Mixed Reality Technology Influences Motivation for Learning in Medical Students

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Abstract

Introduction: Motivation plays an important role in the learning process and strongly influences learning outcomes. However, it remains unclear how the use of technologies like mixed reality (MR) affect student motivation for learning. Our study aims to assess differences in student motivation for learning using MR technology in comparison to large group, didactic learning.

Methods: First-year medical students (n = 18) were given a survey to measure three components of motivation: attention, relevance, and confidence. The survey was given after classroom learning on cardiovascular anatomy and physiology was completed, and again after completing a learning activity on the same topic using MR technology.

Results: The analysis showed overall student motivation to learn in the classroom and from the MR activity were similar ($p > 0.05$). However, the specific motivating factors differed between the two instructional methods. Students were motivated to learn using the MR activity because it better held their attention ($p < 0.05$). In contrast, classroom instruction motivated students to learn primarily because students viewed it as more worthwhile and useful ($p < 0.05$). There was no difference in student confidence as a motivating factor to learn.

Conclusions: These findings suggest MR instructional activities may be designed to motivate student learning by holding their attention because of the variety of interactive learning options it is capable of presenting. However, instructional activities using MR technology may not be perceived by students as being as worthwhile and useful as formal classroom instruction.

Keywords: Motivation; Mixed Reality

Introduction

Motivation is a set of psychological mechanisms that influence the energization and direction of action in pursuit of a goal (Deci and Ryan, 2000). These mechanisms regulate human behavior based on a combination of intrinsic
feelings of self-satisfaction and external demands like reward and punishment. In this manner, motivation is particularly influential on behaviors related to learning. Motivation for learning regulates the magnitude of effort and the direction of goal-oriented behaviors of students (Keller, 2010). It is a major component of deep learning necessary to apply knowledge to complex scenarios, a predictor of academic performance, and is highly correlated with learner well-being and satisfaction (Mann, 1999; Ryan and Deci, 2000).

At the medical school level, a strong motivation for learning has been linked to the efficacy of study behaviors, academic performance, and even choice of medical specialty (Kusurkar et al., 2011). Medical students that are more motivated to learn are also better able to succeed in self-regulated learning environments, find more meaning and value in their educational experiences, and perform better on assessments of academic achievement (Sobral, 2004; Stegers-Jager et al., 2012; Pelaccia and Viau, 2017). In fact, the importance of motivation for learning in regard to student performance may explain the outcomes of medical educational research demonstrating equivalency of instructional methods because motivation for learning may supersede the choice of instructional technique (ten Cate et al., 2011). Furthermore, it has been recommended that the motivational processes be built into undergraduate medical school curricula based on a broad survey of studies on the topic highlighting its importance (Kusurkar et al., 2012).

As medical education has transformed in recent years, technology has taken an increasingly prominent role. However, the effects of technology on motivation for learning have yet to be fully understood. This is particularly the case for technologies like mixed reality (MR), which have been recommended as instructional tools by the Association of American Medical Colleges for over a decade (Candler, 2007). MR is a three-dimensional visualization tool that uses head-mounted displays to permit real time interactivity with computer-generated objects overlaid into the real world. Reviews of relevant literature have found the application of MR in educational settings promotes enhanced learning achievements (Akçayır and Akçayır, 2017; Gerup et al., 2020). Specifically, MR can be implemented in a manner that improves critical thinking, problem solving, and investigation skills (Sotiriou and Bogner, 2008; Dunleavy et al., 2009). Yet, it remains unclear if this technology improves motivation for learning relative to other classroom-based instructional methods. Computer-based learning has been shown to enhance motivation, but also serves as a barrier to learning due to its complexity as it may represent a new skill to be mastered in order to begin the learning process (Lindgren et al., 2016; Hauze and Marshall, 2020).

In this study, we investigate the influence of MR on motivation for learning in a sample of first year medical students. We use a modified version of the Reduced Instructional Materials Motivation Survey (RIMMS) to measure student motivation following completion of an MR learning activity. These results are compared to those obtained after classroom-based instruction to assess the relative impact of MR on motivation for learning in medical school instruction.

