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HOW DESIGNERS LEARN – OBJECTS OF REPRESENTATION AS MEANS OF KNOWLEDGE TRANSFER

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ABSTRACT
This article focuses on design practitioner's facilitation of knowledge transfer at the boundaries of communities of practice. As design problems are becoming more complex and problem aspects turn unpredictable, designers' main responsibilities are shifting towards the facilitation of analytical processes. This paper strives to study the means of this facilitation through pedagogical constructivism. A case study about interfaces for knowledge transfer for the purpose of problem solving is presented; it obtains data through interviews and workshop observations. The case study analyses show how objects of the problem representation can influence the nature and amount of knowledge transfer, and how it can influence the solution generation process. Finally, the implications are discussed through the prism of interdisciplinary collaboration and application in design projects.

Keywords: knowledge transfer, boundaries of practice, rich learning environments

1 INTRODUCTION - KNOWLEDGE FACTOR IN PROBLEM SOLVING

Knowledge is recognized as an important factor for innovative problem solving; organizations are now focusing on both knowledge transfer and creation, resulting in a growing body of literature [1]. Knowledge transfer is "the process through which one unit (e.g., group, department, or division) is affected by the experience and knowledge of another" [2]. There is also an understanding that knowledge is difficult to transfer because it is embedded in the production of practice, embodies individual experiences [2], and has tacit properties [3]. Designers are often described as specialists in the process, rather than specific knowledge areas [4], which makes them dependent on gathering knowledge about design aspects from specialist project stakeholders or from external sources [5, 6].
As design thinking is being applied to new fields and disciplines, the design problems are becoming more complex [7]. In addition, accelerating changes in technology, culture, and markets make design problems comprehensive and design aspects unpredictable and random [8]. This moves design practice to the context of multidisciplinary teams, where complex problems are solved through activities of extensive knowledge transfer and development [9]. Since designers require knowledge transfer to conduct the design process, there is a need to research their role in that context. There is also a need to study how design competence can be used to extract and choose relevant knowledge for problem solving in these teams. Considering these aspects, the research question is: how can designers facilitate the choice and transfer of knowledge for problem solving in a teamwork context?

1.1 Combining Knowledge in a design team and on the boundaries of practice

The recurrence of knowledge transfer in design work happens internally through mental models and problem framing, but also externally through sketches, materials, physical models. These processes do not happen separately, but are entangled, while recognition occurs with practical action [6]. One challenge that designers have in practice is that opportunities for knowledge transfer are not thoroughly explored. This is partly because knowledge transfer often occurs through opportunistic and non-structured activities as well as different sources can be subjective and incomplete.

Cross addresses this problem in his study of collaboration in a design team where designers overlooked important information from the user evaluation report by being too eager to frame the problem [10]. Further in the study he notices the challenges that designers have with extracting, gathering and sharing relevant information. He states that the design team had informal style in information management in comparison to time management as well as relying heavily on the personal, tacit knowledge that was relevant to the problem [10]. According to this case there seems to be a gap in the way designers gather information in the research process and how they put it to use. Moreover, this gap can be further widened by the involvement of other stakeholders in the design-thinking process, which would lead to further misunderstandings. Cross explains how the misunderstanding further increased when designers started developing a solution concept because of the very abstraction of the ideas and use of metaphors to describe practical solutions [10]. The situation described by Cross illuminates how designers might benefit from the facilitation of knowledge transfer, which could be put directly to use. The aim of the research is accordingly to study the suitable learning environment for knowledge-transfer situation from the constructivist standpoint in which the knowledge transfer is seen as product of individualized learning environment.

