International Journal for Multidisciplinary Research (IJFMR)
E-ISSN: 2582-2160 ● Website: www.ijfmr.com ● Email: editor@ijfmr.com

E-module in Real-Time Rendering and Virtual Reality: Impact to Students Cognitive and Skill Performance

Glay Vhincent C. Sumaylo[1], Michael Art R. Napoles[2]

[1]Student, Department of Technology Teacher Education, MSU – Iligan Institute of Technology
[2]Faculty, Department of Technology Teacher Education, MSU – Iligan Institute of Technology

Abstract:
An e-module in real-time rendering and virtual reality using sketchup and enscape is created using the software kotobee. It aims to assess the acceptability and its impact to student's cognitive and skill performance. The use of e-module as a teaching tool aligns with Education 4.0's flexible learning approach. The study is participated by 38 students. They were divided into two groups. The control group who will undergo conventional way of teaching in learning rendering and the experimental group who will utilize the e-module in learning real-time rendering and virtual reality. Results of this study shows that there is a significant difference between pre-test and post-test scores in both groups. It also shows that the mean difference between test scores in the experimental group is higher than the control group by 0.79 points. This implies that the scores of the respondents in the experimental group have improved more than in the control group making the e-module to have a positive impact to student's cognitive abilities. To assess the skill performance of the students in the control and experimental group, the rendered output submitted by the students are evaluated by experts in rendering using enscape. Results shows that the evaluation output mean score of students in the experimental group, which is 15.61, is higher than that in the conventional group with 13.40. This shows that those students in the E-module group have better output than those in the conventional group. This implies that the E-module has a positive impact on student skill performance.

Keywords: Real-Time Rendering, Virtual Reality, Enscape, Sketchup, Kotobee, E-module, Cognitive Abilities, Skill Performance, Technology Acceptance Model, Online Distance Learning, Self-paced Learning

1. Introduction

The implementation of architectural and structural layouts using Computer-Aided Drawing is incorporated into various courses as part of the curriculum, aligning with the demands of the fourth industrial revolution. Industry 4.0 encompasses the seamless integration of modern smart technologies into traditional manufacturing and industrial processes, featuring elements such as virtual and augmented reality, advanced engineering like 3D modeling, printing, and rendering (McKinsey, 2022).

Various design software such as AutoCAD and SketchUp are utilized to enable students to create designs for residential buildings and establishments. While these tools effectively convey a designer's ideas to

clients and users, they have limitations in presenting images realistically. Real-time rendering addresses this limitation. Enscape, a widely used real-time rendering and virtual reality plugin in the field of architecture, does not demand detailed system requirements and is user-friendly for editing and setting up 3D environments. It is also compatible with SketchUp, a primary 3D modeling software used by Drafting Technology students.

In a study conducted by Peter Zeile et al. (2019) on Virtual Design and BIM in Architecture and Urban Design, Enscape was employed to visualize urban environments in virtual reality and construct realistic urban settings for research. Even for those new to virtual reality, handling models in Enscape is reported to be straightforward.

Despite the advantages of using Enscape, there are limited resources available for learning real-time rendering with this software. Students often rely on video tutorials available on YouTube, which may lack a detailed rendering process to provide a proper sequence in using Enscape. To bridge this gap, an instructional material would be valuable to guide students in acquiring knowledge in the field of real-time rendering and virtual reality

We are entering a new paradigm in the field of learning known as Education 4.0. This approach has gained popularity due to its methodical alignment with the Industry 4.0, promising to transform the future of education through advanced technologies (Darshan Vyas, 2021). A key aspect of this paradigm shift is the adoption of modular degrees, replacing the traditional one-shot approach.

In a study conducted by Rawashdeh et al. in 2020 on the advantages of E-modules in university education, it was found that E-modules provide convenience by offering students opportunities to access learning anytime and anywhere. Even outside the physical classroom, E-modules employ various mediums such as texts, videos, audio, collaborative sharing, and interactive visuals to keep students fully engaged during the learning process. The integration of E-modules also allows for minimal supervision from teachers.

This study developed an e-module on real-time rendering and virtual reality using Kotobee, a software program, and an online publishing platform designed for interactive ebooks. Interactive content created through Kotobee can be accessed by any EPUB 3-compliant reader, in addition to the Kotobee Reader. The platform offers features such as emulating outcomes on various platforms and devices, converting PDFs to EPUB, and customizing the appearance of your ebook apps.

Accessible to users of all skill levels, Kotobee provides content in both online and offline modes, retaining interactive components and facilitating learning at any time and place. The Kotobee platform is dedicated to enhancing educational experiences, loaded with components that transform conventional learning into blended learning (Prad Duraisamy, n.d.). With Kotobee, the researcher aims to provide students with an e-module in real-time rendering and virtual reality, accessible on both online and offline platforms anytime and anywhere.

