative relation between the physical distance and the likelihood of collaboration (Allen 1977; Olson and Olson 2000; Olson et al. 2002). In regards to space, not only the proximity of the rooms of the researchers, but also the artifacts in between researchers and whether they can be travelled is important (Kabo et al. 2014, 2015). For instance, the location of the shared artifacts and spaces, such as the water fountain, elevators, stairs and restrooms is highly influential on creating a collaborative work environment. Moreover, as Björklund et al. (2011, p. 80) underline in their research on Aalto University Design Factory, without having the possibility of encountering and interacting with other people in the shared open spaces, having offices in the same building does not necessarily support collaboration. Their observations reveal that new collaborations are established rather 'after overhearing people talk and catching up with different members of the community while getting coffee, eating breakfast, cooking lunch, taking part in the same events, or working on an adjacent desk.'

Third, research on innovation labs and centres and design studios shows that creativity is considered to be an important aspect of interdisciplinary collaborative work. The recent trends in office design claim that creative thinking, innovation and productivity are enhanced by pleasant, open and pressure-free spaces (Haner 2005; see NRS (2015) for a review of the studies on productivity and workspace design). A dedicated work space is critical for teams where interdisciplinary design projects are undertaken (Fixson 2009).

Particularly compared to the traditional offices that offer formal meeting rooms with large rectangular tables to gather around, open spaces that encourage more informal work relations are suggested to support group creativity (Magadley and Birdi 2009; Vyas et al. 2009). Various studies have provided empirical evidence on the relationship between team creativity, collaboration and the design, layout and the atmosphere of the innovation-focused workspace. Sternberg and Wilson (2006), for instance, discuss creativity through architecture in the case of collaboration between neuroscientists and architects. Making a distinction between physical space and information space, Li and Robertson (2011) investigate how physical space, furniture and equipment influence collaborative decision making in medical teams.

The fourth issue highlighted in relation to collaborative work is the flexibility of the space. While flexibility of the interior space, e.g. via mobile and convertible furniture, is usually linked to the previous issue, we believe that it is worth discussing separately. Some studies take flexibility as an issue beyond the interior space, and argue that according to the requirements of the project whenever a need arises, researchers, equipment and even labs should be rearranged (Lehrer 2012; Gieryn 2008; Goldstein 2006). With a focus on design projects, Vyas et al. (2009, p. 166) suggest that spatial flexibility is required for the organization of the materials produced by the students throughout the project, such as paper sketches, post-its, mock-ups and models. According to them, how designers keep and organize these materials is highly influential on team discussions, communication and coordination. They state, 'it is this spatial flexibility of, for example, sticking sketches and drawings on a shared office wall or keeping physical models of different materials on a table that allows designers to discuss, criticize and explore new possibilities of their design work.' Björklund et al. (2011, p. 79) warn us that creating a flexible environment that enables people to rearrange the furniture and equipment is not adequate alone. It is also important to encourage people to do that. Referring to the Aalto University Design Factory, they indicate that the 'unpolished feel and mobile furniture have suggested that it is okay to modify the environments.'

Research design

This paper explores the effect of space on the interdisciplinary collaboration between tutors who come together to carry out an extra-curricular design studio. Our methodological approach was informed by the constructivist perspective, based on the premise that 'human beings act toward things on the basis of the meanings that the things have for them' (Blumer 1969, p. 2). Since understanding the tutors' mindset was crucial in the investigation of interdisciplinary collaboration at the intersection of design, engineering, and social sciences, we were concerned with the 'meaning' and 'action' in their accounts as they reflected on their approaches towards interdisciplinarity, collaboration, and design process, as well as their expectations from the IDS and the METU DF.

In order to generate rich, focused, and intense data, we employed McCracken's (1998) *Long Interview* as the main research method. The participants were selected from tutors of the METU DF. Since the interviews were conducted before the official establishment of the DF, we identified all tutors who have attended at least one of the meetings in which the focus was on the development of the IDS as the participants of this study. Overall, 16 tutors, 5 women and 11 men, participated in the study. We carried out interviews in two rounds: 11 interviews were conducted before the IDS begins and 13 interviews were

conducted shortly after the IDS ends. Although we aimed to talk to all participants in both pre- and post-IDS interviews to understand in what ways and to what extent their opinions and attitudes change, only eight participants were available to attend both. The participants were from the Faculty of Engineering (Departments of Mechanical Engineering, Electrical and Electronics Engineering, Computer Engineering, Metallurgical and Materials Engineering) Faculty of Architecture (Departments of Industrial Design and Architecture), Faculty of Economics and Administrative Sciences (Department of Business Administration). They were in different stages of their career from research assistant to full professor.