Methods

Participants and procedure

The participants of this study were first-year medical students enrolled at a medical school located in the United States. Eighteen students volunteered to participate in this study (15% of a class of 120 students). Participants completed a survey that assessed motivation for learning after finishing the cardiovascular portion of the first-year curriculum that covers basic heart anatomy and physiology. Instruction of this topic included a combination of textbook and large group, didactic classroom learning. Participants then completed an independent learning activity on the same topic using an MR application. The application took students no more than 1 hour to complete and used a virtual, interactive, animated heart model to demonstrate heart anatomy and electrophysiology concepts (Figure 1). The application was designed for the Microsoft HoloLens (first generation) platform and was developed by the
Department of Educational Technology at the University of Central Florida, College of Medicine. Participation in the study was voluntary, and anonymity was maintained. The study received exemption status from the Institutional Review Board.

**Figure 1:** Screenshot from the Cardiovascular MR learning application developed by the Department of Educational Technology at the University of Central Florida, College of Medicine.

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**Instrument**

Motivation for learning was assessed using an adaptation of the Reduced Instructional Materials Motivation Survey (RIMMS). This survey is designed to assess if learner goals have been achieved based on the ARCS model of motivational design that clusters motivational concepts into multiple components, including attention, relevance, confidence, and satisfaction (Keller, 2010). The original survey created by Keller, called the Instructional Materials Motivation Survey, or IMMS, consists of 36 items. The RIMMS instruments was reduced in size and validated for assessing motivation while working with technology by Loorbach et al. (2015). Huang et al. (2006) also assessed the IMMS instrument as a tool for studying motivation using computer-based instruction. These authors concluded that the attention and satisfaction components of the survey were strongly correlated and suggested including survey items of only one of these components (Huang et al., 2006). The version employed in this study has 7 items that correspond to three components of the ARCS motivation model: attention, relevance, and confidence (Table 1). Items were scored on a 5-point Likert scale (1 = not true, 5 = very true).

**Table 1. Motivation survey items and their respective motivational components.**

| Number | Component | Item                                                                                                                                 |
|--------|-----------|-------------------------------------------------------------------------------------------------------------------------------------|
| 1      | Attention | The quality of the MR activity helped to hold my attention.                                                                            |
| 2      | Attention | The design of the MR activity helped to keep my attention.                                                                             |
| 3      | Attention | The variety of animations, examples, exercises, etc in the MR activity helped to keep my attention.                                  |
Relevance

| Page | Relevance | Confidence |
|------|-----------|------------|
| 4    | It is clear to me how the content of the MR activity is related to the things I already know. |                       |
| 5    | The MR activity conveyed the impression that the content is worth knowing. |                       |
| 6    | The content of the MR activity will be useful to me. |                       |
| 7    | As I worked through the MR activity, I was confident that I could learn the content. |                       |

Statistical analysis

A two-factor analysis of variance (ANOVA) with replication was used to test for differences in motivation for learning in the classroom and learning using the MR application. Independent t tests were used to assess group differences in responses for each item. Pearson's correlations were used to assess the relationships between survey items. Cronbach's alpha was calculated to measure internal consistency of the responses. Significance was set at $P < 0.05$.

Results/Analysis

Cronbach's alpha of the instrument administered in this study was 0.72, indicating good scale reliability. The results of the ANOVA revealed no difference in motivation between the two instructional methods, indicating students were equally motivated to learn in the classroom and using the MR application ($F = 1.14, p = 0.29$). However, there was a significant interaction, showing learners were motivated by different components of the motivational model for the two instructional methods ($F = 6.01; p < 0.05$).

Figure 2: Comparison of responses to the motivation survey. Survey items are grouped into three components of motivation, attention, relevance, and confidence.
T tests comparing responses for the survey items found the largest motivating factor for classroom learning was the perceived relevance of the content (Figure 2). In particular, students found the classroom-based exercises to be significantly more relevant and useful to their studies in comparison to the technology-based MR activity ($p < 0.05$). In contrast, learners were significantly more motivated by the ability of the instructional materials to hold their attention. The design of the application and variety of animations, examples, and exercises that comprised the application motivated students to learn more strongly than in the classroom ($p < 0.05$). Like classroom instruction, the MR activity was also found to motivate students through its relevance to prior knowledge, but only for one of the survey items. Students rated the MR activity as higher at making it clear that the content is related to prior learning than classroom methods ($p < 0.05$). There was no difference in the reported confidence in the students' ability to learn the material between the two instructional methods.

