Mixed Reality For Teaching Concrete Formwork

Pavan Meadati, Ph.D.[1], and Parminder Juneja, Ph.D.[2]

[1,2] Kennesaw State University, Marietta, Georgia 30060, USA

pmeadati@kennesaw.edu

Abstract
With rapid advancements in information and communications technologies, usage of technology has become an integral part of students' life. Engaging these technology savvy students in the learning process with their preferred learning style is a challenging task. The differences in teaching and learning styles result in problems such as disengagement of students and loss of learning aptitude. This active student engagement challenge can be addressed through mixed reality (MR) learning environment. It has high potential and can play an important role to enhance students' learning experience by engaging and improving their learning attitude. This learning environment engages students in active learning processes and helps them to focus on their learning. It also encourages students to take more responsibility for their own learning process. It creates ubiquitous learning environment and provides anytime time access which facilitates the students to learn at their own pace and promotes learning beyond the regular classroom boundaries. This paper discusses an undergoing research that aims to improve the engagement and learning ability of the students through MR for learning about concrete formwork.

Keywords
Mixed Reality, Learning Environment, Engagement, Concrete Formwork, Teaching

1. Introduction

Technology became an integral part of Construction Management (CM) students' life. With further advancements of the technologies CM students the usage of the technologies for school related work will continue to grow in future. Engaging these technology savvy students in the learning process with their preferred learning style is a daunting task. The differences in teaching and learning styles result in problems such as disengagement of students and loss of learning aptitude. Additionally, the ability to visualize the built environment and learn construction processes is critical for students in the architecture, engineering, and construction disciplines [Irizarry et al, 2012; Nikolic et al, 2011]. Due to lack of experience, it will be challenging for students to visualize. Incorporating site visits in the curriculum helps the students to corroborate the learning components to the real world. Due to current COVID situation inclusion of site visits in the course became challenging. This pandemic has forced to change the teaching modality from in person face to face to online mode. This online teaching modality has added one more dimension of difficulty to engage and involve the students in the active learning environment. Some of these challenges faced by construction programs across the nation and the world can be addressed by using mixed reality (MR) learning environment. It has high potential and can play an important role to enhance students' learning experience by engaging and improving their learning attitude. It creates an interactive learning experience that mimics real world. As this learning environment involves senses of sight, hearing and touch, it leads to improved student engagement. This learning environment engages students in active learning processes and helps them to focus on their learning. It also encourages students to take more responsibility for their own learning process. It creates ubiquitous learning environment and provides anytime time access which facilitates the students to learn at their own pace and promotes learning beyond the regular classroom boundaries. This paper discusses undergoing research that aims to improve the engagement and learning ability of the students through MR for learning about concrete formwork. The paper is organized as follows:

section 2 the discusses about mixed reality and HoloLens, section 3 discusses about the MR learning environment for concrete formwork, section 4 discusses methodology for data collection and analysis. Finally conclusions are discussed in section 5.

2. Mixed Reality and HoloLens

Mixed reality (MR) is a rapidly developing technology. It was proposed by Milgram and Kishino in 1994. As shown in the Figure 1 “Virtuality Continuum” proposed by Milgram and Kishino (1994) explains the various forms of real and digital environments. As shown in Figure 1, Real Environment is on extreme left end of the continuum and Virtual Environment is on extreme right end. Real Environment describes the environment in which nothing is known about the (remote) world being displayed. This describes the real world as it is seen with one’s own eyes. In this case, no virtual computer-generated images are present. The Virtual Environment right extreme, refers to a world that the user perceives as completely virtual. This is essentially a world in which the user is 100% immersed in a virtual environment. In between “Real Environment” and “Virtual Environment” the continuum has Augmented Virtuality (AV), Augmented Reality (AR), and Mixed Reality (MR). Mixed Reality is also referred to as hybrid reality. It is the merger of real and virtual worlds which produce new environments and visualizations where physical and digital objects co-exist. It allows the digital objects to interact with real objects in real time and space. Based on three different criteria (immersion, interaction, information) MR is classified into 3iV classes: (1) it consists of both real and virtual contents and allows data contextualization; (2) the digital content is required to be interactive in real time; (3) the content needs to be spatially mapped and correlated with the 3D space [Parveaua and Addaa, 2018].