Statement of the Problem

This study aims to assess the acceptability and effectiveness of the E-Learning Module in Real-time Rendering and Virtual Reality. Students learn real-time rendering to enhance the quality and visualization of their designs created in CAD software. However, a significant challenge in learning this is the lack of resources. Currently, there is no existing module that specifically addresses the flow of rendering. As a result, students often rely on online video tutorials, which lack an organized instructional flow for performing real-time rendering.

Research Objectives

The main focus of this study is to develop and assess the acceptability of the e-module in real-time rendering and visual reality using Enscape. The study made use of the interactive e-book production and digital publishing platform Kotobee. This is designed to meet the following objectives:

1. Evaluate the acceptability of the e-module in real-time rendering and virtual reality.
2. Design an e-module in real-time rendering and virtual reality.
3. Test the e-module to the Drafting Technology students.
4. Evaluate performance of the students in the pre-test, post-test and rendered output of the control and experimental group.

3. Literature Review

E-Module in Education 4.0

Education 4.0, a modern approach to learning, integrates advanced technologies and innovative strategies to prepare students for the dynamic 21st-century world (Darshan Vyas, 2021). The focus is on providing a personalized and adaptable learning environment, utilizing emerging technologies like AI, virtual reality, 5G, and more. Education 4.0 shifts from traditional teaching to a digital style, emphasizing achievement in life over test scores, individualized instruction, technological proficiency, and ongoing personal development. It enables students to learn anytime, anywhere, with interactive tools and hands-on experiences.

In this era, digital teaching resources, especially E-Learning Modules, play a crucial role (Rini & Cholifah, 2020). Studies show that digital learning positively impacts students' results and motivation, making them more engaged with instructional resources like e-modules and video tutorials (Chen & Liu, 2017). Teachers must consider the e-module as a learning medium to meet Education 4.0 requirements, given its adaptability to technological advancements (Cahyaningrum & Jaenudin, 2020).

While e-learning modules gained prominence during the COVID-19 pandemic, they remain integral to Education 4.0, contributing to the evolving education system. The development of interactive e-modules in real-time rendering and virtual reality aligns with the demands of this new teaching and learning paradigm.

Enscape as a real-time rendering and virtual reality software

Enscape is a leading virtual reality, rendering, and visualization program in the field of engineering and architecture, streamlining design and visualization workflows into a single process. It is compatible with various CAD programs, such as Revit, Rhino, ArchiCAD, Vectorworks, and SketchUp. Enscape offers

immediate connectivity to design software, allowing real-time visualization of model changes with just one click. It efficiently handles elements like grass and light, producing visually appealing images with minimal effort. Used in virtual reality, Enscape allows clients a 360-degree view of designs and facilitates communication with architects, enabling real-time changes and automatic updates in different CAD file for accurate project cost calculations.

Interactive e-module using Kotobee

Kotobee is a software program and online publishing platform for interactive ebooks. Kotobee can access interactive contents that can be read by any EPUB 3 compliant reader in addition to Kotobee Reader. It contains features like emulating the outcome on various platforms and devices, converting PDF to EPUB, and changing the look and feel of your ebook apps. For users of all skill levels, Kotobee is an intuitive platform. It offers content using Kotobee in both online and offline modes while keeping the interactive components, enabling learning to happen whenever and wherever. The Kotobee platform is committed to elevating your educational experience and is loaded with components that can change conventional learning into blended learning (Prad Duraisamy, n.d)

Interactive e-modules are extensively utilized across various academic levels. In a study by James Andrew Caltrava (2022), an e-learning material for Application in Physical Science was created using Kotobee. The study assessed the effectiveness of this interactive e-learning module through expert and teacher evaluations, focusing on content, instructional quality, and technical aspects. With the rise of remote learning in the new normal, the interactive e-learning module, involving 13 topics related to the application of physical science, proved highly acceptable according to the criteria. The results suggested that such modules, developed using Kotobee, can significantly enhance both student knowledge and skill acquisition while improving teachers' ability to facilitate learning.

Kotobee had positive feedback from previous researchers that aimed to develop an interactive e-learning module. Features such as its interactivity would maintain both in online and offline modality gives convenience to users undergoing distance and self-paced learning. Thus, developing an interactive e-learning module for real-time rendering and virtual reality using enscape can be engaging with the use of Kotobee software.