We used a discussion guide, a set of questions to be asked to reveal the mental construct of the interviewees, in order to let them explain and depict their individual constructs. In order encourage the participants to reveal their thoughts, and to increase the relevancy of things they said, we followed a semi-structured format, and did not hesitate to ask questions in different order. The pre-IDS interview questions focused on the tutors' motivations to be involved in the METU DF and the IDS; their visions and expectations for both themselves and their students; their understanding of the concepts of design, interdisciplinarity and project within their specific disciplines; and their assumptions and existing collaborations, if any, with other disciplines that take part in the IDS. In the post-IDS interviews, we examined to what extent and in what ways participants' motivations, expectations, understanding of the basic concepts and ideas about collaborating with other disciplines have changed. Also, we asked what their and their students' roles were in the IDS and whether they were happy with these roles. The interviews lasted approximately one hour and were conducted at the offices or labs within the university.

The epoche concept was taken into account at this phase, and the interviewers eliminated or at least gained clarity about preconceptions (Patton 2002) and manufactured distance (McCracken 1998) to help assure that the data was as free of bias as possible. However, since the interviewers, the authors of this article, were also the part of the METU DF team; manufacturing distance was not always easy. We paid attention to develop a reflexive and transparent research approach in order to deal with the challenges of our dual role both as the researchers and the team members. Since we are two researchers with different educational background and, thus, different concerns regarding a research project on interdisciplinarity in design, throughout the research (beginning from preparing the interview guide to the data analysis) we kept discussing and comparing our perspectives and possible biases. During both pre- and post-IDS interviews, we arranged weekly meetings with each other in order to examine the interviews that we carried out separately and give feedback to each other.

The interviews were audio recorded and verbatim transcribed. Once the transcriptions were ready, we analysed them thematically. In the analysis line-by-line coding helped us getting a systematic overview of the data, going beyond the impressions left from the interviews (Mason 2002). We first analysed the interviews, coded them and came up with themes separately. Afterwards, we compared our codes and themes to each other and developed an outline. The reason for separate analysis is to conduct 'analyst triangulation' to avoid individual biases (Patton 2002, p. 556). Our overall approach to analysis was interpretive, in the sense of focusing on how participants made sense of their experiences of interdisciplinary collaboration within the context of the IDS. Since we were dealing with a small and close community, and participants could be identified by other team members, confidentiality was paramount in this research. We needed to develop a particular strategy regarding participants' gender in the presentation of our findings. Among our participants there is only one woman among the engineering tutors. In order to prevent this participant

from being easily identified, we chose to use feminine third person pronouns for all participants.

In this research, by exploring a case rather than a population-based sample, we adopt a rich, in-depth and context-dependent research model, which is also essential to the development of new theories. As Kvale and Brinkmann (2009) suggest, doing this, we ask whether the knowledge produced can be transferred to other relevant situations instead of whether findings can be generalized to the entire population. We agree with Riessman (2008, p. 13) on the argument that despite the assumption that the results of case-centred studies are not transferable, 'making conceptual inferences about a social process (the construction of an identity group, for example, from close observation of one community) is an equally "valid" kind of inquiry'.

In order to enhance the quality of analysis, as explained above, we used analyst triangulation. Furthermore, while interviews were our primary source of data, we utilized the participant observation notes that we took throughout the IDS meetings to produce a factual account of the process which also serves as methods triangulation (Patton 2002). For example, to what extent tutors participated in the training and mentorship sessions, and how often tutors came together to plan the IDS were the two questions that needed to be answered by the information offered by the observation notes.

In our research, member check was not possible as we conducted two rounds of interviews and focused on the IDS process. Confronting the participants with the question of 'Did you mean this back then?' would have changed the dynamics in the IDS and might have damaged the working relationships among the tutors. Moreover, in order to ensure authenticity we included quotes from the participants in the manuscript as much as possible.

