***ORIGINAL ARTICLE***

# Perceived difficulty of design thinking activities in co-located and remote environments

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### ABSTRACT

What kinds of challenges do teams face when engaged in design thinking in co-located and remote working environments? This paper demonstrates the perceived difficulty of different design activities and how they compare to one another. A framework comprising nine individual design activities is used to map out experiences of six multicultural, distributed student design teams. The results illustrate how decision-making is perceived as one of the most difficult activities. Shifts in ranking between environments are also explored.

## INTRODUCTION

In recent years, design thinking has been seen as a lucrative way to conduct innovative product development projects in both university education and industry (Dym et al., 2005, Cooper et al., 2009, Brown, 2008). Design thinking is driven by multidisciplinary teams facing multiple challenges in their collaboration, from culture to language. How to manage these multidisciplinary design teams is one of the big, challenging questions of the field (Sheppard et al., 2010).

In design thinking, coaches or facilitators are seen to play an important role, especially when doing globally distributed development. The coach is someone who helps manage the contextualization of engineering design theory and practice (Dym et al., 2005). For the coach to be able to perform their function well, it is important that they have a good understanding of what is going on with the teams. Looking into virtually operating teams, the facilitator's role is seen as crucial for allocating resources and providing specialized support (Bal and Foster, 2000). It has been suggested that the resources needed by a virtual team should be explored in more depth (Furst et al., 2001) and that there is a lack of understanding of multidisciplinary teamwork practices and support requirements (Adamczyk and Twidale, 2007).

A literature gap exists regarding how design thinking coaching differs in online and offline environments. Though current research is mapping out some of the critical parts of design teams' work, no holistic view has been given of the difficulties presented by these different activities. To equip coaches with some insight into what is going on within a specific design thinking team and where pain points may lie, this manuscript seeks to explore the following questions:

- Which are the most difficult design activities for design teams?
- How does co-located versus remote working setup affect the experienced difficulty of the design activities?

## THEORETICAL BACKGROUND

Theoretical background should similarly be a brief, to-the-point discussion only on the most important relevant existing literature establishing key concepts and constructs of the study.

In order to capture a design thinking team's experience in a holistic manner, a framework must be applied. Existing approaches to define design-thinking types of activities can be divided into methods, processes, activities and mindsets (Utriainen, 2015). In this work, design thinking activities are used as a vehicle to capture the designer's experience.

Kok Sim and Duffy (2003) define a design activity as a "rational action taken by a design agent to achieve a knowledge change of the design and/or its associated process (i.e. sequence of actions) in order to achieve some design goal". The general goal of the design activity is to deal with the complexity of the design problem until a design solution(s) is finally achieved (Kok Sim and Duffy, 2003). Reymen offers a similar description: he sees the design activity as a transformation towards the design goal, carried out by a designer, causing a transition of the

state of either the product being designed or the design process (Reymen et al., 2006).

In this paper, design activity is seen as a behavior in which a design team must engage, in order to undergo the design process in its holistic form. The order or timing of these design activities is not predefined, as we cannot know a priori what is the best way to get from the start of the project to the finish. Although there is no single best-practice design process, there are core activities which can be adapted to fit a particular project or situation (Best, 2006).

Activity-based models appear promising compared with the other categories (design thinking processes, methods and mindsets), since they are:

- somewhere between internal embodied behavior and the external design process
- less clustered than processes and can give a better overview into the experience – processes can consist of only 3-4 stages, whereas activities can have 6-35 different categories (Kok Sim and Duffy, 2003, Kumar, 2008, Doorley and Withof, 2012)
- more concrete and thus easier to grasp than the mindsets or processes – e.g. the process stage 'inspiration' will be difficult for two different individuals to understand similarly, since it can be seen as almost any part of the process
- less specific/limiting than methods – not all methods need to be used to get through the design process, but all the activities need to be performed to be successful
- not bound to a specific order and are more flexible than linear processes (Utriainen, 2015)

Emerging from the literary study, a definition presenting eight activity categories was used as a foundation for describing different activities (Lindberg et al., 2010). Slight adjustments were made to these categories regarding design teams' context, used vocabulary, and the literature review. Some wordings were altered and 'Testing and user feedback' was added as an additional category (Utriainen, 2015). The created design activity list can be seen in Table 1.

## METHOD AND DATA

The research conducted in this work was done in the context of the Challenge Based Innovation (CBI) course, which is one of the first experiments to apply human-centered design methodologies at CERN (Kurikka et al., 2016). In CBI, globally distributed teams engage in six months of need-finding, prototyping and user research much inspired by courses like ME310 at Stanford (Leifer and Steinert, 2011) or PDP at Aalto University (Laakso and Clavert, 2014) where approaches from problem based learning and design thinking are applied. Each of the student teams is comprised of designers, engineers and business students and they work in distributed and face-to-face settings.

