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EVALUATING THE USABILITY AND LEARNING IMPACT OF HOLOLENS 2 IN REVIT EDUCATION: A CASE STUDY IN DIGITAL GRAPHICS II

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ABSTRACT: Traditional 2D screens and static 3D modeling tools can limit students' understanding of spatial relationships and design intent in architecture, engineering, and construction (AEC) education. This limitation poses challenges in Building Information Modeling (BIM) courses that rely on platforms like Autodesk Revit. To address this, the present study evaluates the usability and learning impact of Microsoft HoloLens 2, an advanced Mixed Reality (MR) headset, in a Digital Graphics II course.
Students first reviewed their Revit models on desktop computers and then explored the same models using the HoloLens 2. After the experience, they completed a 15-item questionnaire assessing ease of use, interaction effectiveness, visual clarity, technical challenges, and learning outcomes.
Most participants found the device intuitive and effective, citing gesture control and real-world model overlay as key benefits. Some reported challenges with control precision and expressed a need for more training. Technical issues were minimal.
Overall, the study suggests that MR technology can enhance spatial comprehension and engagement, bridging the gap between digital modeling and real-world application. Despite a small sample size, the findings contribute to the growing literature on MR in AEC education and highlight the potential for broader implementation.

1. INTRODUCTION

In architecture, engineering, and construction (AEC) education, Building Information Modeling (BIM) software like Autodesk Revit is essential for developing students' spatial visualization, design comprehension, and construction planning skills. However, traditional 2D screens and static 3D views can limit students' ability to fully understand spatial relationships, scale, and construction sequencing. Recent advancements in Augmented Reality (AR), particularly devices like Microsoft HoloLens 2, offer innovative approaches to enhance visualization and interaction with digital models, bridging the gap between digital design and real-world application (Adams et al. 2022; Tan et al. 2022).
Augmented Reality (AR) is a technology that overlays digital content (such as 3D models, text, and graphics) onto the real world, enhancing users' perception and interaction with their surroundings (Azuma 1997; Foroughi Sabzevar et al. 2023). AR is widely used in various fields, including education, healthcare, manufacturing, and architecture, to provide interactive and immersive experiences (Billinghurst et al. 2015). In AEC education, AR facilitates real-time visualization of building models, and spatial analysis, thereby improving learning outcomes(Verdelho Trindade et al. 2023).
Mixed Reality (MR), a more advanced extension of AR, seamlessly merges the physical and digital worlds, allowing real-time interaction between users and virtual objects in a three-dimensional environment. Unlike AR, which simply overlays information, MR enables users to manipulate holographic models that respond

to their surroundings. This technology leverages spatial awareness, depth perception, and gesture-based interactions, making it a powerful tool for training, simulation, and design visualization (Spitzer et al. 2022). MR is particularly relevant in AEC education, where users can interact with BIM models as if they were physical objects, facilitating a deeper understanding of spatial relationships, construction sequencing, and real-world implementation (Tan et al. 2022).

The Microsoft HoloLens 2 is an advanced Mixed Reality (MR) headset that enables users to interact with holographic digital content in a real-world environment through gesture control, eye tracking, and voice commands (Spitzer et al. 2022). It features improved ergonomics, a wider field of view, and enhanced tracking capabilities compared to its predecessor, making it particularly effective for training, design visualization, and collaborative tasks in AEC education (Tan et al. 2022). By allowing students and professionals to interact with BIM models, and spatial designs in real-time, HoloLens 2 bridges the gap between digital design and physical implementation (Urban et al. 2022). (Tan et al. 2022) conducted a systematic review highlighting that MR technologies provide visual, immersive, and interactive environments, significantly enhancing learning outcomes in AEC education. (Birt and Cowling 2017) found that MR can promote collaborative learning in architectural engineering design by allowing multiple users to engage with 3D models simultaneously, fostering better communication and teamwork. Furthermore, (Urueña et al. 2024) emphasizes the potential of HoloLens 2 in real-time visualization and interaction with digital assets, demonstrating its effectiveness in enhancing AEC education.

Despite the growing interest in MR-based learning, there is limited research on the usability, effectiveness, and challenges of integrating HoloLens 2 specifically into Revit education. Key concerns include ease of use, navigation, interaction methods, visual clarity, and learning impact. Additionally, the extent to which HoloLens 2 enhances student engagement, comprehension, and usability in an academic setting remains unclear.