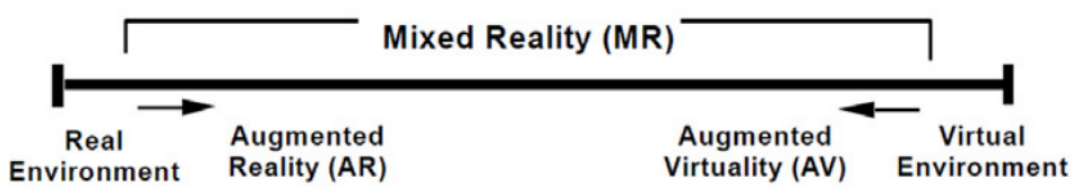

Fig. 1. Milgram and Kishio’s virtuality continuum

Microsoft Hololens is the self-contained, holographic computer. This enables to engage with the digital content and interact with holograms in the world around the user (Microsoft 2023a). It is made up of specialized components such as HoloLens Processing unit (HPU) and advanced sesnsors. These components together enable holographic computing. It’s advanced sensors capture information about what user is doing and the environment in which the user is in. It can see, map, and understand the physical places, spaces, and things around the user. It understands gestures and where user looks, and maps the world around the user, all in real time. It has a “see-through holographic high-definition lenses” and an advanced optical projection system. This generates a multi-dimensional full-color images with very low latency so that user can see holograms in their own world. It’s headband is designed to distribute the wieght around the crown of the user head and saves ears and nose from undue pressure. Headband has an adjustment wheel which ensures comftable fit for a wide range fo adult head sizes. Though it has more computing power than the average laptop, it is passively cooled without fans.Lack of wires, external cameras, or phone or PC ocnnection required makes the user to move freely (Microsoft 2023b).

Fig. 2. Microsoft Hololens (Microsoft 2018 a)

Microsoft HoloLens is useful to create mixed reality environment. It provides an intuitive and immersive environment to explore the concept of reality and human perception in a real-time perspective. It enables digital models to overlay with a real environment objects and facilitates users to interact with the digital content. The following section discusses about the MR learning environment created by the HoloLens to support teaching concrete formwork.

3. MR Learning Environment for Concrete Formwork

Formwork for concrete must be designed to support all applied vertical and lateral loads until these loads can be carried by the concrete structure itself. The goal of the research is to develop a MR learning environment for teaching concrete formwork. By enabling users to experience both the physical and virtual worlds simultaneously, this learning environment allow students to gain some of the physical exploration benefits that are possible with physical design and construction educational activities. This enables building design comprehension to support their learning. This facilitates the students to understand design assumptions, to learn about the formwork components and to learn about the formwork construction steps.

This provides environment to learn about formwork of slab, wall and column. The typical components of slab formwork are shown in Figure 3. Members which support sheathing directly are referred as joists. The cross members which support joists are usually refereed as stringers. The vertical members which support stringers are refereed as shores. The typical components of wall formwork are shown in Figure 4. Members which support sheathing directly are referred as studs. The cross members which support studs are usually refereed as wales. The wales are supported by Ties. The inclined members which are designed to resist the lateral wind loads are refereed as struts. The typical components of column formwork are shown in Figure 5. Members which support sheathing directly are referred as studs. The cross members which support studs are refereed as clamps. The inclined members which are designed to resist the lateral wind loads are refereed as struts.