Virtual Reality in Engineering, Architecture and Design

Various Virtual Reality Technologies are utilized in architecture and design, addressing limitations in conveying design ideas to clients. While sketches can express early-stage concepts, current CAD software like Revit, AutoCAD, Rhino, Vectorworks, and Sketchup enables the transition from a sketch to a 3D model, enhancing understanding across different fields. Despite technological advancements, there are constraints in achieving a realistic view of a 3D model transferred to the virtual world for detailed design applications, as noted by Rui de Klerk et.al in 2019.

Virtual Reality (VR) is transforming the approach of architects and designers by offering immersive experiences for clients. This technology allows real-time visualization of designs in a three-dimensional environment, facilitating quick adjustments and interactive design revisions. VR enhances communication between architects and various stakeholders, including clients, contractors, and designers, leading to

improved accuracy and reduced waste. Additionally, it provides designers with the opportunity to explore new ideas and test various scenarios before finalizing a design.

The Bill of Quantities (BQ) is a traditional building practice, utilized in larger construction projects to list the necessary supplies and labor. However, a study by Jordan Davidson et.al in 2020 explores the integration of Virtual Reality (VR) and Building Information Modeling (BIM) during the design process to enable real-time creation of the BQ. The BQ, once essential, faces challenges due to its complexity, time-consuming nature, and the increasing popularity of unconventional procurement techniques. Additionally, inconsistencies may arise when clients become involved in the process.

Bob Borson (2014) emphasizes the client's active participation in the design process to address potential disagreements in material choices. Combining Building Information Modeling (BIM) and Virtual Reality (VR) offers a solution by involving clients in a virtual world, enabling decisions on elements like windows, doors, and paint. Integrated with Revit, BQ immediately updates, providing clients a clear understanding of project expenses. This ensures an up-to-date, accurate, and comprehensible BQ, enhancing client satisfaction.

Applying VR to 3D design enhances client visualization, aiding in understanding costs and creating a virtual environment with various features. Integrating VR into an e-learning module can educate students on setting up designs in a full 3D virtual environment.

3D modeling, pivotal in architecture, reduces time and costs. The interactive e-module, developed using the ADDIE model, aligns with modern education trends, emphasizing personalized learning in Education 4.0. Enscape software enhances 3D modeling skills, and experiential learning, based on Kolb's theory, improves engagement. Kotobee contributes to blended learning, reflecting the evolving landscape of education and design practices for a dynamic learning experience in the digital age.

4. Methodology

This section gives an outline of the research method used by the researcher in the study conducted.

Research Design

The research method utilized in this study is the quasi-experimental design, allowing the comparison of different groups with and without the intervention of the e-module. In contrast, traditional experimental designs involve the assignment of participants to groups. By employing quasi-experimental techniques, researchers can determine which factors are causally related to one another. These designs essentially use pre-existing groups or specific treatments to examine the effects of an independent variable on a dependent variable. In this study, the independent variable is the e-module in real-time rendering and virtual reality, and the dependent variables are the students' cognitive and skill performance.

In implementing the quasi-experimental research design in this study, participants are grouped into two. The first group is the control group, which undergoes the conventional method of teaching in learning real-time rendering and virtual reality. On the other hand, the second group is labeled as the experimental group, where there will be an intervention of the developed e-module in their learning real-time rendering and virtual reality.

Research Participants

This study employs a quasi-experimental design and includes a total of thirty-eight (38) participants. The individuals taking part in this study have previously acquired skills in 3D modeling and design through courses such as CAD Architectural Drafting, Civil Drafting, and Visual Graphic Design. These foundational courses are essential prerequisites for understanding real-time rendering and virtual reality. To ensure a diverse representation, participants are grouped into two groups, each consisting of nineteen (19) members with both high-performing and low-performing students. Both groups undergo a pre-test to assess their prior knowledge of real-time rendering and virtual reality. This pre-test helps establish their initial performance levels before introducing the e-module for real-time rendering and virtual reality.

Research Instruments

Research Instrument refer to various techniques employed by the researcher to collect data and gain insights from the respondents. The first section of the survey questionnaire focuses on the demographic profile of the respondents, which includes their name, gender, age, previous GPA, college, course, and combined family monthly income.

To assess the cognitive impact of the e-module on students, multiple-choice questions are used as both pre-test and post-test questions. To ensure the validity and reliability of the included questions, a validation process was conducted based on de Guzman et al.'s Assessment of Learning 1. Subsequently, statistical analysis was employed to ensure the consistency and accuracy of the research instrument.

To assess the impact of the e-module on students' skill performance, a rubric was formulated to evaluate the rendered output of the participants. Expert evaluators based their scores on the criteria provided in the rubrics.

The e-module in real-time rendering and virtual reality undergoes evaluation by experts in the field to ensure its validity and reliability in providing information about these emerging technologies. The criteria from the Department of Education's Learning Resources Management and Development System (LRMDS) Educational Soundness General Evaluation Checklist were utilized in this evaluation (DepEd, 2009).

