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THE ROLE OF PHYSICAL, SOCIAL AND MENTAL SPACE IN CHEMISTRY STUDENTS' LEARNING

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Abstract

'Learning environment' usually refers to the social and pedagogical contexts in which learning occurs. However, physical learning environment and its relation to learning are often neglected. The present study explored the relationship between chemistry student perceptions of physical space, social space and mental space regarding learning. Qualitative data were collected among chemistry students by focus-group interviews (n=21). The data showed that the students' experienced competence and sufficiency of guidance, through either social or physical modalities, were strongly related to their sense of safety. This, in turn, may affect cognitive resources available for learning, which should be addressed in pedagogical design.

Keywords: Higher education, physical space, sense of safety, guidance

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1. Introduction

Learning environment' many times refers to the social, psychological and pedagogical contexts in which learning occurs (e.g. Mitchell, 1996; Lindblom-Ylänne & Lonka, 1999; Kember & Leung, 2009). However, physical learning environment and its relation to pedagogy and learning are often neglected (Woolner et al., 2007; 2010; Lansdale et al., 2011).

It has been shown that the environment and the tools provided by it may be seen as affordances that essentially enhance one' s competence or takes one to the state of inability, thus hindering or complementing, i.e. blending with, one' s own mental abilities (Paavola, Hakkarainen & Lonka, 2004; Norman, 1993; McLaughlin & Faulkner, 2012). They may also become fixed interpretations according to their conventional functions, failing to see new potentials or new ways of seeing them (Hakkarainen et al., 2004, p. 23). Although these kinds of theoretical models that consider the role of physical environment as a part of a complex and multidimensional learning process have been presented, empirical research on this is nevertheless scarce.

Besides the physical environment and the affordances thereof, the learning or working environment or activity systems involve also the dimension of conceptual artifacts (Latour & Woolgar, 1979; Hakkarainen et al., 2004). Also, pedagogical practices may be harmful or productive with regards to learning. Study activity takes place in a dynamic interplay between the learner and the learning environment. This may cause either constructive or destructive frictions (Lindblom-Ylänne & Lonka, 1999; Vermunt & Verloop, 1999): guidance should be regulated in relation to the student' s competence in order to avoid either excessive pampering and passivisation of the students or to avoid leaving them without necessary scaffolding with regard to the process of learning.

This study originates from an initiative to redesign a Finnish university chemistry laboratory in a way that it would be better aligned with the current pedagogical understanding, in order to foster learning and the development of expertise. Besides the learning aspects, there exists an economical concern (Kamarazaly, Mbachu, & Phipps, 2013) about the high expenses of different university facilities, which can well be extended to chemistry laboratory facilities. Teaching and research laboratories in the natural sciences are the most expensive learning spaces at the universities. There is a continuous need to maintain and upgrade sophisticated and up-to-date laboratory facilities. In addition, the utilization rates are disproportionately low. With regard to these issues, the flexibility of the spaces becomes crucial.

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In this study, our main focus is on the laboratory of organic chemistry which is a highly complex learning environment. Students need to learn to apply abstract multilevel knowledge, also known among chemistry educators as the chemistry triplet (Taber, 2013), on practical and tactile tasks of a trained chemist expert, already as a novice student (see e.g. Johnstone, 2000; Taber, 2013). Expert knowledge is tacit in nature, it is embedded in experiences and action (Nonaka & Takeuchi, 1995).

2. Problem Statement

Although there exists various strata of research concerning the learning environment, it usually refers to the social, psychological and pedagogical contexts in which learning occurs. However, physical learning environment and its relation to pedagogy and learning is often neglected.

3. Research Questions

In our study we wanted to deepen our understanding on how students perceive their physical learning environment and which factors either facilitate or pose a challenge to learning. More specifically, our research question was: what is the relationship between student perceptions of physical space, social space and mental space regarding learning?

4. Purpose of the Study

This study originates from an initiative to redesign and renovate the chemistry laboratory environments of a major Finnish university. As an embodiment of evidence-based design, we aimed at increasing understanding of learning by considering the two-way interaction between contemporary pedagogical knowledge and the practical challenges arising in given physical space.

5. Research Methods

In this study, we collected qualitative data among university chemistry students by using semi-structured focus- group interviews (n=21, representing different genders). We wanted to conduct the interviews in direct study context in the middle of a laboratory work session. The interviews were conducted contextually in close connection with the laboratory environment itself. In fact, the students were interviewed in the middle of a laboratory working session and they continued their work right after the interviews. The interviews involved three key themes: 1) use of spaces and technological tools in learning, 2) sources of interest and engagement, and 3) factors that either facilitate or pose a challenge to learning.

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While we had three general themes orienting the interviews and that were embodied in the structured questions, we did not restrict our analysis according to these questions. Rather, as the student responses were varied and the discussions flowed beyond any of the pre-planned questions, in the analysis we aimed at reaching central phenomena regarding the experienced physical environment and its relation to learning (regardless of the specific questions or background theories that structured the interviews).

More specifically, in the first phase of analysis, each of the researchers conducted individually a preliminary classification of data into salient themes with the help of Atlas-TI programme for qualitative analysis. In the second phase, the researchers compared and cross-checked their initial findings in order to define the central themes prevalent in the data. These themes were further processed during another phase of individual analysis, aiming to challenge and broaden the themes and consider their contexts and collocations within the data. The emerging themes were further developed by repeated research meetings in an iterative fashion. The aim of this fluctuation of individual and collective phases of analysis was to ensure the data-drivenness of the analysis. As each of the researchers found somewhat similar topics as central, regardless of their different scholarly backgrounds, these topics may be seen to represent rather well the nature of the data themselves rather than certain theoretical presuppositions.

