Flexible environment and creativity: a preliminary case study of interdisciplinary student design teams

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ABSTRACT

A case study of five interdisciplinary student design teams was conducted to inform future research strategies for the next phases. The students conducted a semester-long design project using a flexible environment, a classroom featuring movable furniture and wheeled whiteboards. In order to confirm the positive impact of the flexible environment on creativity, observation, interviews and surveys were conducted. The findings suggested that team interactions enhanced creativity, and the students valued the positive influence of the flexible environment. From the findings and additional insights gained during the study, research strategies to examine the impact of physical environment, team interactions, and shared mental models on creativity are proposed.

Keywords

Interdisciplinary teams, flexible environment, engineering creativity

RESEARCH FOCUS

The focus of this preliminary study was to confirm the evidence to support initial hypotheses and to inform research strategies for the next phases. The questions that guided the processes were:

1. Does flexible environment foster team creativity?
2. Is the level and quality of interdisciplinary team interactions associated with team creativity?
3. What are the additional themes and hypotheses that need to be investigated during the next phases of the study, and how are they going to be carried out?

APPROACH

The complete study is planned to undergo three phases, phase 1: preliminary case study (fall 2008), phase 2: full-featured case study (fall 2009), and phase 3: experimental study with a control group (spring 2010). The findings summarized in this paper are the results from the first phase of the study. Throughout the creativity literature, the need for empirical evaluations of an environment that fosters creativity was well established. While little was known about the impact of physical environment on creativity, a cylindrically shaped meeting space with flexible features used by a design-consulting firm in Pennsylvania inspired the idea that physical environment may influence creativity of a team. During the first phase, flexible furniture and wheeled whiteboards were implemented to a classroom. A qualitative approach was used to identify patterns and themes.

FINDINGS

Analysis of interviews and observations as well as the students' final design reports answered the three research questions initially asked. First, the students reported that the flexible environment and visualization tools (e.g. whiteboards) fostered their creativity. Especially, all of the students who were interviewed mentioned that having whiteboards to visualize their ideas helped them to be more creative. However, it was noted that an experimental study including a control group would need to be conducted to validate this notion. Second, the positive impact of interdisciplinary team interactions on creativity was observed. The teams that showed more active interactions produced more creative design in the final reports. Third, a possible role of shared mental models among members was suggested. The teams that produced more creative outputs were showed higher coordination and less conflict during the process. It was speculated that those teams might have had higher levels of shared mental models.

ACKNOWLEDGMENTS

This material is based upon work supported by the National Science Foundation under Grant No. 0648439. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author and do not necessarily reflect the views of the National Science Foundation. The author would like to thank Dr. Lisa McNair for her thorough guidance throughout the process.

BIOGRAPHICAL SKETCH

Kahyun Kim is a graduate student currently pursuing Ph.D. in Industrial and Systems Engineering at Virginia Tech with a concentration on human factors and ergonomics. Her research interest is in team cognition as well as the impact of various factors on team performances and effectiveness.

BACKGROUND

Effect of Environment on Creativity

Unlike other factors, not many empirical studies evaluated physical environments that are conducive to creativity. A case study of a design team at a large pharmaceutical company investigated whether or not spatial factors influenced creativity. The findings indicated an increased level of creativity when a design studio with flexible features (e.g. movable tables) was utilized. However, the level of creativity was determined solely based on participants' subjective opinions in this study [5]. This study showed the need for more systematic evaluation on the subject. Recently, the framework of Creative Knowledge Environment (CKE) was proposed. The authors identified six components of the CKE: task characteristics, individuals, group characteristics, work situations, physical environment, and organizational environment. They also acknowledged the need for empirical evaluations [3].

Team Interactions and Creativity

The effect of the level and type of interactions on team creativity seems to be an area of disagreement among many researchers. Some studies reported that verbal interactions among team members interfered with collaboration during creative idea generation processes [6], [7]. In contrast, other researchers suggested that creativity was a collective process and interactions did not interfere with team creativity [2], [8] and may even enhance creativity when mediated by an appropriate tool [4].

METHODS

As mentioned earlier, the complete study is planned to undergo three phases. The current work described in this paper is the first phase that was conducted during the fall semester of 2008. The focus of this preliminary case study was confirming initial evidence to support original research questions, generating additional themes and hypotheses that need to be further investigated, and informing research strategies for the remaining phases.