Lastly, in assessing the acceptability of the e-module in real-time rendering and virtual reality. The Technology Acceptance Model (TAM) proposed by Davis in 1989 were utilized. This includes students' insight of the e-module in terms of: Perceived Usefulness, Perceived Ease of Use, Behavioral Intention to Use and User's Willingness. The technology acceptance model used by the researcher in this study as a way to collect data and conduct a study evaluation for the acceptability of the e-module. It is designed to obtain information on the efficacy of the e-learning module as an essential source of information on real-time rendering and virtual reality.

5. Results and Discussions

This chapter presents the analysis and interpretation of data gathered from thirty-eight (38) participants in this study, divided into two groups: nineteen (19) students in the Control group and nineteen (19) students in the experimental group.

Table 1. Significant difference between pre-test and post-test scores of control and experimental groups | n=19

Groups	Type of Test	Mean Score	Standard Deviation	Mean Difference	t-statistics (p-value)
Control Group	Pre-test	11.3684	3.1484	7.8421	10.7938* (0.000)
	Post-test	19.2105	2.8979		
Experimentalx Group	Pre-test	12.6842	3.1279	8.6316	10.8008* (0.000)
	Post-test	21.3158	2.2374		

*Note: * p-value is <0.05 which means significant*

Table 1 displays the significant difference between pre-test and post-test scores comparing the conventional and experimental group. Using the independent sample t-test, Table 3 reveals that there is a significant difference between pre-test and post-test scores between the control and experimental group. Mean difference between test scores in the experimental/treatment group is higher than the conventional group by 0.79 points. This implies that the scores of the respondents in the module group have improved more than in the conventional group. This result is similar to findings of the systematic review of Liu et al., (2016), that blended teaching which includes the utilization of an e-module found to be more effective or closely effective compared to face-to-face teaching approach. In a study of Ravat et al., (2021) on comparing blended teaching with traditional teaching for physiotherapy students. Results indicates that the students' academic grades were significantly higher for the orthopedics module during both semesters, demonstrating an average large effect of blended teaching over the face-to-face approach.

The e-module on real-time rendering and virtual reality does not only include text to deliver its lessons; instead, it incorporates video tutorials and animated videos for students to visualize and reflect upon while studying the module. According to Hughes and Roblyer's study (2023), integrating animated videos can have a significant impact on students' motivation to learn, increasing their interest in the specific lesson and influencing their cognitive performance.

In e-module-based learning, students have the option to revisit specific pages where they may have forgotten information and seek clarification for their questions. The e-module on real-time rendering and virtual reality includes audio-visual media, electronic text, and interactive quizzes, enabling students to fully engage in learning through the module. This is supported by Tarigan et al.'s study (2023), where they explored the impact of an interactive digital learning module on students' academic performance and memory retention. Interactive digital learning modules help students improve their comprehension and facilitate meaningful learning by incorporating interactive quizzes for student participation, as well as videos and video tutorials that spark curiosity and motivation, encouraging them to accomplish specific tasks.

Table 2. Descriptive statistics of the respondents' perceptions regarding the perceived usefulness, perceived ease of use, behavioral intention to use and users' willingness to use the e-module in rael-time rendering and virtual reality | n=19

Technology Acceptance Model (TAM)	Median (overall)	Variance (overall)	SD (overall)	Interpretation
Perceived Usefulness	4.00	0.98	0.98	Agree
Perceived Ease of Use	4.00	1.06	1.01	Agree
Unified Theory of Acceptance and Use of Technology (UTAUT)	Median (overall)	Variance (overall)	SD (overall)	Remark
Behavioral Intention to Use	4.00	1.15	1.06	Agree
Users Willingness	4.00	1.36	1.17	Agree

Note: 1.00-1.80 = Strongly Disagree; 1.81 – 2.60 = Disagree; 2.61- 3.40 = Neutral; 3.41 – 4.20 = Agree; 4.21 – 5.00 = Strongly Agree

The overall median result, which is 4.00, indicates a positive perception of the respondents regarding the perceived usefulness of e-modules. Moreover, the overall standard deviation of 0.98 (<1.00) indicates that most of the values are within the range of 0.98 from the mean value. It also shows low variability in data points. Despite undergoing self-paced learning, students still got positive feedback in learning using the e-module. Since there is no existing module in rendering that the participants of this study can refer to guide in performing rendering, Majority of them find the e-module useful which help them improve their skills in real-time rendering. Developing an e-module as a learning guide for student to learning this emerging technology is in support with the Kowitlawakul et al., 2017 statement that the call for online learning and its constant growth in need because of the rising use of e-learning due to technology integration in education to encourage favorable learning outcomes for students. The e-module in real-time rendering and virtual reality got a positive outcome in students' perception on its perceived usefulness. This is similar to the study of Mislinawati and Nurmasyitah, 2018 that students who participated their survey perceived the e-learning module to be useful. The overall median in Table 6, which is 4.00, indicates that the majority of the respondents have positive behavior regarding their intention to use the e-module.