Space and the collaboration among the IDS tutors

In the post-studio interviews, overall, all tutors in the IDS team expressed positive thoughts and opinions about the experience of the first IDS, which they call 'the trial'. They indicated that students tried and did their best to finalize their projects, and tutors who contributed to the IDS, whether by organizing seminars and workshops on certain topics or by attending feedback sessions, devoted their already limited and valuable time to support the IDS. Although they appreciated the effort made by both students and the tutors who took an active role in the IDS, once they started to reflect on the IDS process from their disciplinary standpoint, the positive tone of their accounts faded in, and the issues that 'could have been different' came forth. Exploring these issues, in the analysis we identified the lack of a shared space dedicated to the IDS as a central concern. Space, on which there was not much emphasis in the pre-studio interviews, is suggested to have a great impact on (1) the participation of the tutors, (2) the commonality of their expectations from a design project, and (3) the interaction not only between students and tutors, but also among tutors as an interdisciplinary team. Furthermore, our findings show that the problems related to space to a certain extent have a second dimension, which is *time*. As we will present in the following three sections, where we examine *participation*, *commonality* and *interaction* separately, space- and time-based problems raised by the tutors seem to both invite and amplify each other.

Participation: being and feeling inside the IDS

In the post-studio interviews we asked whether the tutors were happy with the roles they took in the IDS. They responded that, they accounted for the amount of their as well as other tutors' participation. During the IDS, tutors' participation took two forms. The first one was undertaking a seminar or a workshop in the first week on a topic that would facilitate interdisciplinary collaboration between students. Although these seminars and workshops were open to all tutors and some also included feedback sessions that would benefit from the disciplinary perspectives of other tutors, participation was very low. Apart from the tutors who carried out these sessions, only few tutors attended and followed the sessions from beginning to the end, and other few who turned up occasionally stayed for short periods. The second form of participation was attending the mentoring sessions that were organised in the last 3 weeks of the IDS, on Mondays, Wednesdays and Thursdays, between noon and 2 pm. Tutors showed better attendance in these sessions where they provided feedback on the student teams' projects. More than half of the IDS tutors attended at least one of these nine sessions.

Our findings based on the interviews are aligned with the observation notes in demonstrating that the members of the Faculty of Architecture had higher visibility during both the training week and the mentoring sessions. Among the members of the other two faculties, Faculty of Engineering and Faculty of Economic and Administrative Sciences, apart from one engineering tutor who showed regular attendance, participation was low. Reflecting on this situation, the general tendency in the engineering tutors' accounts was to explain why they did/could not attend the IDS more often. In the description of the role she takes, for example, one engineering tutor says, 'I was only involved in mentoring but could not be team player [in the whole IDS], could not get involved. I was more of an observer and guide.'

The primary reason behind poor participation was indicated as the difficulty of sparing time for IDS in their busy schedules. Since IDS was a voluntary extra-curricular activity, taking an active role in the IDS brings additional workload that would not replace with tutors' existing teaching and administrative duties in their departments. While the lack of time was the most often voiced reason behind engineering tutors' poor participation, in their accounts we identified the venue of the IDS as a more subtle issue closely related to their distanced stance. As we explained earlier in the article, since the DF building was not ready yet, another venue had to be allocated for the IDS. This was a design studio in the Department of Architecture. This studio, however, was not suitable for all seminars and workshops carried out in the first week. It was relatively small and the layout of the furniture did not support team activities. This is why two other places at the faculty, a large seminar room and another larger design studio, were also booked for the IDS activities. Thus, the IDS activities took place in a couple of available places in the Faculty of Architecture building, where the tutors from Industrial Design and Architecture have their offices. Although the tutors shared positive opinions regarding the use of the Faculty of Architecture building as the venue in the absence of the DF building, a closer look into the data reveals how the lack of a shared and independent space for the IDS seems to support the poor participation of engineers by inviting a faculty-based 'we/they' distinction. This distinction has implications for the feeling of belongingness and encouragement for involvement, as the following quote by an engineering tutor illustrates: 'But well, I didn't feel myself deeply involved. This is probably because [the IDS] was, in terms of space, over *at that side*. I mean, the students definitely need a place. I mean at least they need

some space to 'park'. I mean, all in all, as it was the Faculty of Architecture who provided that space… eee… I was grateful at that point. But *we* couldn't get involved in that way.'