2 RESEARCH METHODS

The theoretical perspective for this study relies on constructionism, advised by Seymour Papert to explain individually constructing knowledge by creating meaningful objects [11]. Construction that takes place "in the head" often fittingly happens when it is reinforced by construction "in the world." Papert describes "in the world" as when "a" [11]. It attaches a special importance to the role of constructions in the world as a support for those in the head, thereby becoming less of a pure mental concept. This theoretical framing which is useful to study designers' facilitation of knowledge transfer can be described by Papert's two principles: "First, relate what is new and to be learned to something you already know. Second, take what is new and make it your own: Make something new with it, play with it, build with it. So for example, to learn a new word, we first look for a familiar "root" and then practice by using the word in a sentence of our own construction" [11].
The case study discussed in this paper presents a workshop of two groups of four design students, including both genders equally. One group used communication based on the mathetic principles described above, while the second discussed the problem in front of the whiteboard. This case study serves to exemplify and examine the characteristics of the knowledge-transfer process in a group setting in a learning situation [12], and it is suitable for examining an event and the process that occurred through it. In addition, the case study allows the examination of not only events, but also artifacts such as participant models (Figure 1) [13] and the relevant personal experiences of the participants. Data for the case study have been gathered through a participatory observation approach, and using sound recordings. The participant groups discussed their experiences in group post-workshop interviews of each group. The workshops were chosen for the case study because the intention was to test a method for increasing a designer's ability to learn about an existing situation, which may allow for an easier framing of a design problem. The workshop is conducted outside of the course activities and is presented to the participants as a service design exercise with the goal to enhance their service design skills. Service design is a cross-disciplinary practice combining design, logistics and management, which produces systems and processes aimed at providing a holistic service to a user [14]. Service design focuses on discovering the problem area for a user or an organization by mapping stakeholder relationships and networks. To do this, service designers often use complex charts, or giga-maps which describe visible and hidden power structures [15].

3 KNOWLEDGE TRANSFER THROUGH OBJECTS OF REPRESENTATION

The two groups of master students in design were given a workshop task to use their own experience and knowledge to generate a stakeholder map around a problem defined by an imaginary client, in this case a municipality that wants to provide a service for a "problematic child". The term "problematic child" is chosen in order to reflect on client's approach to the situation, and engage interpretative design brief capabilities of participants, that might stimulate knowledge transfer. Participants were instructed to initially map the institutions around the "problematic child," then the stakeholders in

these institutions, and finally the relationships in the stakeholder network. Participants then proceeded separately with the workshop. The first group of students were given objects (markers) to represent stakeholders in their service design project and different thread materials to represent relationships between the stakeholders (see Figure 1). Participants metaphorically translated the material properties of the threads into a description of the relationships between the stakeholders. For example, copper wire was described as being stiff, highly conductive, shiny, and cold; the participants wrote these properties down so that everybody could share that understanding. The second group of students were not instructed about the communication tools, but ended up using whiteboard drawings to communicate their understanding of the design problem.

Both groups discussed the task, then switched focus shortly after to which institutions had the most influence on the child. Both groups tried to incorporate what they knew or assumed in a circular, ripple model to explain the central position of the child and the degree of influence and importance institutions have on it (Figure 1). The center represented the child, the first ring portrayed the family, and the last ring contained institutions such as police, childcare centers, and medical or psychological help services.

The next step was to describe representatives of these institutions such as "teacher," "father," the "best friend," and "nurse." Participants were now encouraged to use the threads and their properties to describe relationship between these stakeholders as accurately as possible. Additional rules were introduced to describe reciprocity, dependency, and the character of these relationships. The pin heights, where and how they were tied, and the thread material enabled designers to describe a story with complex relationships. For example, if the thread is loose, the relationship is not fully developed, and if it is tight, that means conflict. Similarly, if the thread is tied from top of one pin to the bottom of another, that represents the position of power in this relationship network.

