The Effects of a Mobile Augmented Reality Accounting System on University students' Achievement and Cognitive Load

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ABSTRACT:

This study investigated the effects of a Mobile Augmented Reality Accounting System (MARA) on university students' learning achievement in accounting asset knowledge. The study was motivated by the need to address the complexity and abstract nature of accounting asset concepts. Conventional multimedia learning (CML) systems often fail to integrate real-world contexts with virtual learning environments, limiting students' opportunities to develop intuitive understanding of accounting knowledge. A quasi-experimental design was adopted, with learning mode (MARA versus CML) serving as the independent variable. Learning achievement and cognitive load were examined as the dependent variables. A total of 60 undergraduate students from a university in China participated in the study. This study employs descriptive and inferential statistical analysis methods to perform statistical processing and analysis on the collected data. ANCOVA was conducted to examine differences in learning achievement and cognitive load between the two different groups. The findings revealed that students who learned through MARA achieved significantly higher learning outcomes and experienced lower cognitive load than those who learned through CML. Overall, the findings suggest that MARA is an effective instructional tool that enhances learning achievement while reducing cognitive load in accounting asset education..

Keywords: Augmented Reality, Accounting Education, Learning Method

Introduction

The rapid development of mobile technology has profoundly changed people's daily lives. The current generation, having grown up in a digital environment, are typical "digital natives" (Rebollo et al., 2022). Given the widespread use of mobile technology by students in their daily lives, integrating these technologies into educational practices has become increasingly necessary (Trajkovik et al., 2018). With the continuous development of the digital economy,

AR has become a highly anticipated emerging technology, widely applied in various fields, especially higher education. It is generally believed that technology plays a crucial role in shaping real-world experiences, and its impact on education is particularly profound. As an emerging technology, AR seamlessly blends the real and virtual worlds, making it a transformative technology (Akçayır et al., 2016). Since its introduction into education in 1995, AR has continuously enriched learning environments, providing learners with numerous benefits (Garzón, 2021). However, poor interface design and fundamental differences between augmented reality (AR)-based teaching methods and traditional teaching methods can present significant challenges. These challenges highlight the importance of fully considering learners' cognitive processing when designing AR-based learning environments. In this context, a deep understanding of the characteristics of the target subject is crucial when integrating emerging technologies into education.

Instructional materials and learning activities that surpass students' cognitive capacities may impose excessive cognitive demands, which can reduce their learning motivation and negatively affect learning performance (Leahy & Sweller, 2016; Sweller, 1990). Cognitive load represents the mental effort required by working memory when individuals engage in cognitive tasks and is generally categorized into three dimensions (Liao et al., 2019). Due to the limited processing capacity of human working memory, it is necessary to establish an appropriate relationship between cognitive load and instructional design. Consequently, effective cognitive load management is particularly important when developing technology-enhanced learning environments, including those incorporating AR.

This issue is particularly prominent in the field of accounting education. For a long time, accounting has been considered a practical discipline rather than a purely theoretical one (Stevenson et al., 2018). Before being formally incorporated into bookkeeping education, accounting had already developed into a specialized professional field (Evans & Paisey, 2018). This historical background showed that accounting education was closely related to business practice. Many studies had shown that accounting education could not meet the changing needs of the contemporary business environment, particularly in equipping graduates with the necessary knowledge, skills, and attitudes (Gunarathne et al., 2021). Therefore, exploring the application of augmented reality in accounting education may offer valuable insights into how technology-enhanced learning environments can better support students' understanding of abstract accounting concepts and their application in real-world contexts.

Research Questions

The key issues that this study aims to address are as follows:

1. Does the use of MARA enhance university students' learning performance in comparison to CML?

2. Does the use of the MARA reduce university students' cognitive load compared with CML?

Literature Review

AR IN EDUCATION

AR is an emerging technology that is gaining popularity, especially in higher education. It is a new technology with broad potential applications across multiple professional and academic fields. The main appeal of this technology lies in its integration of real-world and digital elements. AR is often used for visualization, which can sometimes place learners in a relatively passive position (Lilligreen & Wiebel, 2023). Azuma (1997) points out that AR "combines real objects with virtual objects in a real environment," allowing for "real-time interaction," and that "virtual objects are three-dimensional and precisely aligned with real objects." In educational settings, AR promotes learning by presenting diverse visual information. Literature reviews indicate that substantial research evidence shows that in educational contexts incorporating AR technology, students' academic performance, engagement, motivation, and satisfaction are significantly improved (Saltan &

Arslan, 2017). Compared to traditional textbooks, Augmented Reality (AR) can capture learners' attention by recreating real-time events. AR is particularly effective in subjects like history, where students often lack interest. As a cutting-edge teaching method, AR can stimulate students' interest in learning accounting asset and encourage them to become active learners.