Selection of the Faculty of Architecture, which corresponds to 'that side' in the quote, as the venue seems to discourage the engineering tutors from involving in the IDS activities due to the venue's falling into the territory of another disciplinary area. The faculty-based we/they distinction was also mentioned by another engineering tutor as part of the discussion on the relationship between the ownership of the venue and the involvement of disciplines.

> Well, I was not very active in IDS. Saying I wasn't active, I mean, overall it was a little bit more, I mean, you know, an architecture faculty-based procedure was followed. I don't mean a bad thing. As engineering, what we do in our graduation projects is quite different. When I said I wasn't active, I meant, I didn't push 'our way' as I wanted to see how the process followed here's like, how design happens in this faculty.

Throughout the we/they distinction, the engineering tutors from various departments are presented as one homogenous group, and tutors from architecture and industrial design as another homogenous group. Based on the presumption that these two areas follow different design processes, she suggests that in the territory of the designers, engineers should take the role of an observer to learn how things are going on there. Although she stresses her approval of the leading role of the architecture and industrial design tutors, the division of roles in this way seems to undermine the equal participation of all disciplines, and as she concludes, 'while engineering students could get involved, engineering tutors could not get much involved in the IDS.'

In the account of another engineering tutor, we/they distinction appears in the form of a guest/host comparison. In response to her students who express their dissatisfaction regarding the low participation of the engineering tutors, she says,

> I told them that these things were related to space, right now, we're kind of guests there, in the following times I would give a speech there, and there would be someone from mechanical [engineering], and these kinds of complaints decreased over time. But, the very first week, they felt like they were attending a workshop organized by the industrial design or architecture department -not an overall interdisciplinary thing. It may be psychological. But it could have been better organized. Especially after we move to a common space.

Thus, the venue's being in the territory of the Faculty of Architecture makes the engineering tutors feel like the guest, and assigns the role of the host to the architecture and industrial design tutors, who teach and have their offices in the building. As stated by the previous tutor in a similar way, the curriculum is also considered to be shaped by the uneven participation of the engineering and design tutors following these roles. The lack of a shared independent venue, then, had a detrimental effect on establishing interdisciplinarity, which was the main goal of the IDS.

The accounts of tutors from the Faculty of Architecture reveal that they were aware of and worry about the invisibility of their engineer colleagues in the IDS. They address this situation as a problem that could have solved by better planning of the IDS. One of them indicates that if as a team tutors could come together more often before the IDS begins, they could discuss other alternatives for the selection of venue, which would simultaneously affect the participation of the engineering tutors as well as the first week's curriculum design. The quote illustrates her suggestion for how it could be possible to go beyond the

territory of a disciplinary group, and to adopt a genuinely interdisciplinary approach in the training week of the IDS: 'Exercises that would represent every discipline could have been given consecutively. Students could have been studied in different places. For two days they could be here, we could have done our philosophical discussions followed by basic exercise here, and afterwards they could have gone to the Department of Mechanical Engineering.'

Commonality: concepts and ideas versus prototypes

The duration of the IDS was 4 weeks. Since the first week was dedicated to seminars and workshops, students had 3 weeks to work on their projects. During these 3 weeks, students followed the design process with three stages: conceptual design, detailed design, and prototype development. At the end of each stage, which lasts for a week, teams presented their work to IDS tutors and other students to get feedback. At the end of the first stage, two teams proposed to develop apps. Since the production infrastructure offered by DF building was not ready to use yet, the tutors decided not to insist on tangible prototypes as the project outcome. They agreed on that the teams could finalize the project with models instead of prototypes as well as apps, since the primary aim of the first IDS was to observe and test how students come together and collaborate in interdisciplinary teams. As a result, in the interviews, all of the tutors who took a role in the IDS indicated that overall it was a successful event, because all teams remained intact until the end, and they managed to attend the final presentation with a completed project.

This result, which was successful according to the expectations from the first trial, however, was asserted to be inadequate for the following 'well-settled' IDSs, which will be carried out in its actual venue where production infrastructure is available and open for the use of students. This was particularly a shared concern in the accounts of engineering tutors, according to whom, when projects remain conceptual as it has happened in the first IDS, they are incomplete and unsatisfactory for the tutors and students of engineering departments. Stressing that the students did their best within the existing conditions and resources, an engineering tutor explains her concern as follows:

> Because a certain environment had been offered to the students at the Faculty of Architecture. It was offered within a certain order. Since there hadn't been an opportunity for production, the definition of the problem [within the project] couldn't address the engineering perspective. I believe, as a result, things were up in the air in students' mind. Because engineering students always desire to bring a certain engineering solution. But I think this studio stuck on the conceptual phase.

