Learning Affordance of Mixed Reality in Undergraduate Construction Management Curriculum - A Wood Framing Case Study

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Construction management education is facing dual challenges: 1) there is a severe shortage of skilled workforce in this industry; and 2) hands-on experience for skill development and tacit knowledge acquisition has been traditionally time-consuming and resources intensive. The current state of undergraduate construction and engineering education in the United States effectively import certain types of knowledge (e.g., technical knowledge), but are not as effective at preparing students to integrate knowledge, skills, and affective elements (e.g., identity formation) as they develop into professionals. The consequence of this approach is that graduates entering the workforce struggle to transfer what they learned in school to what is required of them as a professional. This research investigates if emerging technology such as mixed reality (MR) could facilitate student learning and career- specific competency development. It studies the affordance of mixed reality by incorporating virtual design and construction information into real hands-on lab activities to enhance authentic learning experience and skills development using a MR-intervened wood framing lab of a lower-division undergraduate building materials course as a case study. The case study is expected to help collect empirical data of student behaviors and learning experiences with MR intervention. Specifically, the case study addresses two research questions (RQs): 1) it aims to explore if there is observable student behavior and performance difference between MR-facilitated learning and traditional learning, and 2) it investigates success factors & best practices of research design, data collection & analysis for future efforts in technology-intervened construction management educational research. The research method involved setting up a wood framing lab that had 2 group sessions: 1 control group (4 teams) using traditional paper drawings and 1 experiment group (3 teams) using HoloLens with embedded MR model. Students teams (with 4~5 students per team) were required to complete the wood structure within 5 lab sessions. Student teams were supervised by lab technicians and assigned project managers played by senior students from an upper division project controls class. Student behaviors and perceptions were compared between the two sessions. The behavioral data included both video capturing and audio recordings and would be analyzed using Behavioral Observation Research Interactive Software (BORIS). Perceptual data of students' overall lab experience were collected using a pair of pre- and post-survey questionnaires. Statistical analyses would be conducted to determine if there was significant difference between the two sessions.

Due to weather constraints, the originally scheduled 5 lab sessions were cut to 3 and students were not able to complete the whole wood structure. However, more than 12 hours of video and audio data were still collected. The perceptual data was also collected via the pre- and post-lab survey questionnaires. The preliminary analysis of video and audio data revealed some interesting findings. For the experiment group (teams with HoloLens), there was an apparent learning curve with the technology even though there was a dedicated training session conducted for them. Student tended to complain a lot at the very beginning on obtaining measurements of sizes and locations necessary to process (cut) materials and lay out installation due to a "technology shock". Starting at the end of the 2nd lab session, a lot of positive feedback on HoloLens started to emerge, mainly because of the benefits of direct visualization of structural connections and the ability to verify installation against the design. Some students were trying to avoid using the technology and seemed to be indifferent about it, so there were quite some idle moments for certain students. The steep learning curve resulted slower project process of the experiment group compared with the control group. In the meantime, it was noticed that for the control group, students with some prior construction or carpentry experiences immediately became the leaders of their teams, while in the experiment group the one with more technology savviness tended to lead. The control group tended to have everyone one more involved in the installation without much idling compared with the experiment group, and they had more questions regarding how the wood structure should look like based upon the 2D drawings, while no such questions were asked in the experiment group because they saw the 3D representation directly. This research and its findings could establish important theoretic and practical foundations for future efforts in the field of technology-intervened construction management education and training.

Keywords: Construction workforce, mixed reality, authentic learning, wood framing