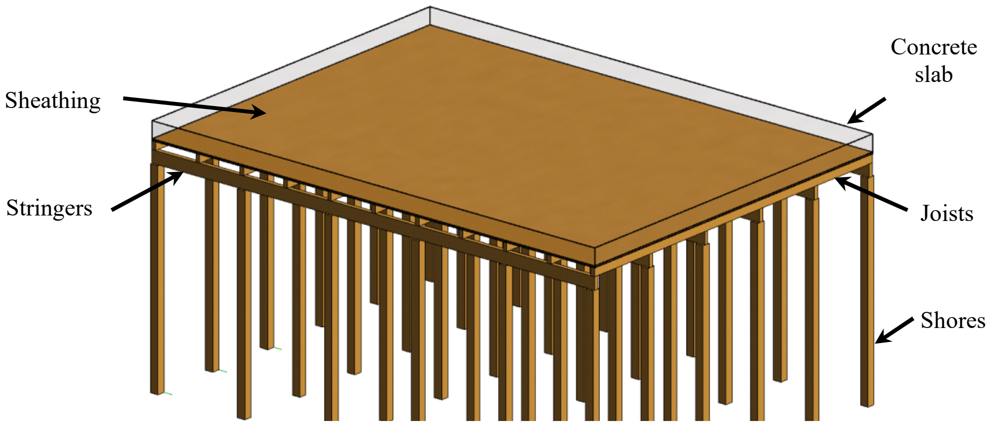

Fig. 3. Typical components of slab formwork

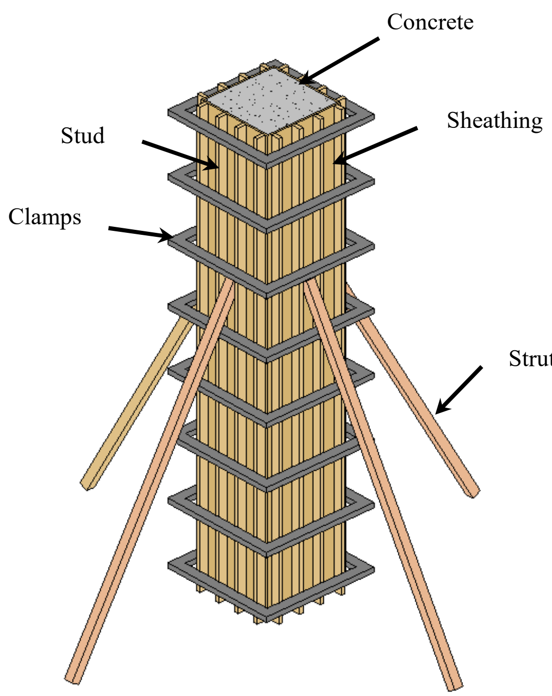

Fig. 4. Typical components of column formwork

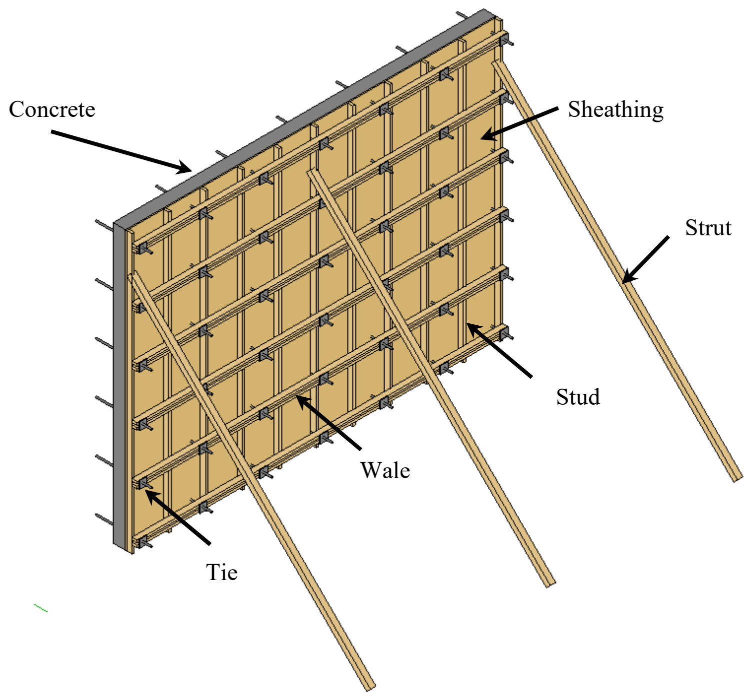

Fig. 5. Typical components of wall formwork

The 3D models of formwork of slab, wall and column created in Unity software. Unity has powerful game development engine which can work on multiplatform [Unity, 2023]. These models are exported to HoloLens with required programming scripts to create the required MR learning environment for concrete formwork. In this, environment users interact with digital models using gazing and hand gestures. The core hand gestures, including air tap, drag and bloom are shown in Figure 6. In order to implement the instructions, students have to gaze on the targeted components and to act with core hand gestures. Students can select the components of the digital model individually to investigate the component detail. The digital model can be hidden or transformed through scaling, translating and rotating, so that students can explore it from different angles and perspectives.