It was suggested that a space that offers production facilities is in the first place a great source of motivation for students. From the accounts we understand that the studio environment is considered to support teamwork and close interaction within the group, however it is small and does not inspire students to go beyond the conceptual level, although in the curriculum the conceptual design stage ends at the end of the second week. Moving to the following stages, detailed design and prototype development, can only be possible by the involvement of production tools and equipment. The production environment, which one tutor calls 'the factory' with reference to the DF, on the other hand, offers the large space where students test their ideas and experience hands-on

learning. Such a shared, independent and production-oriented environment would increase the sense of belongingness of the students, since working on a physical artefact would make them feel it is 'their' rather than the tutors' place.

According to the accounts of engineering tutors, carrying out the IDS in a venue that provides production facilities requires reconsidering the design of the curriculum of the IDS on two grounds. First, the scope of the seminars and workshops should be extended. It was recommended to add technical training sessions to the curriculum in the case of choosing a more production, thus engineering, oriented IDS: 'Maybe more technical training… for instance if there's a need to use the CNC, mechanical students take the class for it… But our electrical students have no idea, ID students may have a production technologies course, but something like this can be offered to them.' In this way, as another tutor suggests, the curriculum of the IDS can be 'enriched'.

Second, going beyond mere design ideas and concepts through the involvement of production facilities necessitates extending the duration of the IDS. 4 weeks were too short to end up with a working prototype, therefore an IDS that would address the interest and expertise of engineering students and tutors has to be longer to provide students with enough time to experiment with the materials, tools and equipment. Among the tutors, however, there was not a consensus on the expectations regarding the quality of the prototype. The overall sense we gained from the data was that production is an essential dimension of the IDS for engineering tutors. The significance of a completed and working prototype, on the other hand, was not equally emphasised. This implies that their insistence on a space that offers production facilities and prototypes among final projects requirements is primarily related to their disciplinary involvement in the process rather than the end product of the IDS.

Interaction: coming together with tutors and students

Interaction is an important aspect of interdisciplinary collaboration as it provides the ground on which a shared understanding can be build. The significance of tutors' getting to know each other and the disciplines took part in the IDS was highlighted by all tutors in both pre- and post-studio interviews. This is particularly because interdisciplinary collaboration is accepted to be essential, but, according to the tutors, could not become a dimension of the organizational culture of the university sufficiently. In the pre-studio interviews, tutors had the expectation of coming together in a number of meetings to both understand the disciplinary perspectives of other tutors, and to design a curriculum that is inclusive for all disciplines. In the post-studio interviews, this expectation was replaced with the disappointment of failing to achieve none. Since the tutor team came together in only two meetings shortly before the IDS begins, they did not have sufficient time to work on the curriculum. In the meetings, firstly a coordinator was assigned, and secondly the tutors were asked whether they would like to give a seminar or a workshop on a specific topic that they found relevant for the IDS. Thus, although the tutors were given the chance to shape the schedule of the training week, i.e. which seminar would fit better in which slot, neither the content of the seminars and workshops, nor how they would support each other was discussed. The method adopted in the meeting encouraged individual rather than collaborative contributions to curriculum design. Reflecting on this situation, overall, tutors agreed on the claim that IDS students were more successful than tutors in establishing interdisciplinary collaboration.

The following quote very well illustrates the reflection of the tutors on their interaction before and during the IDS: 'We didn't come together and brainstorm much. We didn't discuss things like what our flaws are or what can happen in the project. The students did but we didn't. We did at first but then it was like we let it slip.' Another tutor makes an evaluation of tutors' interaction during the IDS, underlining its significance in overcoming the discipline-based biases:

> [At the university] the departments are so detached from each other. And the departments have, I don't want to say biases, some established opinions about each other. Thus, both to understand these, and to see how others work, I followed most of the lectures in the first week. The later steps progressed intermittently. The idea or the plan we had at the beginning that we, the tutors as a team, would provide critiques to students all together wasn't actualized. It was actualized once in the second week, afterwards it dispersed.