The students were asked to determine how easy or difficult each of the nine design activities were for their global teams as a part of a comprehensive online survey. The survey was sent out after the teams had completed their projects and had been working together for six months. 37 out of the 44 students completed the survey.

A Likert scale varying from 1 (Very easy) to 5 (Very difficult) was used to map out the individual experiences. To distinguish differences between remote and co-located work environments, students were asked to assess the difficulty in both environments separately. Students were also asked to name the most difficult activity and why they felt it was hard for the team in an open text field.

The students were also surveyed regarding their background, time usage and other factors that might be useful for later cross-referencing. As a secondary source of data, in situ observations of the coaches' and students' work were made and a short survey introduced to the coaches. The students' deliverables including reflections and the final documentations were also used to gain insights.

## RESULTS

An illustration of the perceived difficulty in remote and co-located environments is presented in Figure 1. The higher the average, the more difficult the students felt the activity was.

The individual averages on the co-located and remote activities are listed below together with ANOVA StatPlus p-levels regarding how similar the activities were perceived in the two environments: (Re)defining the problem (Co-loc=2.70, Remote=4.22, p=0), Grasping external knowledge (Co-loc=2.62, Remote=3.05, p<0,14), Knowledge pooling (Co-loc=1.62, Remote=3.62, p=0), Synthesis (Co-loc=2.22, Remote=3.57, p=0), Making decisions (Co-loc=2.49, Remote=4.43, p=0), Ideation (Co-loc=2.20, Remote=3.09, p<0.002), Concept specifying (Co-loc=2.49, Remote=4.11, p=0), Making it tangible (Co-loc=2.11, Remote=3.86, p=0), Testing and user feedback (Co-loc=2.73, Remote=3.14, p<0.18).

Unsurprisingly, all the co-located activities were perceived as easier (ranging from 1.6 to 2.7) than the remote activities (ranging from 3.1 to 4.4) and remote work was perceived on average 32% more difficult than co-located work. The average variance for remote activities was lower (1.02) than for co-located work (1.18) which indicates that the student's experiences differ slightly more regarding face-to-face environments. Comparing answers between teams they all seem to have a fairly similar perception in remote environments e.g. all six of the teams gave Making decisions, (Re)defining the problem and Concept specification high marks.

**Tab. 1.** Design activity framework used in the research

| Design Activity | Description |
|---|---|
| (Re)defining the problem | Working on the problem space and redefining what the team is solving |
| Grasping external knowledge | Expert interviews, research, needfinding and benchmarking |
| Knowledge pooling | Sharing results with the team, putting up gathered material on walls and whiteboards, saturating information |
| Synthesis | Working with the gathered materials, getting out key insights, seeing patterns and making sense of what has been done so far |
| Making desicions | Selecting next steps with the team, converging, path selection |
| Ideation | Coming up with multiple solutions, flaring, divergent thinking, brainstorming |
| Concept spesifying | Focused work, concept development, getting from low resolution to a higher resolution |
| Magin it tangible | Prototyping, realizing, building |
| Testing and user feedback | Testing concepts and prototypes, gathering feedback, learning from the prototypes |