The descriptive statistics shows that most of the respondents agree that learning real-time rendering and virtual reality using the e-module would be easy for them. They generally agree that the e-module is easy

to use, clear, and flexible to interact with. Students quickly became familiar with how to operate the e-module, making it easy for them to use. In general, the overall median of 4.00 shows the positive perception of the respondents regarding the perceived ease of use of e-modules. This implies that this system is easy to use by end-users.

Descriptive statistics reveal that the majority of respondents agree they intend to use the e-module, especially in the future, and most of them also express their willingness to recommend its use in real-time rendering and virtual reality. The overall median in Table 6, which is 4.00, indicates that the majority of the respondents have positive behavior regarding their intention to use the e-module.

Most of the respondents agree that they will use the e-module with their colleagues and by themselves. Moreover, the overall median, which is 4.00, shows a positive perception of the respondents regarding their willingness to use the e-module in real-time rendering and virtual reality.

Table 3. Significant difference in the output score between module and conventional groups. | n=19

Groups	Mean Score	Standard Deviation	Mean Difference	t-statistics (p-value)
Control Group	13.404	0.906	2.210	1.9106 (0.0721)
Experimental Group	15.614	0.783		

*Note: * p-value is ≤ 0.05 which means significant (2-tailed)*

The table above presents the significant difference in the output score between the module and conventional groups. The t-test analysis reveals that there is no significant difference between the output scores of the two groups. Though the mean output scores show that the module group has a higher mean score than the conventional group by 2.21, the difference between these mean scores is not that statistically significant.

Implementing the e-module in the conventional way of teaching can enhance students' performance, although it may not exhibit a significant difference for those students using the conventional method. Nevertheless, it remains an effective approach to increasing students' competency in real-time rendering and virtual reality. This effectiveness is supported by Chen et al.'s 2019 study on the development of an e-learning module to facilitate student learning and outcomes. The self-regulated online module represents an innovative instructional.

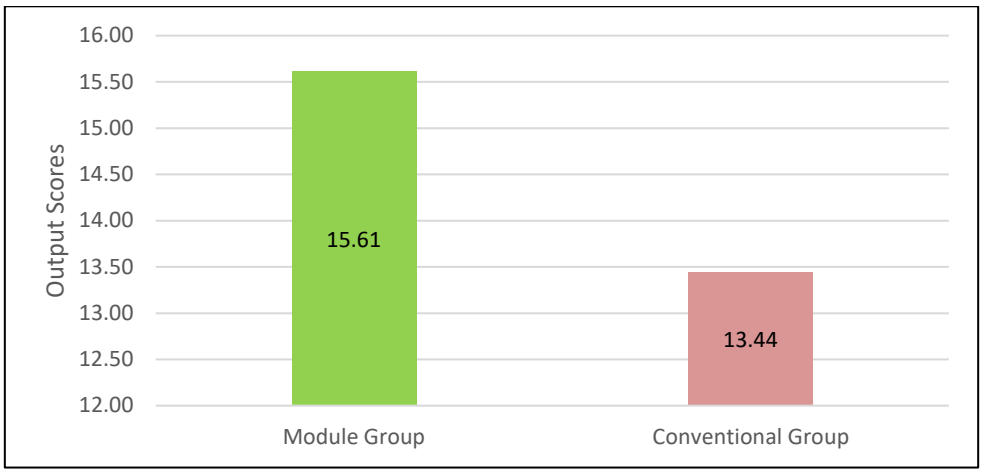

Figure 1. Comparison of output scores between experimental and control groups based on the evaluation of skill performance

As shown in Figure 1, the evaluation output mean score of students in the E-module group, which is 15.61, is higher than that in the conventional group. This shows that those students in the E-module group have better output than those in the conventional group. This implies that the E-module has a positive impact on student skill performance.