AR In Accouting Education

AR is an emerging technology development in the field of accounting education (Al-ansi et al., 2023). Research shows that AR technology has been successfully applied to accounting education and has achieved positive results. Zainuddin (2021) developed an AR application called Lively, creating an interactive virtual classroom for accounting courses. This application facilitated teacher-student communication, distribution of teaching materials, and learning assessment, increased student motivation, and demonstrated potential teaching advantages for Alpha generation learners. Omar et al. (2023) developed an AR application for accounting students in Malaysia, which enhances students' understanding of accounting concepts through 3D virtual explanations and interactive flashcards. Most students found the application user-friendly and helpful for their learning. Hadi et al. (2022) developed an AR application for teaching accounting ethics in Indonesia. This application guides students in making ethical decisions by setting up interactive cases involving multiple stakeholder roles. The system analyzes students' ethical judgments and provides real-time feedback on the potential consequences, thereby reinforcing learning outcomes. User feedback confirmed the application's effectiveness in teaching accounting ethics; respondents in the sample generally believed that the application helped in learning accounting ethics knowledge.

Performance And Cognitive Load

The use of 3D objects significantly enhanced students' comprehension of complex concepts, enabling them to approach problem-solving challenges more imaginatively (Tepla et al., 2022). Research has demonstrated that interactive 3D objects provide students with spatial and visual illustrations that help concretize abstract ideas into tangible forms, thereby enhancing comprehension (Fatemah et al., 2020). This immersive learning approach helps deepen understanding of complex concepts, thereby improving academic performance. For instance, Topu (2024) underscored that AR-enabled 3D objects in a science education setting remarkably enhanced students' problem-solving capabilities through hands-on interaction.

Cognitive load refers to the total mental workload exerted on working memory for processing information at a specific moment (Sweller, 1999; Cooper, 1998). Cognitive load describes the burden on working memory when students complete cognitive tasks (Liao et al., 2019). According to Cooper (1998), cognitive load can be divided into two types. Intrinsic cognitive load stems from the complexity of the learning content itself and is usually unchangeable through instructional design; extraneous cognitive load originates from the teaching materials used to present information to learners, and its level can be adjusted by optimizing the teaching materials and instructional design.

Experiment

Experiment design

This study employed a quasi-experimental research design. One class was assigned to the experimental group and taught using MARA; the other class was assigned to the control group and received traditional instruction. Notably, both groups were taught by the same instructor with over eight years of experience teaching accounting courses to ensure consistency in the teaching process.

Experiment participants

The participants in this study were two first-year undergraduate classes majoring in design at a university in Shandong Province, China. There were a total of 60 students in the two classes. None of the students had basic accounting knowledge.

Experiment instruments

This study used pre-tests and post-tests to assess participants' learning performance. Both tests were designed and developed by the researchers, and each test lasted 20 minutes. The pre-test was administered two weeks before the start of the experimental treatment, and the post-test was administered after the completion of the experimental treatment. The first four questions tested the definition of assets, including their characteristics. The next four questions tested the classification of assets, including long-term and short-term assets, and tangible and intangible assets. Questions 9-12 involved asset lending, covering the increase and decrease of assets. Questions 13-16 tested asset management, including methods of asset management. Questions 17-20 tested asset depreciation, including the use of the "useful-life method" for depreciation.

Cognitive Load Questionnaire (CLQ) was designed to measure participants' cognitive load during the learning process in Asset. CLQ used in this study was adapted from Leppink and van den Heuvel version of Cognitive Load Questionnaire. Apart from that, CLT (Leppink, & van den Heuvel, 2015) was applied in this CLQ. The duration allocated for completing this test was 15 minutes.