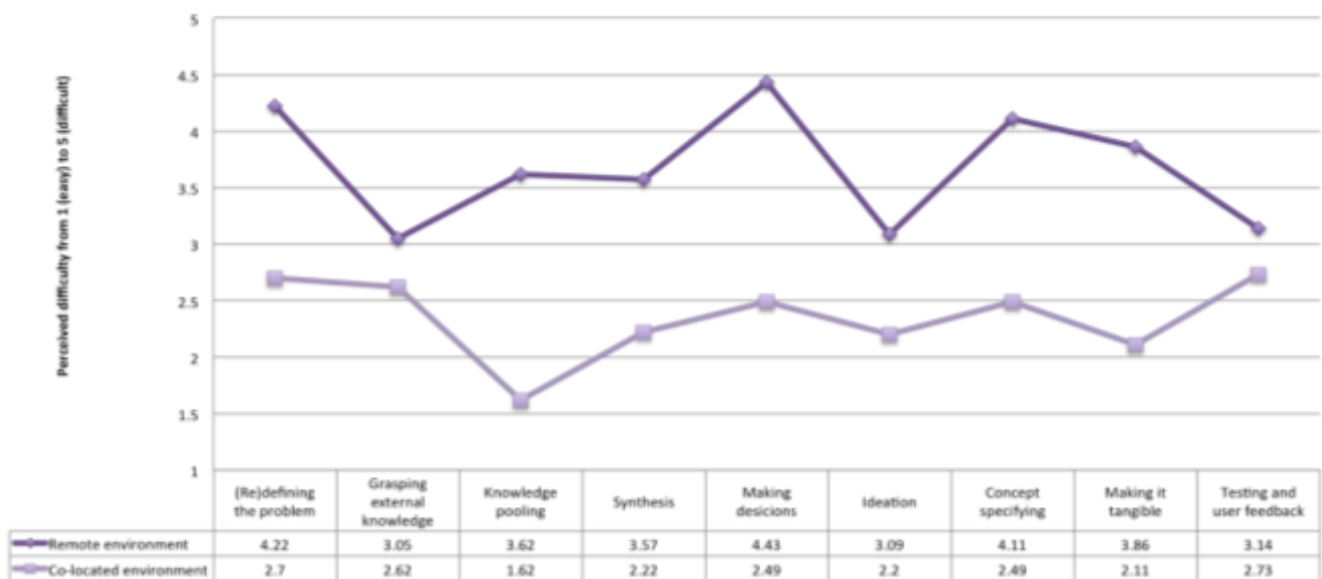| | (Re)defining the problem | Grasping external knowledge | Knowledge pooling | Synthesis | Making desicions | Ideation | Concept specifying | Making it tangible | Testing and user feedback |
|---|---|---|---|---|---|---|---|---|---|
| Remote environment | 4.22 | 3.05 | 3.62 | 3.57 | 4.43 | 3.09 | 4.11 | 3.86 | 3.14 |
| Co-located environment | 2.7 | 2.62 | 1.62 | 2.22 | 2.49 | 2.2 | 2.49 | 2.11 | 2.73 |

**Fig. 1.** The averaged perceived difficulty in remote and co-located environments as assessed by team members

Out of the nine activities, Making decisions remotely was perceived as the hardest. How come? Operating over low-quality internet connection and different time zones were not the only challenges when making decisions online. First, team members felt that everybody needed to be present at the same time and the whole group should agree on a decision. In comparison, an idea is easy to get and share asynchronously (e.g. coming up with a concept in the morning shower and sharing it through Facebook group later in the day) but a decision online seemed to need everyone's synchronous presence. Another dilemma comes with how this precious time together was spent and as several students point out their groups got stuck in discussions that did not lead to action. "We didn't know when to finish thinking and start doing!", pointed out one Finn designer. It might be that those long discussions were actually spent catching up with knowledge pooling and synthesis that might have been not done properly done before the decision-making point.

By contrast, co-located Knowledge pooling was perceived as the easiest activity to perform by the

students. Knowledge pooling consists of each individual team member sharing their unique knowledge regarding the project, which tends to happen quite automatically when you sit around the same table. One can easily see what the other team members are up to, spot when they get excited about a discovery and discuss advancements over an afternoon coffee. This changed when the team operated in a distributed setting. Beyond the increased possibility of misinterpretations induced by the virtual environment, an Australian designer points out that it was difficult to have all members 'offline' at some points, who missed large parts of information and that it was hard to know if people have followed-up on posts or viewed materials on shared platforms.

The experiences of the teams were statistically significantly different in online/offline environments, excluding Grasping external knowledge and Testing and user feedback. Whereas Grasping external knowledge is about researching the state of the art and approaching external experts linked to the project, Testing and user feedback is about engaging with the target audience and involving them in the development work. It seems that when external people's presence is linked with the activity, the team members' experiences are more similar. This might be due to the fact that while the team is operating remotely from an internal point of view they are engaging with externals face-to-face from a local point of view.

When working remotely, Knowledge pooling rises in ranking from least difficult to fifth most difficult activity. In general, we observe that the difficulties faced by teams in co-located and virtual environments are different from one another. The coaches might not be aware of some of the changes. Ten out of thirteen coaches mentioned that they would have benefitted from supporting material and methods regarding decision-making. However, the coaches asked for no support in Knowledge pooling, Testing and user feedback and Grasping external knowledge, which are the three activities that change their ranking most between environments.

## DISCUSSION AND CONCLUSIONS

As we can see from the data, online and offline design environments measurably differ from one another and different environments allow certain parts of the design work to be done more easily than others. Decision-making is one of the most difficult activities online - what kinds of tools and interventions could be designed to alleviate this unease? What kind of novel UX solutions could be produced to not only make decision-making bearable online, but actually have team members prefer to do it using computers? The presented design activity framework could be used to assess the impact of collaborative support tools on the quality of design solutions, which is currently is particularly difficult (Adamczyk and Twidale, 2007).