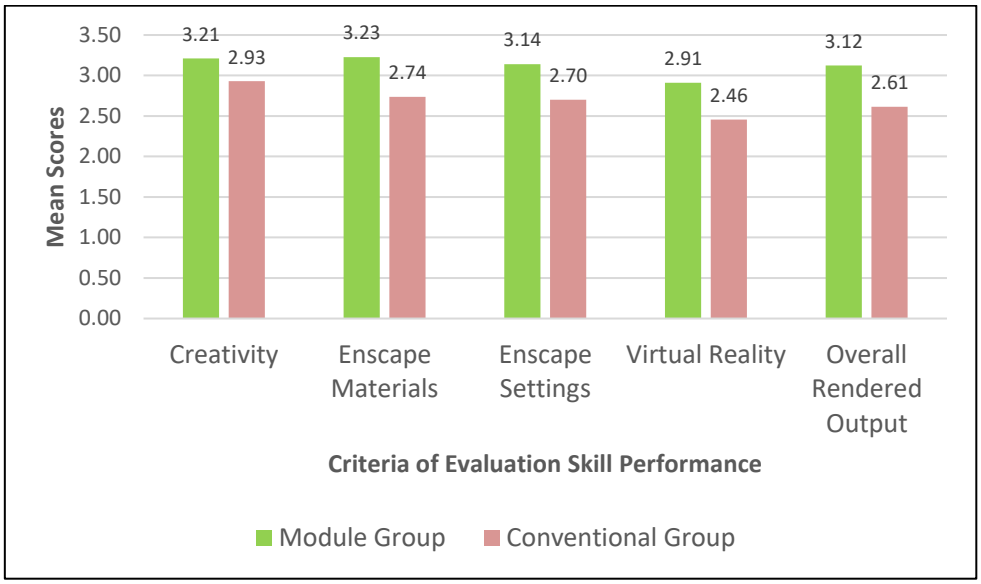

Figure 2. Comparison of mean output scores between control and experimental groups by each criterion of evaluation skill performance

Note: 1.00 – 1.75 = Poor; 1.76 – 2.50 = Fair; 2.51 – 3.25 = Good; 3.26 – 4.00= Excellent

Qualitative feedbacks of the respondents with regards to the e-module in Real-Time Rendering and Virtual Reality

Thematic analysis is a qualitative research technique used to identify, examine, and summarize themes within a dataset (Braun & Clarke, 2006). In this research, participants answered open-ended questions, and thematic analysis was applied to gain insights into their experiences, comments, and challenges in using the e-module.

Participants' feedback on the e-module experience varied across different aspects. Approximately 13% found the use of e-modules in real-time rendering and virtual reality challenging, citing difficulties in learning at their own pace. However, some acknowledged the overall greatness of the experience despite challenges, including extensive reading requirements. A larger portion, 38%, described their experience as good or great, attributing it to good reading comprehension and the enjoyment of re-reading modules. About 13% found the e-module interactive, highlighting engaging activities, especially in real-time rendering and virtual reality, offering a more immersive learning experience than traditional methods. A smaller percentage, 6%, viewed the e-module as an effective way of learning, recognizing its positive impact on their educational journey. Overall, these perspectives showcase the diverse nature of participants' experiences, encompassing challenges, positive engagement, and effectiveness in the learning process.

Participants overwhelmingly commend the e-module, with 38% highlighting its easy accessibility, favoring it over conventional methods for its convenience and readily available information. Additionally, 31% found the e-module instrumental in understanding lessons, attributing its effectiveness to facilitating learning along the way. About 19% appreciated the e-module's immersive and interactive experiences, particularly in real-time rendering and virtual reality, enhancing engagement compared to traditional methods. Another 6% lauded the e-module's well-organized structure, deeming it effective for complex topics. A similar percentage acknowledged its utility in teaching. Overall, feedback underscores the e-module's positive aspects, emphasizing accessibility, helpfulness, interactivity, organization, and teaching efficacy.

When it comes to the impact of the e-module to student’s cognitive abilities, Thirty-one percent found it notably flexible and accessible, emphasizing its positive influence on cognitive abilities by allowing anytime access for information gathering and studying lesson steps. Another 25% emphasized the immersive experiences in real-time rendering and virtual reality, noting enhancements in spatial awareness, visualization skills, critical thinking, problem-solving, memory retention, attention, and focus. Additionally, 25% focused on the e-module's effectiveness, evidenced by improved cognitive abilities indicated through pre-test and post-test score differences. Thirteen percent found it helpful in enhancing skills, contributing to better understanding and improved task output. Lastly, 6% appreciated the aspect of challenging oneself, noting personal improvement through self-imposed challenges. Overall, participants recognize the e-module's positive impact on cognitive abilities, immersive experiences, skills enhancement, and the effectiveness of self-challenges.

Student’s qualitative comments on the most beneficial part of the e-module is there are a significant 25% find the rendering and designing aspect most beneficial, emphasizing its value in learning house design. Another 25% highlight the interactive feature, emphasizing engagement with 3D models for enhanced understanding. Additionally, 25% appreciate the content's organization and revisit ability. Nineteen percent express overall satisfaction with all aspects for their specificity and clarity. Another 19% value the ease of access with just one click. Lastly, 6% appreciate the assessment aspect for its easy access and organization. In summary, participants recognize various benefits in the e-module, covering content specifics, accessibility, and interactive features.