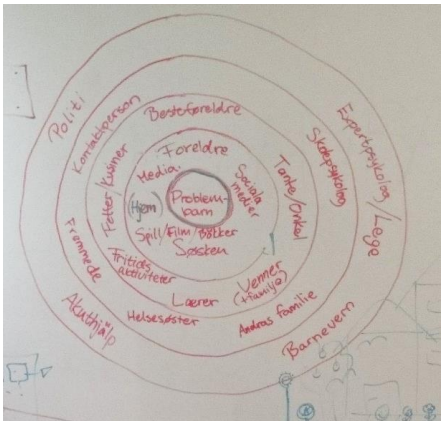

Figure 1. "pin and thread method"; Figure 2. "whiteboard drawing discussion"

The difference in the process started as the groups progressed from mapping the institutions towards mapping the stakeholders. The "pin and thread" group was using pins to map every single possible stakeholder in the network, with pins chosen according to color. The "whiteboard" group was much more focused on the narrative within "institutions," naming stakeholders only when it was necessary to support the story. Even though participants were explicitly asked to map relationships in the stakeholder network, the whiteboard group did not do it; and when asked to explain relationships they did so orally as a part of a narrative. In contrast, the pin and thread group spent more time discussing and mapping each relationship while choosing the threads to describe it. Furthermore, stakeholder activities became a matter of discussion and part of the mapping process for both groups. The whiteboard group had more focus on moving institutions within their ripple model, while the "pin and thread" group soon abandoned the following ripple model and focused on clustering stakeholders in groups according to activities related to the problematic child.

When asked to generate solutions, the whiteboard group focused on framing their problem description around the ripple model, asking "How can we keep the problematic child within the inner circle so that it doesn't slip towards the edges of its environment?" They provided three concept solutions, which did not involve stakeholders within the mapped network but rather provided a service outside it. The first solution focused on training parents to deal with the problem; the second solution was a service

that would help the parents and the child through home visitations; and the third solution focused on building a network of parents of problematic children, to be used for learning and developing individual strategies.
When asked to describe their concepts, participants in the pin and thread group explained: "We anticipate that the problematic child and its parents might need additional support from other stakeholders in the network. We discussed how we can allow a stakeholder network to support the child." Their first concept included a website on which friends of the problematic child can learn about the problem and obtain ideas on how they could be more supportive; and the second concept revolved around influencing the problematic child positively. They tried to design their concepts around activities in which older siblings can be figures of influence and provide support for the child.
Additionally, participants in the pin and thread group commented on this method of mapping the stakeholder's network in the interview. They had noticed the amount of detail they managed to trap using this method: "We were surprised by how many stakeholders are involved in this network." They described their insights on using this tool as: "It is fantastic how much overview one gets from others through this method. It enables you to decide what to do next in the process very effectively. Unfortunately, it would be difficult to share with somebody who did not participate in the workshop." One of the participants noticed that: "Working with materials makes sense. This just would not work for example on a touchscreen. It's just so much easier to remember when you are moving pins while discussing the problem." Another participant replied: "Yes, it almost feels like we know them (stakeholders)". The whiteboard group participants explained that the task was too abstract and that therefore they wanted to spend more time on finding principle solutions then learning about the problem. One of the participants explained: " There needs to be a broader systemic solution for these kind of problems". The pin and thread group discussed stakeholders using representation objects, and their solution revolved around methods of supporting stakeholders. The whiteboard group, however, focused on keeping the child at the center of the ripple model and their solutions involved stakeholders that were not originally mapped.

4 FINDINGS – VECTORS FOR RICH LEARNING

The pin and thread method used by participants in the first group applies Papert's principles of learning [11], with the assumption that this method can create a richer learning environment for designers in the context of knowledge exchange. Expectedly, the study provides indications that the group using objects of representation had voluminous exchange of knowledge, however the effects of this knowledge exchange comprise also narrowed focus and more practical and detailed approach to problem solving. This seems to have happened because objects of representation steer participants' focus on different information. The constructivist pedagogical approach explains this through the dependency of objects and learning: "The more objects are available in a concrete form and way, and the more focused communication occurs, the more effectively and efficiently learning can be supported in knowledge managed environments." [16]. In this case study, both groups' solutions seem to be an outcome of the focus that objects of representation create. Accordingly, rich learning environment developers are required to find the suitable format for representing knowledge, the semantic distance to domain knowledge, and the creative act of meaning generation [11].
There are three vectors for rich learning [18]. The first vector focuses on the relationship between content and participants, with a goal of enabling participants the ability to handle objects with minimal semantic distance to the problem formulation. In the study, the problem was defined around relationships, and accordingly, the threads that represent relationships were more defined and relatable than stakeholders represented by improvised object like markers. The results might be different if participants could generate representations of stakeholders like Lego-figures or similar items. The whiteboard group on the other hand created their own graphic model spending less time on building semantic closeness to it. This prevented semantic closeness to the problem formulation but enabled openness to many personal interpretations and therefore solutions outside of their model.
The second vector of learning addresses the allocation of tasks to participants, with a goal of binding them more tightly to the environment to support effective articulation and sharing of knowledge. In the case study, pin and board group participants used time to build common understanding of the metaphorical meaning of the thread materials and defining many stakeholders in the network; this is an important step for binding participants in the environment. The whiteboard group on the other