This study aims to evaluate the usability and learning effectiveness of HoloLens 2 in a Digital Graphics II course, where students use Revit to create architectural sketches and 3D model visualizations. By assessing user experience, interaction challenges, and educational impact, this research will offer valuable insights into the potential of HoloLens 2 for enhancing Revit tutorials and inspiring students.

2. METHODOLOGY

This study employs a mixed-methods research design to assess the usability and learning impact of the HoloLens 2 in the Digital Graphics II course, where students learned to use Autodesk Revit to create architectural sketches and visualize 3D models. A total of 15 students participated in the study, selected through convenience sampling from those enrolled in the course. Ethical considerations were addressed through voluntary participation, confidentiality assurances, and institutional approval. The findings from this study provide valuable insights into the effectiveness of the HoloLens 2 in supporting Revit-based learning and highlight areas for further improvement in MR-enhanced educational environments.

2.1 Experimental Procedure

During the Digital Graphics II course, students learned how to create a Building Information Modeling (BIM) model for a two-story office building using Autodesk Revit on desktop computers. They followed a textbook and instructional videos provided by the instructor over a 12-week period, with their progress evaluated weekly. Through this process, students gained hands-on experience and foundational knowledge of BIM. In the remaining weeks leading up to the end of the term, students were given 2D drawings of a one-story school building as their final project and were required to create a BIM model based on those drawings. The model included architectural components and furniture and was adjusted according to BIM Holoview guidelines before being uploaded to the platform. Before submitting their final project, students had the opportunity to view the completed BIM model of the school building using the HoloLens 2 headset through the BIM Holoview platform. The experience was conducted in Table mode, allowing participants to walk around the MR model, interact with it using their fingers, and perform gestures to move, rotate, zoom in, and zoom out. In the MR view, the roof was hidden to enable interior exploration of the building. In this study, Reference mode (full-scale walkthrough) was not used due to classroom space constraints. The experiment followed a structured four-step sequence:

1. **Desktop Review (10 minutes):** Students explored their model on a 2D/3D monitor to recall its components and layout.
2. **Basic Instructions (1 minute):** Students received brief guidance on wearing the device and using gestures to interact with the model, zooming, rotating, and moving it vertically. They were also encouraged to walk around the model for a more immersive viewing experience.
3. **HoloLens 2 Interaction (3 minutes**): While students viewed the model, the instructor reminded them how to use gesture-based navigation (e.g., zoom, rotate, move) and encouraged them to walk around the model for a full spatial exploration.
4. **Post-Interaction Survey (10 minutes):** Students completed a questionnaire designed to assess usability and learning outcomes. The survey included 15 questions addressing ease of use, visual clarity, interaction effectiveness, technical challenges, and learning impact. Additional open-ended comments were also collected.

Figure 1 shows a student interacting with a Revit model using Microsoft HoloLens 2 during the experiment conducted in the Digital Graphics II course. Figure 2 displays the Mixed Reality (MR) model generated from the student's project, as visualized through the HoloLens 2.

Figure 1: Student interaction with a Revit model using HoloLens 2

Figure 2: MR model visualized through the HoloLens 2

2.2 Questionnaire Development

The 15-item questionnaire used in this study was self-designed to explore students' experiences using the HoloLens 2 in the Digital Graphics II course. It was structured around five key dimensions informed by usability and learning research: (1) ease of use, (2) visual clarity, (3) interaction effectiveness, (4) technical issues, and (5) learning impact. The development drew on established principles in usability evaluation (ISO 2018; Nielsen 1994) and prior AR/MR education studies.

The questionnaire included both multiple-choice and open-ended items to capture quantitative trends and detailed qualitative feedback. To enhance content validity, it was reviewed by two academic experts—one specializing in AEC education and the other in human-computer interaction and mixed reality. Although formal psychometric testing (e.g., factor analysis, reliability analysis) was not performed due to the small sample size (N=15), the instrument functioned as an exploratory tool for identifying patterns in student responses and user experiences. This limitation is acknowledged, and future studies should aim for statistical validation with larger sample sizes to strengthen generalizability.

Questions 1 through 14 are presented in Tables 1–5. The final open-ended item (Question 15) is discussed in Section 3.6. The overall goal of the questionnaire was to assess students' perceptions of MR usability, model clarity, feature effectiveness, and the learning value of HoloLens 2 integration in Revit education.