5. CONCLUSIONS

The results of the research show a significant improvement in both student cognitive and skill performance on the use of e-modules in virtual reality and real-time rendering.

The study found that students who used the e-module had higher pre-test and post-test results, demonstrating the tool's efficacy as a teaching tool. The effectiveness of the module-based instructional strategy was demonstrated by the more significant improvement in scores that the module group showed when compared to the control group. Participants' reactions to the acceptability assessment of the e-module were highly favorable. The e-module generated strong behavioral intentions to utilize it and was thought to be very helpful and simple to use. There was agreement among participants on the e-module's usefulness and applicability, as evidenced by their readiness to use it given its accessibility and relevance.

The results of the research showed that when it came to assessing rendered product, students in the experimental group did better than those in the conventional group. Participants consistently performed well in all evaluated categories, which included creativity, use of enscape materials, use of enscape settings, implementation of virtual reality, and total rendered outcome. The output scores of the module and control groups did not differ significantly, but the module group's students continuously obtained better mean scores across all parameters, demonstrating their superior performance.

The study concludes by emphasizing the beneficial effects of the e-module on students' utilization of virtual reality and real-time rendering concepts, creativity, and skill development. The outcomes demonstrate how well the e-module-based teaching strategy on real-time rendering and virtual reality works to improve student cognitive and skill performance.

6. RECOMMENDATIONS

Based on the results of this study, several recommendations emerge. Firstly, educational instructions should consider implementing e-modules in virtual reality and real-time rendering in teaching. The study demonstrates a significant enhancement in student cognitive skill performance with the use of e-module in real-time rendering and virtual reality. Secondly, incorporating the e-module into the curriculum is suggested to improve students' pre-existing knowledge and their ability to apply virtual reality and real-time rendering concepts. Thirdly, future researchers are encouraged to develop an advanced rendering version of the e-module. Additionally, educators are advised to create dynamic and interesting e-modules that are easily accessible and relevant to the course material. Allowing students to interact with these teaching resources can enhance their learning process and facilitate the understanding and practical application of complex ideas. Lastly, the research strongly advocates for the integration of interactive and engaging e-modules in virtual reality, real-time rendering, and other emerging technologies, providing a pathway for more effective teaching and learning experiences.

ACKNOWLEDGEMENT

I would like to express my gratitude to everyone who has participated in this study. Special thanks are extended to my adviser, the panelists, the faculty, and the students for their help, involvement, and commitment to this project. Additionally, I would like to acknowledge the experts in the field of rendering and module development who assessed the e-module in virtual reality and real-time rendering. My heartfelt thanks go to the students whose participation and assistance were essential in obtaining the required information. I sincerely appreciate the constant support of my partner and family during this

journey. Lastly, I extend my gratitude to the Almighty God, who provided insight and understanding for this research.

