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Virtual Labs: Experiencing Internet-Based 3D Spatial Training

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VIRTUAL LABS: EXPERIENCING INTERNET-BASED 3D SPATIAL TRAINING

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EXTENDED ABSTRACT:

Spatial skills are critical for higher-level thinking, reasoning and creative processes (Sorby et al., 2005). Thanks to today's Internet technologies, students can access virtual labs for gaining and improving their spatial skills. Smith (1964) estimated that spatial ability plays a key role in at least 84 different fields, including medicine, dentistry, mathematics, chemistry, engineering, and computing and so on. This pervasiveness makes it important to create training methods that help people gain spatial skills needed to comprehend visualizations. In spite of the importance of spatial skills, it is usually costly to access spatial training facilities (e.g., physical robotics), especially for developing three-dimensional (3D) spatial skills. Internet technologies have made online learning an achievable goal in education (Balamuralithara and Woods, 2009). Virtual labs have vast advantages in becoming an alternative to physical labs. The virtual lab is one possible technique that makes it possible to share expensive equipment among several universities or education centers.

In this research, we designed and implemented two different types of Internet-based training systems for students to gain and improve their 3D spatial skills in a virtual lab setting. One system is to give students a remote control through an Internet Application to manipulate an actual robot which performs object rotation and movement tasks in a professional lab, and the other system is a 3D computer simulation system, where students can conduct the same tasks as the ones through the remote robotic system. Due to the lack of real interactions with peers and instructors with virtual labs (Balamuralithara and Woods, 2009), we add a team pair component in this study to minimize student online isolation and to increase the learning outcomes in a collaborative learning setting.

Based on the Social Decision Scheme theory (Davis, 1973), small group interactions can be seen as a combinatorial process where the task elements (ideas, task responses, preferences, resources, etc.) must be combined in such a way to allow a group to reach consensus on a particular task (Davis, 1982). A shared representation is any task, situation-relevant concept, norm, perspective or cognitive process that is shared by most or all of the group members. In this context, task-relevant means that the shared representation will have some implications for the choice alternatives involved, and the degree to which a shared representation will impact group decision processes will vary based on the function of relevance. We expect the higher the shared task representation, the higher learning outcomes for team pairs in terms of both their perceived learning and actual spatial skills. Therefore we propose for both spatial training systems (i.e., remote robotic tool and computer simulation) that:

Hypothesis 1a: A shared task representation will have a positive effect on perceived learning.
Hypothesis 1b: A shared task representation will improve spatial skills.

Prior research indicates that the most common bases of member attraction are familiarity (Ancona and Caldwell, 1992). Group discussions and group judgments are dominated by knowledge that members held in common prior to their meeting. Kiesler and Sproull (1992) identified team member familiarity as an important factor to consider when designing Computer-Supported Collaborative Learning (CSCL). When students know their team members well, they have acquired knowledge about their partners that they can use to interpret their partners' messages, identify their strengths and weaknesses, and adapt their communication to their partners' specific needs. Hence we propose that for both spatial training systems:

Hypothesis 2a: Familiarity of members in a team pair participating in an activity will have a positive effect on perceived learning.
Hypothesis 2b: Familiarity of members in a team pair participating in an activity will improve spatial skills.

In this study, we recruited 208 students at their common meetings places (e.g., cafeteria) at a university. The incentive was a coupon for a free coffee and a dessert. The experiment involved pairs of students: one operated the system, while the other one manipulated the system with the first student acting as an advisor. Team pairs were built by the students and the researcher. For familiar teams, students were asked to bring someone they know, and for unfamiliar teams, the researchers in the filed study randomly selected two unfamiliar students to form up a team. They were randomly assigned to either the remote robotic or computer simulation virtual lab experiment. The average age of participants was 25.24; 68% were male and 32% were female. At both the beginning and the end of the experiment, the respondents were asked to take a ten-question spatial skill assessment test with equivalent difficulty level in order to measure their actual learning outcomes. After the experiments, the respondents were asked to fill out a questionnaire constructs in order to examine the proposed hypotheses.

Data analysis results indicate that all proposed hypotheses were strongly supported. We found that a shared task representation greatly impacted perceived learning (H1a), but had a negative impact on the improvement of spatial skills (H1b). This negative result was mainly caused by the initial design of computer interfaces, which confused students, and students had to spend extra time discussing the interface issues before they could figure out a problem solution. In terms of team pair familiarity, H2a and H2b showed that it had a significant impact on both perceived learning and improved spatial skills.

Our study revealed a significant difference between the two Internet-based training systems regarding experimental duration, with a shorter simulation time in both cases. Experience with the Internet had a positive effect on perceived learning, but the simulation was more familiar to students who have experiences with online 3D games. However, in terms of all other measures, no significant differences were found between the two systems. The overall study results are positive, in that our study demonstrates that the two different types of the Internet-based 3D spatial training systems (i.e., remote robotic tool and computer simulation) can effectively serve as an alternative and affordable spatial training tool for students. Therefore, there is great potential in developing and using virtual labs for spatial training in higher education to improve students' spatial ability that they need to succeed in many professions.

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