3. RESULTS AND DISCUSSIONS

3.1 General Experience and Ease of Use

The first category of questions assessed participants' general experience with AR/MR and HoloLens 2, as well as the ease of use of the HoloLens 2. The results indicate that the majority of participants were new to both AR/MR and HoloLens 2, with only 20% (3 out of 15) having prior AR/MR experience and just 7% (1 out of 15) having used HoloLens 2 before. Despite this, 27% (4 out of 15) found the device ‘very comfortable’ to wear, with 60% (9 out of 15) rating it as ‘comfortable’, while only 13% (2 out of 15) felt discomfort. Interaction using gestures was generally smooth, with 60% (9 out of 15) finding it Easy or ‘very easy’, while 20% (3 out of 15) found it difficult, and 20% (3 out of 15) were ‘neutral’.

Regarding the ability to zoom, rotate, and move the model, 40% (6 out of 15) reported having complete control, while 33% (5 out of 15) mostly managed well, 20% (3 out of 15) faced some difficulties, and 7% (1 out of 15) was ‘neutral’.

In terms of navigation, 40% (6 out of 15) felt ‘mostly’ in control, 13% (2 out of 15) felt ‘completely’ in control, while 20% (3 out of 15) felt ‘a little’ in control, and 27% (4 out of 15) remained ‘neutral’. Overall, these findings suggest that most first-time users adapted well to the HoloLens 2, but some required additional guidance to navigate and interact more effectively. The results are shown in Table 1.

Table 1: Ease of Use

#	Question	Response Options	Number of Responses (N=15)
1	Have you used Augmented Reality or Mixed Reality before?	Yes	3
		No	12
2	Have you used HoloLens 2 before?	Yes	1
		No	14
3	How comfortable were you while wearing the HoloLens 2?	Very Uncomfortable	1
		Uncomfortable	1
		Neutral	0
		Comfortable	9
		Very Comfortable	4
4	How easy was it to interact with the model using gestures or voice commands?	Very Difficult	0
		Difficult	3
		Neutral	3
		Easy	5
		Very Easy	4
5	Were you able to easily zoom, rotate, and move around the model?	Not at All	0
		A Little	3
		Neutral	1
		Mostly	5
		Completely	6
6	Did you feel in control while navigating the model?	Not at All	0
		A Little	3
		Neutral	4
		Mostly	6
		Completely	2

3.2 Visual Clarity

The second category of questions asked about the visual clarity of the HoloLens 2. The results indicate that the visual representation of the model was perceived positively by most participants. A significant 60% (9 out of 15) rated the model as ‘very clear’, while 27% (4 out of 15) found it ‘clear’, suggesting that the display quality was generally well-received. Only 7% (1 out of 15) reported ‘blurry’ visuals, and 7% remained ‘neutral’, with no participants selecting ‘very blurry’. Regarding model rendering quality, 87% (13 out of 15) reported ‘no issues’ or no ‘issues at all’, Only 7% noticed ‘a few issues’, while another 7% remained ‘neutral’, and no one reported major rendering problems. These findings suggest that the HoloLens 2 effectively delivers high visual clarity and stable rendering, though minor variations in perception may be influenced by individual user experience or environmental factors. The results are shown in Table 2.

Table 2: Visual Quality

#	Question	Response Options	Number of Responses (N=15)
7	How clear was the visual representation of your model in the HoloLens 2?	Very Blurry	0
		Blurry	1
		Neutral	1
		Clear	4
		Very Clear	9
8	Did you notice any issues with the quality of the model rendering (e.g., missing parts, lag, or distortion)?	Yes, Many Issues	0
		Yes, A Few Issues	1
		Neutral	1
		No Issues	8
		No Issues at All	5

3.3 Interaction Effectiveness

The third category of questions was about the interaction effectiveness of the HoloLens 2. The results indicate that most participants found the HoloLens 2 features useful for evaluating their Revit model. 53% (8 out of 15) rated the features as 'mostly' helpful, while 33% (5 out of 15) found them 'completely' helpful, meaning that 86% of users had a positive experience. Only 7% (1 out of 15) rated the features as 'a little' helpful, and another 7% remained 'neutral', with 0% selecting 'not at all'. This suggests that the HoloLens 2 effectively supports model evaluation, though some users may need more guidance or feature improvements. Regarding the most useful features, 'gesture control' was the most favored, with 73% (11 out of 15) of participants selecting it. 40% (6 out of 15) found the 'ability to overlay models in a real-world environment' useful, while 20% (3 out of 15) valued 'spatial awareness'. These findings indicate that gesture-based interactions are a strong point of the HoloLens 2, but enhancing spatial awareness features could further improve user experience. The results are shown in Table 3.