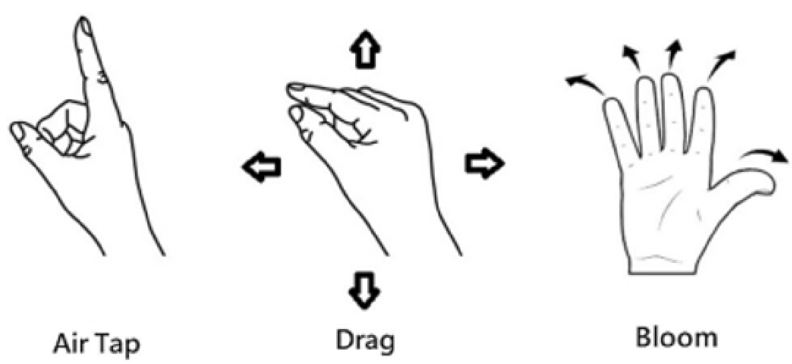

Fig. 6. Core hand gestures used in MR learning environment for concrete formwork

4. Methodology for Data Collection

One of the objectives of the study is to investigate the effectiveness of students in learning design and construction of concrete formwork through MR environment. This study plans to collect qualitative and quantitative data to sufficiently address the research objective. At the beginning of the study, two groups of students will be recruited to participate in the control and experimental groups. The control group learns with traditional 2D drawings as the sole information source. The experimental group will learn through MR learning environment. Both groups of students will be required to participate in the pretest first to quantify their abilities with respect to a certain level of understanding in design. For the experiment group, a 10min briefing and experience sessions on the operation of HoloLens will be given to familiarize with its operations. This ensures that the students can focus on learning design and construction during the test without being distracted when operating the HoloLens in MR learning environment. After the learning session, a posttest with similar difficulty will be used to assess the students' design abilities, as in the pretest. The comparison between pre and post-test surveys provides the results of the effectiveness of students in learning design and construction of concrete formwork through MR learning environment. The experimental group will also be asked to take the survey to assess the usefulness of MR learning environment to help the students to understand design assumptions, to learn about the formwork components, and to learn about the formwork construction steps. Students will be asked to express their satisfaction on these with 5-point Likert-type scale.

5. Conclusion

This work-in-progress paper introduces an undergoing research that aims to improve the engagement and learning ability of the students through MR learning environment for concrete formwork. At the time of this paper, the actual development of MR learning environment and data collection process are still ongoing. However, this paper offers a comprehensive overview of the motivation, research objective, research design and methodology, as well as data collection and analysis plan. This learning environment serves as a new teaching tool and helps to be more effective in communicating the information to the students. As this learning environment involves senses of sight, hearing and touch, and helps students to be actively engaged in the learning process. The MR learning environment has the potential to make a paradigm shift in teaching and learning process of concrete formwork. It is expected that the results and findings from this study will inform the research design and improvements in the next phase of this project.

References

Irizarry, J., Meadati, P., Barham, W. S., Akhnoukh, A. (2012). "Exploring Applications of Building Information Modeling for Enhancing Visualization and Information Access in Engineering and Construction Education Environments". International Journal of Construction Education and Research, Vol. 8, No 2, pp 119-145.

Microsoft (2023a). Microsoft Hololens. Online at https://www.microsoft.com/en-us/hololens. Accessed on January 25, 2023.

Microsoft (2023b). A new way to see your world. Online at https://www.microsoft.com/en-us/hololens/hardware. Accessed on February 2, 2023.

Milgram, P., and K. Fumio, K. (1994). "A Taxonomy of Mixed Reality Visual Displays." IEICE Transactions on Information and Systems, online at http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.102.4646&rep=rep1&type=pdf. Accessed on February 28, 2023.

Nikolic, D., Jaruhar, S., and Messner, J. I. (2011) "Educational Simulation in Construction: Virtual Construction Simulator." Journal of Computing in Civil Engineering, Vol. 25, No. 6, 2011, pp. 421–429.

Parveaua, M., Addaa, M. (2018). 3iVClass: a new classification method for virtual, augmented and mixed realities. Proceedings of Computing Science, Vol. 141, pp. 263–270.

Unity Technologies (2023). Unity for multiplatform. Online at https://unity.com/solutions/multiplatform. Accessed on January 10, 2023.