There were several significant correlations between student responses to the survey items regardless of instructional method used to facilitate their learning (Table 2). First, there was a strong positive correlation between how students regarded the quality of the instructional material and the design of the material in terms of holding their attention. Second, students that indicated the design held their attention also indicated the variety of instructional materials held their attention. Third, the better the design of the material was at holding their attention, the more confident the students were in their learning. Lastly, the more the students felt the material was related to things they already knew, the more confident they were in their learning.

**Table 2. Pearson correlation matrix of survey item responses.**

|       | Item 1 | Item 2 | Item 3 | Item 4 | Item 5 | Item 6 | Item 7 |
|-------|--------|--------|--------|--------|--------|--------|--------|
| Item 1 | .      |        |        |        |        |        |        |
| Item 2 | 0.69†  | .      |        |        |        |        |        |
| Item 3 | 0.61   | 0.69†  | .      |        |        |        |        |
Discussion

The aim of this study was to evaluate the influence of MR technology on student motivation to learn cardiac anatomy and physiology in comparison to classroom instruction. While multiple uses of virtual reality and MR in medical education have been studied, little is known about how it effects motivation to learn (Kamphuis et al., 2014; Antoniou et al., 2017; Zielke, 2017; Hanna et al., 2018). We found the MR application primarily motivated students to learn by holding their attention through its design and the variety of examples and exercises it utilized. The application included an interactive heart animation that contracted at a rate controlled by the user. It also included buttons that allowed the students to freely navigate through the content and flashcards to help review high-yield concepts. The design of the instructional materials offered elements that are interactive, novel, and varied, all factors that have long been known to increase student attention (Keller 1983). Designing instructional materials that hold student attention has been shown to aid learning, as evidenced by the strong correlation between sustained attention during learning activities and academic achievement (Steinmayr et al., 2010).

Another component of motivation that our survey assessed was relevance. Students are better motivated to learn when it is clear to them how their learning relates to their educational goals (Chang and Lehman, 2002). The MR activity was able to motivate students to learn through its relevance to what they already knew. Student responses to the instrument show the MR activity made it significantly clearer how the content was related to other content students were learning in comparison to instructional materials used in the classroom. However, given the procedure employed in our study, these findings may reflect the fact that the MR application was administered after the classroom instruction and therefore built upon what was already learned in the course. This interpretation would suggest MR may be used effectively as a tool to reinforce classroom instruction, although more research is needed to elucidate the precise effects.

The third and final component of motivation we evaluated was confidence. Although we found no difference in reported confidence between classroom and MR instruction, we did find a significant correlation between student responses related to attention and confidence, as well as relevance and confidence. Instructional materials that are better at holding student attention and that are more relevant to what students already know give students more confidence in their learning. Educational methods that increase learner confidence benefits the learning process by decreasing student anxiety and increasing positive expectations of learning outcomes (Loorbach et al., 2007). Therefore, learning activities that hold student attention and that clearly relate to prior knowledge may benefit student learning regardless of whether MR technology is used in the educational activity. However, our findings suggest MR technology may better facilitate a varied instructional design to hold student attention more so than didactic instruction, although further investigation is warranted.

Conclusion

Our investigation revealed that medical students are equally motivated to learn in a large group, didactic setting and by independently completing a learning activity using MR technology. However, we found substantial differences in what motives students to learn for each instructional method. The use of MR technology in medical education
instruction may help motivate students to learn, particularly if it employs a varied design that holds student attention, and if the relevance of the content is made clear to the students. However, students may not be as motivated to learn by the perceived worth and usefulness of the activity in comparison to classroom instruction that is part of the formal curriculum. While we found a positive impact of MR technology on student motivation for learning, future research is needed that focuses on the optimal role for MR technology in medical school curricula.

**Take Home Messages**

- Medical students are equally motivated to in large group settings and by using MR technology.
- The precise motivational factors differ for students learning in large group, didactic settings in comparison to those learning using MR technology.
- Instruction using MR technology may motivate students to learn by better holding their attention.
- Future research is needed that focuses on the optimal role for MR technology in medical school curricula.

**Notes On Contributors**

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**Appendices**

None.

**Declarations**

*The author has declared that there are no conflicts of interest.*

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