Table 3: Interaction Effectiveness

#	Question	Response Options	Number of Responses (N=15)
9	Did the HoloLens 2 features help you effectively evaluate your Revit model?	Not at All	0
		A Little	1
		Neutral	1
		Mostly	8
		Completely	5
10	Which features did you find most useful during your review? (Select all that apply)	Gesture control	11
		Spatial Awareness	3
		Ability to Overlay Model in a Real-World Environment	6

3.4 Technical Issues

The fourth category of questions was about technical issues. The results indicate that no participants (0%) reported technical problems while using the HoloLens 2, with all 15 out of 15 (100%) stating 'no issues'. This suggests that the device functioned smoothly with no major tracking, software, or hardware glitches affecting usability. When asked about potential improvements, responses varied across different aspects of the experience. Some participants emphasized the need for more time to learn the controls and use the device effectively, while others suggested wider lenses for an improved field of view. One participant mentioned lag when moving and looking, though they noted it was not a significant problem. Other feedback included a request for more HoloLens-based projects, easier object interaction (grabbing/accessing corners), and the ability to experience the model from inside the building. However, some participants explicitly stated they thoroughly enjoyed the experience and found it to be positive overall. The results are shown in Table 4.

Table 4: Technical Issues

#	Question	Response Options	Number of Responses (N=15)
11	Did you encounter any technical problems while using the HoloLens 2? (e.g., tracking issues, software glitches, discomfort)	Yes No	0 15
12	If you could change one thing to make the experience better, what would it be? • *"More time to figure out how to use it."* • *"I thoroughly enjoyed the experience."* • *"Make lens more wide."* • *"I wish I could use it a while longer to use the functions it offers."* • *"Easier to grab/access the corner."* • *"Maybe a walkthrough inside the building."* • *"More Projects done involving the HoloLens."* • *"It was a good experience."* • *"When moving and looking it was a little laggy, but it was not a big problem."* • *"I would probably have liked to learn about the controls previously so it would have been easier to use."* • *"I could be in the building."*		

3.5 Learning Impacts

The last category of the questions was about learning impacts. The results indicate that using the HoloLens 2 had a positive impact on participants' understanding of their Revit models. 67% (10 out of 15) stated that it 'made it better', while 13% (2 out of 15) found it 'made it much better'. Only 13% (2 out of 15) reported 'no impact', and 0% felt it worsened their understanding, suggesting that the HoloLens 2 is an effective tool for enhancing spatial comprehension in model visualization. Regarding recommendations for future use, 100% of participants supported using the HoloLens 2 for similar model reviews. Specifically, 67% (10 out of 15) responded 'definitely yes', while 27% (4 out of 15) selected 'probably yes'. No one selected 'neutral', 'probably not', or 'definitely not', indicating strong approval for its continued use in model evaluation. The results are shown in Table 5. It is important to note that one participant did not respond to this section.

Table 5: Learning Impact

#	Question	Response Options	Number of Responses (N=15)
13	How did using the HoloLens 2 impact your understanding of your Revit model?	Made it Much Worse Made it Worse No Impact Made it Better Made it Much Better	0 0 2 10 2
14	Would you recommend using the HoloLens 2 for similar model reviews in the future?	Definitely Not Probably Not Neutral Probably Yes Definitely Yes	0 0 0 4 10

3.6 Additional Comments

The final question (15. Please share any additional feedback or suggestions for improving the HoloLens 2 experience) invited participants to provide open-ended feedback. Overall, the comments reflected a generally positive experience, with many students expressing enthusiasm for the technology. Responses such as "It was awesome," "Very cool," and "Love my major" demonstrated high levels of excitement and engagement. However, several participants noted a lack of prior instruction or training, with remarks like "I wish I knew how to control it better" and "I wish I had gotten more experience with using this tool." These responses suggest that providing more structured guidance or tutorials beforehand could improve user confidence and interaction effectiveness. One participant also mentioned initial difficulty with the system recognizing grabbing actions, though this improved over time, indicating that interaction responsiveness may benefit from further refinement. In summary, while students enjoyed the experience, more comprehensive onboarding, and minor technical adjustments could enhance overall usability and engagement.