Similar to participation, the primary reason behind the poor interaction between tutors was indicated as the lack of time that tutors could spare to come together. It was indicated that the tutor team was too large to be flexible in terms of arranging quick meetings. Some tutors suggested to work in task-based smaller teams within the large IDS team.

The role of space in facilitating (or hindering) interaction was discussed particularly with reference to mentorship meetings, especially through the selection of the venue. Engineering tutors suggested that once the shared, independent and 'working' DF building is complete and open for the students' use, it will be easier to come together with the students and support their projects. In their descriptions, a space that encourages inter-disciplinary interaction, and eventually collaboration, has two features. First, it should belong to students. This means that it should be open for 24 hours, and students should be able to work, socialise and even sleep there whenever they like. It was suggested that once students enjoy spending time there and use it actively, it is inevitable that there will be rich interactions between teams. Being sure of that they will find some students working there, tutors, then, can pop in whenever they are available (e.g. when they want to take a break, on their way to home in the evening, etc.). In the below quote a tutor explains, contrary to their experiences in the IDS, how a shared, independent and actively used place can foster the interaction between many people, both tutors and students, with different schedules:

> We tried to keep the students at the Studio. But they were disappearing at a certain time. But if we had a venue that we could keep open until very late, if we went to their working space—they came to the Architecture—it would have been very different. Because we have different classes and meetings at different times to attend to. But if we had an address to stop by, the students would have thought the tutors would come here.

Second, it was suggested that the building designed for the IDS should be at equal distance to all tutors in order to support interaction. In this, however, equal distance corresponds to being in no one's territory, rather than physical proximity. The issue of proximity requires further emphasis, since the Faculty of Architecture is placed in a central location of the campus. To remind the distances between buildings, from the Business Administration Department it was a 200 m walking to the Faculty of Architecture, while the Engineering Departments were spread towards the other side of the campus, around within 1 km. The DF building, on the other hand, is placed in a relatively deserted area of the campus far from both the departments and the social facilities such as dormitories, student clubs and cafes and restaurants. Moreover, it is not on the route of the campus shuttle, thus

transportation is an issue that needs to be solved once the DF building is over. In the interviews, however, the location of the building did not emerge as a problem. Instead, the independence of the building seems more crucial for the tutors, since, as the findings show, once the space is not within the territory of a department or a tutor, tutors feel more comfortable and flexible in suggesting individual solutions regarding how to come together with students. For example, one engineering tutor says that it is possible to set office hours in which she would like to invite the IDS students to her office. In the first IDS, however, she indicates, the tutors had to go to the Faculty of Architecture to attend the mentorship sessions, and they did not have flexibility in terms of arranging individual meetings with the student teams.

Discussion

This study examined the accounts of faculty members from the fields of industrial design, architecture, engineering and business, who come together to design and conduct an extra-curricular interdisciplinary design studio, with a focus on space. Aligned with the existing literature, its findings confirm that there is a close relationship between space and inter-disciplinary collaboration. Yet, contrary to the existing studies which have been interested in the already in-use innovation labs, design factories and studios, this study explored a case in which a purpose-built and dedicated DF building does not exist, and the IDS was carried out in a couple of rooms and studios in the Faculty of Architecture. Doing this, it demonstrated how collaboration is limited by the lack of a shared, independent and working space, and offered new insights regarding the relationship between space and interdisciplinary collaboration.

In our findings space often intersects time. The importance of space is further emphasized through time, which is a scarce resource for the faculty, who have already busy schedules. While the significance of devoting time in developing a shared understanding for the IDS was acknowledged by all tutors, the majority of them showed low participation throughout the IDS. A few invested time in the IDS to learn about the perspectives of other disciplines, yet in the absence of other tutors their participation did not make much sense in terms of developing a common language and vision. Regarding this situation, an overemphasis on time can bring along the claim that if the IDS was organized in a less busy time of the year, tutors would show active participation, and disregard the significance of space. However, the we/they distinction, which also took the form of guest/host dualism, offered by the engineering tutors demonstrated that by leading to the creation of disciplinary territories and boundaries, physical space can have a detrimental effect on people's willingness to spare time and effort for interdisciplinary collaboration. Magadley and Birdi (2009) indicate that innovation teams should be encouraged to get out of the usual workplace where they have other responsibilities, and instead come together in a separate, pressure-free physical space, especially when they have limited time. We extend this argument, suggesting that the space for interdisciplinary collaborative work should also be independent and be perceived as at equal distance to all team members.