hand, by not having means of representation was unsuccessful in attempt to define aspects of the problem such as relationships and stakeholders, and has eventually failed to include specific stakeholders in their model. This led to unstructured learning process where the aspects of the problem emerged randomly. Finally, the third vector addresses the actual activities to be set and the processes to be performed for learning or problem solving. The whiteboard group discussed their solution in the context of the generated ripple model, while the pin and thread group moved pins and organized threads by height, tension and material metaphor. The verbal and motoric activity generates a framework for what can be explained throughout the workshop boundaries. The type of activity, the engagement of senses and cognitive abilities, and load can shift the focus of learning. As the result of using whiteboard the second group actually used their body language to describe concepts and was much more engaged verbally.

5 IMPLICATIONS FOR DESIGN ENVIRONMENT

The findings illustrate how the involvement of Papert's learning principle in teamwork can create focused knowledge transfer. In this case study, it seems that the more objects of representation were used, the more detailed knowledge was transferred, but also the more narrowly the problem definitions and solutions were formulated. Using objects of representation in the way illustrated in this study, participants seemed to narrow down and focus on already-defined problem framing. However, if the goal is to have a broader discussion and explore possibilities in the wider sense, the vectors for rich learning should be adjusted differently. The conclusion is therefore that objects of representation allow effective knowledge transfer but at the same time can prevent complementary knowledge transfer and generation that enables wider exploration of opportunities in problem solving settings. The focus of the study was on how the participants can explore, and therefore choose complementary knowledge that can lead to novel solutions rather than whether they can just learn from each other. In that sense this case study research design has failed to provide expected answers. Still, the vectors for rich learning can be beneficial in design pedagogics and practice, and can also expose the influence that a facilitator might have in the design process.
Different phases of design process demand different kinds of activities [4]. In the beginning of the process, when the wide range of design aspects are considered the vectors for rich learning can be used to randomize the emergence of knowledge. In the case study the randomness is caused by the lack of instruction to the participants. The randomness of ideas and exposed knowledge can be also attempted by either casual semantic closeness of the objects of representation, random allocation of tasks to the participants and randomly generated activities to answer these tasks. In the later stages of design process, as the problem definition emerges and design aspects become more prominent, such as relations and stakeholders in the study, the vectors for rich learning could be more specifically designed and deployed by the facilitator of the knowledge transferring process. The further research is needed with adjusted research design to study this proposition.

According to constructivist pedagogics effective learning can only occur in situations which are suited for individual knowledge-transfer. On one hand, learner capabilities determine the individual method and extent of grasping information. On the other hand, the design of the environment has to address learner capabilities directly or indirectly, since learners have to interact with elements of that environment [19]. To comment on this in the light of the case presented by Cross in section 1.1, the designers do not only need a formalized role within the team for knowledge transfer, but also the skill for its facilitation. This skill should fit design practitioners' regime of competence, which is collecting knowledge in teams through visual means, rather than only generating evidence to use in the design practice. Moreover, this skill may be found in ability to manipulate creative teams' focus, through the utilization of a constructivist approach to learning by using vectors of the objects of representation. The formulation of the tasks around the objects of representation, their order and character can be used to shift the focus of learning.

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