For future work, it would be also interesting to look into the difference between good and bad kinds of difficulties, since some of the activities might be difficult for a reason. Let's take Re-defining the problem as an example, which was listed as one of the most difficult activities. This is seen as a key activity in design (Norman, 2013) and Lande and Leifer (2009) state that: "The ambiguity with which projects are defined is something that students find unsettling and most certainly are not used to. As engineers, they have been trained to eliminate ambiguity, not preserve it, and to minimize any existent uncertainties". This kind of struggle should be supported, not eliminated by the coach.

As this work was explorative, here are some suggestions for improvements among many:

- Looking into alternatives for the framework, using e.g. mindsets or process steps
- Studying if this framework is useful for coaches when providing feedback on teams' pain points real time
- Trying out the framework in diverse projects to check if this pattern is unique to this specific student sample or takes another shape in another population

These and other kinds of avenues need to be further researched to equip the coaches with the best information possible to enable future of online collaboration - at the current level it seems to be inferior in every single measured aspect to co-located design thinking work.

## REFERENCES

Adamczyk, P. D. and Twidale, M. B. 2007, Supporting multidisciplinary collaboration: requirements from novel HCI education. In: Proceedings of ACM CHI 2007 Conference on Human Factors in Computing Systems, pp. 1073-1076.

Bal, J. and Foster, P. 2000, Managing the virtual team and controlling effectiveness. International Journal of Production Research, 38:17, 4019-4032.

Best, K. 2006. Design Management: Managing Design Strategy, Process and Implementation.

Brown, T. 2008, Design Thinking. Harvard business review, vol. 86, no. 6, pp. 84–92, 141.

Cooper R., Junginger, S. and Lockwood, T. 2009, Design Thinking and Design Management: A Research and Practice Perspective. Design Management Review, 20: 46–55.

Doorley, S. and Withoft, S. 2012. Make Space. John Willey&Sons. Inc., Hoboken, New Jersey.

Dym, C. L., Agogino, A. M., Eris, O., Frey, D. D. and Leifer, L. J. 2005, Engineering Design Thinking, Teaching, and Learning. Journal of Engineering Education, 94: 103–120.

Furst, S., Blackburn, R., & Rosen, B. 2001. Virtual team effectiveness: a proposed research agenda. Information Systems Journal, 9(4), 249–269.

Kok Sim, S. and Duffy, A. H. B. 2003, Towards an ontology of generic engineering design activities. Research in Engineering Design, 14(4), 200–223.

Kumar, P. P. 2008. Design process modeling: Towards an ontology of engineering design activities. Clemson University.

Kurikka, J., Utriainen, T. M., & Repokari, L. 2016. Challenge based innovation: translating fundamental research into societal applications. International Journal of Learning and Change, 8(3-4), 278-297.

Laakso, M., & Clavert, M. 2014. Promoting creativity and design thinking skills among university students. Originally in Bas, E. & Guilló, M.(eds.): INJUVE Special Issue on "Youth and Future Images, 1-14.

Lande, M., & Leifer, L. 2009. Prototyping to learn: Characterizing engineering students' prototyping activities and prototypes. In International Conference on Engineering Design (pp. 507–516).

Leifer, L. J., & Steinert, M. 2011. Dancing with ambiguity: Causality behavior, design thinking, and triple-loop-learning. Information Knowledge Systems Management, 10(1-4), 151-173.

Lindberg, T., Gumienny, R., Jobst, B., & Meinel, C. 2010. Is there a Need for a Design Thinking Process? In Design Thinking Research Symposium (pp. 243–254).

Norman, D. 2013. Rethinking Design Thinking. Core 77. Retrieved July 13, 2015, from http://www.jnd.org/dn.mss/rethinking_design_th.html

Reymen, I. M. M. J., Hammer, D. K., Kroes, P. a., Van Aken, J. E., Dorst, C. H., Bax, M. F. T. and Basten, T. 2006. A domain-independent descriptive design model and its application to structured reflection on design processes. Research in Engineering Design, 16(4), 147–173.

Sheppard, S., Gilmartin, S., Chen, H. L., Donaldson, K., Lichtenstein, G., Eris, O., Toye, G. 2010, Exploring the Engineering Student Experience: Findings from the Academic Pathways of People Learning Engineering Survey (APPLES). Center for the Advancement of Engineering Education.

Utriainen, T. M. 2015 Mapping the difficulty of design activities in product design team work, (MA thesis, Aalto University).