We presented three issues over which the effect of space on collaboration becomes evident: participation, commonality and interaction. These issues are not fully separated from each other. To the extent that the tutors do not frequently participate in the IDS, they do not adequately interact with other tutors. As a result, they encounter problems in developing a common language, goal and notion of a design project, the commonalities

which are the basics of interdisciplinary collaboration (Wagner et al. 2011; NRS 2004; Bennett et al. 2012). Research has shown that failure in creating these commonalities is the main reason behind the conflicts occur in the interdisciplinary relations between designers and engineers (Pei et al. 2010). In our findings, this was most evident in terms of the final outcome of the project. While for design tutors a model that represents the physical qualities of the students' designs was sufficient to be submitted at the final presentations, according to engineering tutors only a working prototype would be the acceptable outcome of the IDS. These dissimilar expectations, however, were grounded on the studio/workshop comparison, which directly matches the conventional spaces used during both the education and the professional practice of the two disciplines. Therefore, the lack of a shared space that addresses the expectations of the tutors from various disciplines sharpened the work environment-based dualisms.

Earlier in this article we stated that the literature on space and collaboration identifies four concepts: interaction, proximity, creativity, and flexibility. The first two concepts are relevant to our findings, but in an unexpected way. The literature points out a close relationship between proximity and (chance of) interaction. The Faculty of Architecture, where the IDS took place, is in a central location at the campus. Yet, in the tutors' accounts, the concern was not about physical proximity, rather the distance between buildings was delineated as a matter of ownership. Once the construction work is completed at the DF building, this problem is expected to be solved. However, afterwards proximity can be an issue as the designated place is around 3 km away from the engineering departments at the edge of the campus with limited transport opportunities. The issue of proximity needs to be followed up in further research once the IDS moves to its own building.

We are surprised to see that the theme of creativity did not emerge in the interviews. After all, it is an essential dimension in design and innovation work (Vyas et al. 2009). In our case, it is not taken as an essential dimension of interdisciplinary design projects. Nor, different from the emphasis in the existing studies, was it discussed in relation to the design of the DF building, i.e. how the building supports creativity of the teams. Since the IDS emphasizes interdisciplinary and collaborative work, collective creativity is what something we hoped to see. As mentioned above, regarding the design process the accounts were clustered rather around the studio/conceptual design and workshop/building a prototype distinction. We suggest that once the sense of collectivity is established, collective creativity may be considered relevant by the IDS tutors.

The fourth concept, flexibility, appeared not only in terms of the space design, furniture and equipment, but also as an approach towards the use of time. Regarding the former, which is aligned with the understanding of flexibility in the literature, the tutors from the Faculty of Architecture responded to the spatial needs that appear in the various activities of the IDS. When the assigned space was not adequate enough for the planned activity, quick solutions were implemented. For instance, speed networking activity took place at the parking area out of the building since the students formed a large circle to talk to each other; for the group activities that required students to gather around a table, a large design studio was used; and seminars were held at the largest seminar room of the Faculty. Flexibility, or rather inflexibility, of the use of time, on the other hand, emerged as an issue that remained unsolved. Tutors indicated that flexible use of time could be possible, for example, by being able to turn up whenever they were available. Yet, to realize this, the IDS should be carried out in its own, independent place that is open to students, so that tutors would be sure that whenever they turned up they would find some students working there. Flexibility of the use of time was also suggested to be increased by working in

smaller team sizes, since it would be easier and faster to arrange a meeting with only a couple of tutors.

As a final note, we find it worth highlighting that despite the discipline-based differences in their approaches towards the IDS, the tutors agreed on the idea that compared to their tutors, students were more successful at establishing interdisciplinary collaboration. This claim, which of course needs to be investigated from the perspective of the students as well, is still valuable when taken as an insight that the tutors gained through their observations of student teams. It parallels the recent argument in the design literature that engineers and designers who experience interdisciplinary collaboration during university years find it easier to cooperate with each other in the later years. The design and conduct of interdisciplinary courses and programmes, then, require further attention from scholars in both engineering and design fields.

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