Smart Dorm Room Project

Twenty-one students were selected from a semester-long senior-level interdisciplinary class at Virginia Tech. They consisted of five interdisciplinary teams including students majoring in computer engineering, communication, marketing, and industrial design. Students were tasked with designing various features of a "Smart Dorm Room" that uses pervasive computing technology to assist students with special needs while they live on-campus in their freshman year. Each team was asked to design one 'smart' feature (e.g., interactive furniture) of a Smart Dorm Room, and they were asked to produce a final design report at the end of the semester. To enable the flexible use of physical space, the classroom featured movable tables not oriented toward any specific direction and numerous wheeled whiteboards around the walls. To enable flexible social space, students were encouraged to self-organize in interdisciplinary teams and cooperatively conceptualize team projects within the configuration of a Smart Dorm Room where technology transparently interacts with users. During the semester, two coders observed team meetings and coded the transcriptions in order to determine the level and quality of interactions among team members. Also, the students' perceptions of the impact of the flexible learning environment on creativity were investigated using interviews, questionnaires and a focus group session. The students' final design reports were reviewed to evaluate creativity of each team's final product. For the content analysis, three assessment criteria were used: diverse user application (Did the product consider diverse population?), novelty of ideas (Was the idea original?), and innovative technology (Would the product be used in a new, pervasive way that would be seamlessly integrated with the user's environment?).

RESULTS

Flexible Environment and Creativity

During the interviews, the students suggested that the flexible environment and visualization tools fostered their creativity. Especially, all of the students who volunteered to be interviewed stated that the use of wheeled whiteboards supported their creative process. Some listed movable whiteboards as the creative force of the class. Students said whiteboards supported collaboration during the conceptual stage of the project by "giving everyone a focus point to look at" and "a common piece of notepaper" for visualizing ideas. However, it is noted that an experimental study including a control group will need to be conducted to validate this notion.

Team Interactions and Creativity

The positive impact of interdisciplinary team interactions on creativity was observed. The level and quality of interdisciplinary team interaction was determined from coding samples of observation transcripts. A pattern that teams with higher level of interactions with less signs of conflict showing better performance during the creative process and producing more creative product was emerged. For example, Team 2 (numbers 1-5 were assigned to each team for identification) indicated the highest level of interaction during discussions including cohesive communication as well as social bonding among team members, and Team 2's final design report indicated the highest level of creativity. Interviews also suggested that interdisciplinary team interaction was enhancing creativity of students. It was mentioned that having members with different backgrounds could "spark a whole new level" of ideas in the discussion.

Emerging Themes and Future Direction

During the data analysis, a possible role of shared mental models among members was suggested. The teams that produced more creative outputs were more coordinated throughout the project and showed less conflict during the process. In order to explain this phenomenon, it was speculated that those teams might have had higher level of

shared mental models among the members. In addition, the current study revealed limitations of the case study design. It was indicated that a single case study was not sufficient to prove the positive impact of the flexible environment, because it did not offer comparisons with a non-flexible environment. Hence, we decided to use a true experimental design including a control group that does not use the flexible environment during the third phase of the study.

NEXT STEPS

Designing an Environment Conducive to Creativity

From the current study, it was suggested that employing flexible features into a classroom might foster creativity of student design teams that operate inside it. The implementation of the flexible features was originally inspired by the practice of a design-consulting firm in Pennsylvania. They developed a cylindrically shaped meeting space that has movable desks and chairs as well as wall-mounted whiteboards covering most of the wall surface. The space is named 'kiva', after an underground circular room where Native Americans held rituals and community meetings. The schematic design of the kiva is depicted in the Figure 1.

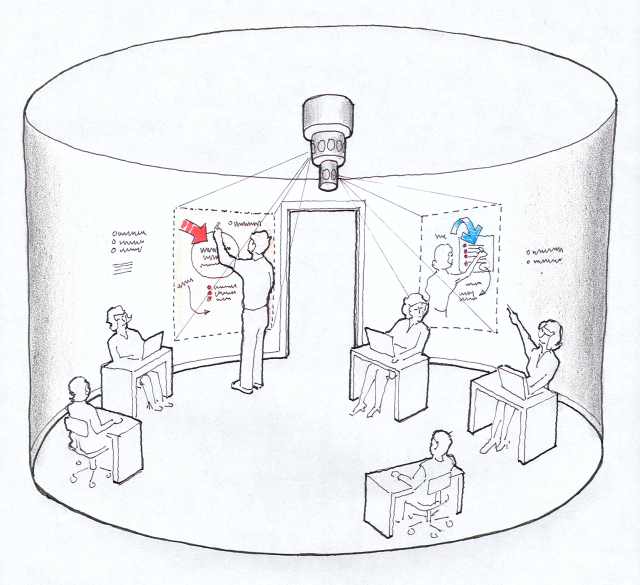

Figure 1 Illustration of the kiva. Most of the perimeter of the room is covered with whiteboard to allow a continuous flow of ideas. The apparatus in middle of the ceiling allows simultaneous image capture from and projection to the entire circumference. ***(Figure created by Ronald B. Kemnitzer, FIDSA)***