6. Findings

6.1. Student expectations towards physical and social learning space and their experienced competence Physical space

When discussing with the students their perceptions of the laboratory learning space, the students had rather readily articulate views concerning their surroundings, especially the deficiencies that they perceived. These concerned rather concrete features of the laboratory environment, rather than discussing it from more abstract pedagogical viewpoint as such. The students were faced with fundamental human issues such as having sufficient space for working in general, or the presence of danger.

Students were also hoping that the laboratory environment would include different functional spaces, such as one designed for paper work and searching information through different modalities (e.g. computer, smart phone, books and notes). When laboratory environments accommodate solely practical laboratory procedures students find themselves obliged to carry out other study-related tasks in unpurposeful settings.

While the students expressed many deficiencies regarding the functionality and usability of the physical learning space, they also reported enthusiasm and elevated sense of

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competence regarding the use of laboratory equipment. Expressly, many informants conveyed their deep interest and even engagement at being able to put together complex, for them new pieces of equipment into a functional instrument that actually gave the expected output.

Social space. The students reported that each assistant teacher has a unique style in teaching and therefore the guidance that the students receive varies greatly in terms of pedagogical design. Many students reported that a crucial part of learning for them was to get affirmations for their own assumptions and anticipations either from the teacher or from peer students. They greatly valued the ability to openly discuss their questions and uncertainties.

The ability to work independently in the laboratory seemed to be an important indicator of competence for the students, and they were also very aware of the requirements of independence that they would face in their future jobs in the field of chemistry.

Nonetheless, the students emphasized the importance of a supportive environment and sufficient and clear instructions for laboratory work in practice. In fact, the general experience was that no matter how many theories one had taken an extremely good hold of, putting things into practice formed a gap that sometimes felt overwhelmingly confusing or distancing. What the students often felt was that the overall picture of the process was fragmented and the instructions, arbitrary and scarce. It appears that the chemistry learning culture involves an assumption that the hands-on skills and tacit knowledge of a chemistry professional would soak into the students automatically and nonverbally and that too much explicit guidance would jeopardize this development from happening.

6.2. Fit, misfit and sense of safety

A specific question about what hinders the students from learning in the physical and social learning environment led a major part of the informants to discuss first the social environment (the assistants, in particular, but also the peer students) intertwined with the physical space (space and the instrumentry) and finally, to discuss very deep- rooted matters of safety. The social and physical learning environments have a very strong affinity in these interviews, and this affinity and collocation is embedded in discussions about safety.

It seems that they are missing out on a more intermediate stage (i.e., there’ s a misfit between theory and application and the instructions given) where the students can comfortably develop their skills when starting to work on the actual experiments in the laboratory.

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Some even described experiences of panicking while performing their everyday laboratory experiments. Many took up the important issue of being able to discuss and confirm their own assumptions in order to overcome their doubts about safety issues.

The fundamental issues of safety appear salient in the student reflections concerning their physical surroundings. That is to say, they may be seen to overwhelm the students´ mental processes, which in turn, from a pedagogical point of view, is something that occupies space from intended learning. The findings led us to ponder further the relation between the social and physical modalities, on the one hand, and their relation to safety, on the other. An essential factor in chemistry laboratory learning context seems to be perceived student safety, which, in turn, appears to be regulated by an appropriate amount of guidance through both social and physical modalities.

7. Conclusions

How the place in itself is related to learning is often undermined or neglected, and there is hardly any empirical research on the relation between the physical aspect of the learning environment and pedagogical practice.

In most previous research, the social aspect of learning and pedagogical support has been discussed separately from the physical learning environment, while the physical environment has been considered on its own, in many cases independently. In the complex learning process, all three dimensions are present and in interaction with each other. These findings are in line with theories of networked expertise, emphasizing how intellectual activity is both physically and socially distributed (Hakkarainen et al., 2004, Lonka 2009; Paavola, Lonka, & Hakkarainen, 2004).

In contrast, previous studies in higher education approach the learning environment as a merely pedagogical or social construct (Lindblom-Ylänne & Lonka 1999; Lizzio, Wilson & Simons 2002; Vermunt & Verloop, 1999) without addressing the role of physical learning spaces. The dynamic interplay between the student and the learning environment should be expanded by taking into account the affordances of varying conceptual tools and artifacts (Lonka, 2009).

Having to worry incessantly about being threatened either by one’ s safety being at stake or by one’ s sense of competence and self-worth being challenged, hampers learning in a fundamental way. The sophisticated pedagogical processes are rendered meaningless if the cognitive capacity is harnessed in the use of basic needs, e.g. survival process, as opposed to higher cognitive processes such as learning and development of expertise (e.g. Helmreich & Merritt, 1998; LeBlanc, 2009; Harvey et al., 2010; Mälkki, 2010).

Our study makes a contribution to the field of evidence-based design in its user-oriented and holistic approach.

According to previous research, intellectual prostheses, such as physical tools available, are essential in learning and intellectual processing, since also different artifacts eventually become part of one' s "cognitive architecture" (Hakkarainen, Lonka, & Paavola, 2004). We might even call it physical scaffolding of intellectual development, as opposed to instructional scaffolding (Puntambekar & Hübscher, 2005; Wood, Bruner, & Ross, 1976). It is necessary to distinguish pedagogically when to offer structuring of the working environment and guidance through suitable means, and when to pull back on guidance in order to offer the students the space to think and experiment for themselves. In cases where the students' safety is at stake, it is even more crucial to consider ways to minimize the cognitive and emotional load by concrete and tactile as well as technologically advanced means and thereby enhance the mental resources for learning that the students have at their disposal.

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