REFERENCES

1. Almelhi, A. (n.d.). Effectiveness of the ADDIE Model Within an E-Learning Environment in Developing Creative Writing in EFL Students. English Language Teaching | CCSE. https://doi.org/10.5539/elt.v14n2p20
2. Astalini, A., Darmaji, D., Kurniawan, W., Anwar, K., & Kurniawan, D. A. (2019, September 5). Effectiveness of Using E-Module and E-Assessment. International Journal of Interactive Mobile Technologies (iJIM). https://doi.org/10.3991/ijim.v13i09.11016
3. Cahyaningrum, D., & Jaenudin, A. (2021, February 22). The Relevance of E-Module Based on Problem Based Learning in the Era of the Industrial Revolution 4.0. Atlantis Press. https://doi.org/10.2991/aebmr.k.210220.007
4. Danišová, N., Ruzarovsky, R., & Velíšek, K. (2012, December). Designing of Intelligent Manufacturing Assembly Cell by Moduls of System Catia and E-Learning Module Creation. Advanced Materials Research, 628, 283–286. https://doi.org/10.4028/www.scientific.net/amr.628.283
5. Davidson, J., Fowler, J., Pantazis, C., Sannino, M., Walker, J., Sheikhkhoshkar, M., & Rahimian, F. P. (2019, June 15). Integration of VR with BIM to facilitate real-time creation of bill of quantities during the design phase: a proof-of-concept study - Frontiers of Engineering Management. SpringerLink. https://doi.org/10.1007/s42524-019-0039-y
6. Delita, F., Berutu, N., & Nofrion, N. (n.d.). Online Learning: The Effects of Using E-modules on Self-efficacy, Motivation and Learning Outcomes. Turkish Online Journal of Distance Education. https://doi.org/10.17718/tojde.1182760
7. Denton, M. (2021, August 28). The 8 Most Important Benefits Of eLearning For Students. Archy Learning. https://archylearning.com/blog/the-8-most-important-benefits-of-elearning-for-students/
8. Development of an e-learning module to facilitate student learning and outcomes. (2020, October 23). Development of an E-learning Module to Facilitate Student Learning and Outcomes - ScienceDirect. https://doi.org/10.1016/j.teln.2020.10.007
9. Education 4.0. (n.d.). https://www.linkedin.com/pulse/education-40-darshan-vyas
10. Fadieny, N., & Fauzi, A. (2021, March 2). Usefulness of E-module Based on Experiential Learning in Physics Learning. International Journal of Progressive Sciences and Technologies. https://doi.org/10.52155/ijpsat.v25.1.2783
11. Harve, A. (2023, October 26). How to Design & Develop e Learning Modules for Small, Medium, and Large Enterprises. Hurix Digital. https://www.hurix.com/create-e-learning-modules/
12. Hendriyani, Y. A. S., & Effendi, H. (2020, December 12). The Development of Interactive Project Based E-Module in Visual Program Course. Atlantis Press. https://doi.org/10.2991/assehr.k.201209.226
13. Hüseyin, Z. (2019, October 31). Impact of note taking during reading and during listening on comprehension. Educational Research and Reviews, 14(16), 580–589. https://doi.org/10.5897/err2019.3812
14. Indovance, M. (2022, April 12). Top 10 Benefits of 3D Modeling for Design Development and Manufacturing. Indovance Inc. https://www.indovance.com/knowledge-center/top-10-benefits-of-3d-modeling-for-design-development-and-manufacturing/

15. J. (2023, February 4). How to Make a Module - The 10 Essential Elements. Jevannel's Blog. https://jevannelacademy.com/how-to-make-a-module/
16. Kotobee Facilitates the Transition to Online Learning For Teachers in the Philippines. (n.d.). Kotobee Case Study. http://www.kotobee.com/case-study/mary-rose-genova
17. Mailizar, M., Almanthari, A., & Maulina, S. (2021, February 13). Examining Teachers' Behavioral Intention to Use E-learning in Teaching of Mathematics: An Extended TAM Model. Contemporary Educational Technology, 13(2), ep298. https://doi.org/10.30935/cedtech/9709
18. Mba, T. C. (2023, February 24). 6 Reasons Why Online Learning Can Be More Effective Than Enrolling In A Face-To-Face Training. eLearning Industry. https://elearningindustry.com/reasons-why-online-learning-can-be-more-effective-than-enrolling-in-face-to-face-training
19. Pamungkas, S. F., Widiastuti, I., & Suharno, S. (2019, June 26). Kolb's Experiential Learning for Vocational Education in Mechanical Engineering: A Review. AIP Publishing. https://doi.org/10.1063/1.5112427
20. Petty, J. (2018, April 27). What is 3D Modeling & What's It Used For? Concept Art Empire. https://conceptartempire.com/what-is-3d-modeling/
21. Ravat, S., Barnard-Ashton, P., & Keller, M. M. (2021, May 17). Blended teaching versus traditional teaching for undergraduate physiotherapy students at the University of the Witwatersrand. South African Journal of Physiotherapy, 77(1). https://doi.org/10.4102/sajp.v77i1.1544
22. Real-Time Rendering Software for Architecture | Autodesk. (2022, October 21).
23. Autodesk. https://www.autodesk.com/solutions/real-time-renderingvResearch guides: Virtual Reality in the Classroom: What is VR? (2022, December 17). What Is VR? - Virtual Reality in the Classroom - Research Guides at University of Toronto. https://guides.library.utoronto.ca/c.php?g=607624&p=4938314
24. Ruanto Calatrava, J. A. (2022, October 12). Development and Evaluation of E–Learning Materials With Kotobee Application in Physical Science for Grade 11 Students. International Journal of Multidisciplinary: Applied Business and Education Research. https://doi.org/10.11594/ijmaber.03.10.08
25. Seeing the invisible: From imagined to virtual urban landscapes. (2020, January 3). Seeing the Invisible: From Imagined to Virtual Urban Landscapes - ScienceDirect. https://doi.org/10.1016/j.cities.2019.102559
26. Tarigan, W. P. L., Sipahutar, H., & Harahap, F. (2023, September 9). The impact of an interactive digital learning module on students' academic performance and memory retention. Computers and Children, 2(2), em004. https://doi.org/10.29333/cac/13654