After observing positive results from the first phase of the study, it has been decided to construct two kivas at Virginia Tech, as part of joint research effort among several academic departments. The construction will be completed before the beginning of fall 2009. For the next phase of the study, the student design teams will use the kiva for their design activities throughout the semester. This will enable us to investigate the impact of full-featured environment (including cylindrical space as well as flexible features) on interdisciplinary student design teams. Before the full-featured study at Virginia Tech, a small-scale exploratory case study at the original kiva at the design-consulting firm during summer 2009 is planned. Interviews with creators of the kiva will provide insights into what led to the design decisions to create this space, which they believe fosters creativity. Also, video recordings of design meetings that take place in the kiva will allow us to identify communication and behavior patterns of expert users, which may inform the data analysis of student users at Virginia Tech.

Measurement of Shared Mental Models

During the current study (phase 1), it was theorized that the level of shared mental models among team members influenced the level of team performance, which in turn led to differences in team creativity. Having established that, a new hypothesis was emerged: teams showing higher levels of shared mental models will show higher team creativity. In order to quantify the level of shared mental models, pairwise relatedness ratings will be collected for both teamwork mental models and task-work mental models based on Cannon-Bowers and others' well-accepted conceptualization of shared mental models [1].

Measurement of Creativity

In the current study, the level of creativity was determined based on the content analysis of final design reports. The assessment criteria for the content analysis were based on the definition of creativity as well as the purpose of the design task at hand. However, it was suggested that the final design reports did not capture the creative processes the teams experienced. In order to reach the final design decisions, the teams conducted several brainstorming sessions throughout the semester and their design evolved through multiple stages; but these were not included in the final design reports. In this perspective, it was suggested that product creativity alone might not be a sufficient representation of team creativity. Thus, in addition to product creativity, the level of creativity exhibited by each team during the brainstorming sessions (process creativity) would be measured for the future phases.

Experimental Study

Based on the findings, it is suggested that an experimental study including a control group is imperative to prove the positive impact of a physical environment on creativity. Also, mixed methods of both qualitative and quantitative approach will need to be adopted in order to triangulate the data throughout the various dependent variables. Based on these suggestions, we decided that the phase 3 would be conducted as a laboratory-based experimental study. To simplify the data collection, a brainstorming task would be used in order to measure creativity. The teams under the experimental condition will be placed in the kiva, and the teams under the control condition will be placed in a rectangular space with no flexible features. The schematic comparisons between the two spaces are shown in figure 2.

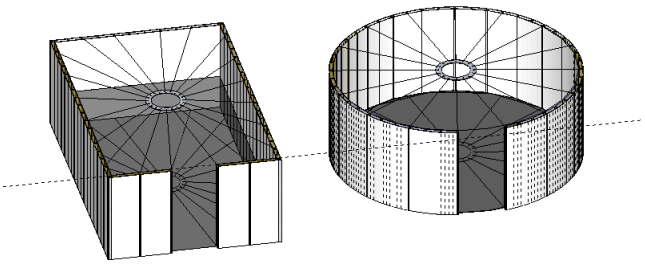

Figure 2 Comparisons of Two Environments for Phase 3 ***(Figure created by Kristen Carleton, Virginia Tech)***

EXPECTED BENEFITS OF PARTICIPATION

Because this study is still in its preliminary stage, many details need to be determined regarding the future phases. Participating in the graduate student symposium where experienced researchers and practitioners in the field of creativity and cognition will be present will offer an opportunity to receive valuable feedbacks for shaping future directions. For example, practitioners will be able to offer profound insights into what should be measured to determine the level of creativity in creative processes as well as creative products. Also, discussing with experienced researchers will help us identify limitations of the current study design and form better research strategies to improve validity and reliability of the study.

Interdisciplinary approach and empirical nature of this study will not only benefit from but also contribute to the symposium. As noted earlier, the topic of environments conducive to creativity needs more empirical work in order to confirm theoretical conceptualizations. This study will provide other participants an opportunity to be exposed to empirical work that attempts to evaluate environment that fosters creativity. Also, an interdisciplinary research strategy that encompasses the field of industrial engineering, human factors, and engineering education will offer participants a different perspective to approach team creativity research.

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