3.7 Overall Interpretation of Results

Overall, the results demonstrate that Microsoft HoloLens 2 is a highly effective tool for enhancing student engagement and understanding in Revit-based construction education. Despite the majority of participants having no prior AR/MR experience, most adapted quickly and reported high levels of ease of use and satisfaction. Visual clarity and model rendering quality were consistently rated positively, and gesture-based interaction stood out as particularly beneficial. Importantly, students reported that using HoloLens 2 improved their understanding of spatial relationships within their models, and all participants recommended its continued use. The absence of significant technical issues further confirms the device's reliability. These findings suggest that HoloLens 2 can successfully bridge the gap between theoretical modeling and real-world spatial comprehension, positioning MR as a valuable addition to construction education.

4. RESEARCH CONTRIBUTION AND NOVELTY

While numerous studies have explored the usability and educational potential of AR/MR/VR technologies in architecture, engineering, and construction (AEC) education, this study offers a focused and original contribution by examining the use of the HoloLens 2 specifically within the context of a Digital Graphics II course centered on Autodesk Revit. Unlike generalized or simulation-based MR applications, this research investigates how MR integration supports students in transitioning from traditional desktop-based 3D modeling to immersive, spatially anchored interactions in a mixed-reality environment.

The study targets first-time MR users and explores how initial exposure to MR technology influences students' comprehension, usability perceptions, and overall engagement including their motivation and willingness to adopt the technology in future educational contexts. The structured design of the experiment (desktop modeling → MR interaction → survey) paired with the classification of student feedback into five dimensions (ease of use, visual clarity, interaction effectiveness, technical issues, and learning impact) provides a replicable and structured framework for assessing the role of MR in early-stage design education. Collectively, these elements distinguish this study as a novel contribution to the growing body of literature on MR applications in architectural and construction education, particularly in foundational courses where hands-on exploration, spatial visualization, and early exposure to innovative tools are critical to student success and long-term engagement.

5. LIMITATIONS

One of the primary limitations of this study is the small sample size (N=15), which falls below the recommended threshold for quantitative user testing. However, prior research supports the effectiveness of small groups in usability studies. According to (Virzi 1992), approximately 80% of usability problems can be identified with just four or five participants, and adding more participants yields diminishing returns in discovering new issues. Similarly, (Nielsen 1994) argues that qualitative user testing can provide valuable insights even with small sample sizes. While this justifies the study's exploratory nature, future research should involve larger participant groups to provide more statistically generalizable results and to validate the impact of HoloLens 2 on learning outcomes in Revit-based construction education.

Additionally, while the study gathered subjective feedback on visual clarity and usability, it did not include quantitative measurements of critical hardware parameters such as field of view (FOV), resolution, latency, or spatial tracking accuracy. These variables are known to significantly influence user immersion, interaction quality, and overall MR experience. The lack of controlled environmental conditions and hardware calibration may have introduced variability in student responses, particularly in areas like visual clarity and gesture precision. Future research should consider standardizing environmental settings (e.g., lighting, spatial layout) and documenting hardware performance metrics to improve the comparability, replicability, and technical rigor of MR usability studies.

Moreover, while this study captured valuable subjective feedback regarding students' perceived learning improvements, it did not control for prior experience in reviewing or working with Revit models, an important factor that may have influenced student perceptions. Although all participants received 12 weeks of structured instruction in Revit and had their progress evaluated weekly, individual differences in prior software experience, confidence, or modeling skills were not explicitly measured. Future studies should consider grouping participants by expertise level to better understand how Mixed Reality affects learning for novice versus advanced users. Additionally, incorporating objective metrics such as assignment performance, knowledge retention tests, or system usage logs would strengthen the evaluation of learning outcomes and enable a more rigorous comparison between MR-assisted and traditional learning methods.

6. CONCLUSION

This study evaluated the usability and learning impact of the HoloLens 2 in a Digital Graphics II course, where students used Mixed Reality (MR) technology to review and interact with Revit models. The results suggest that HoloLens 2 enhances learning by providing an immersive and interactive experience that improves students' understanding of spatial relationships, model components, and design visualization. Most participants found the device intuitive and effective, with gesture control and real-world model overlay identified as particularly beneficial features. Some students reported minor challenges with control precision and emphasized the need for additional training prior to independent use. Although technical issues were minimal, the study underscores the importance of structured onboarding and improved interaction feedback to maximize usability. Overall, these findings indicate that MR technology can help bridge the gap between digital modeling and real-world application, offering a more engaging and practical learning experience in architectural education. While the small sample size limits generalizability, the insights contribute to the growing body of literature on AR and MR in construction education. Future research should include larger participant groups, assess long-term learning retention, and refine MR-based instructional strategies to enhance both usability and educational effectiveness.

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