The CLQ consists of twelve questions in total. Questions 1 to 4 assess intrinsic cognitive load. These questions are associated to the contents and terminologies of Asset. The questions fundamentally assess whether the participants would need to exert significant intrinsic mental effort to understand the Asset. Questions 5 to 8 assess extraneous cognitive load. These questions assess whether explanations and instructions about the Asset in the app are unclear, ineffective, and requiring significant extraneous cognitive efforts to navigate. Questions 9 to 12 assess germane cognitive load. The lecture greatly enhanced my understanding of the asset and the formulas covered, deepened my knowledge of related concepts and definitions, and improved my overall comprehension of the subject. Participants are required to respond to all twelve questions after the treatment. Each question uses a rating scale ranging from 0 to 10, where a rating of "0" signifies that the statement does not apply at all to their experience, and a rating of "10" indicates that the statement completely applies. This scale allows participants to express the extent to which they feel different aspects of cognitive load during the MARA.

Experiment procedures

The intervention lasted seven weeks. In the first week, researchers arranged orientation sessions and system demonstrations for all participants. Participants received an overall introduction to the learning activities and were clearly informed that they could pause or withdraw from the study at any time for any reason. Researchers explained the specific functions of the experimental system and how to operate it to each participant in detail. Subsequently, each participant was provided with a mobile device. After the system demonstration, each participant had ten minutes to practice operating the system to familiarize themselves with it; this arrangement helped to effectively mitigate the novelty effect that might have influenced the research results. For the next five weeks, the learning process for each unit followed the same procedure. That is, starting from the second lesson, both groups of participants followed the same learning schedule, completing five learning units sequentially. To reinforce the learned content, each topic included a corresponding quiz for review and reinforcement. During the intervention, if participants encountered operational or learning-related problems, researchers only explained which operations were permitted and which were not, without providing specific learning guidance under any circumstances. This was intended to avoid disruptive biases in the learning process. This approach effectively prevents research bias introduced by unforeseen factors. After the intervention, both groups of participants underwent post-test assessments, which included evaluations of their accounting asset knowledge, cognitive load.

Data Analysis

The collected data were statistically analyzed using the SPSS. As Field (2013) noted, SPSS provides reliable and accurate statistical support for data analysis. The data analysis in this study aimed to examine the effects of mobile augmented reality (MARA) applications on improving student learning performance and cognitive load. To test the statistical significance of the difference in means between the two treatment groups, this study used analysis of covariance (ANCOVA) and t-tests (Nordstokke & Zumbo, 2010).

To analyze the collected data, this study employed descriptive and inferential statistics. After controlling for the influence of covariates, analysis of covariance (ANCOVA) and t-tests revealed significant differences between the two groups of students in terms of learning performance, cognitive load.

Results

Results for RQ1: Impact on learning achievement

To examine the impact of MARA on student learning performance, this study employed one-way analysis of covariance (ANCOVA) for data analysis. Post-test scores were used as the dependent variable, and teaching methods (MARA teaching vs. CML) were used as independent variables. This study included pre-test scores as covariates in the analysis to eliminate the influence of differences in students' prior knowledge levels before the experiment on the research results. The results showed that this hypothesis was valid ($F = 3.16$, $p > 0.05$), indicating that the data met the preconditions for ANCOVA. ANCOVA analysis was then performed. The results are shown in Table 2. Teaching methods had a significant impact on student learning performance ($F = 21.26$, $p < 0.01$, $\eta^2 = 0.51$). Therefore, integrating augmented reality technology into accounting education can significantly improve student learning performance, and the effect size is relatively large ($\eta^2 = 0.51$).

Table 1. The ANCOVA result of the two group's performance

Group	N	mean	SD	F	η2
Experimental Group	30	55.17	18.35	21.26*	0.510
Control Group	30	30.33	15.7		

**P < 0.01

Results for RQ2: Impact on cognitive load

To answer research question 2, this study used an independent samples t-test to compare the difference in cognitive load between the experimental and control groups, examining the impact of integrating Mobile Augmented Reality (MARA) applications into the learning system on students' cognitive load. The results are shown in Table 3. The difference in cognitive load between the two groups was statistically significant ($t = 2.37$, $p < 0.05$). This indicates that students using the MARA experienced a lower cognitive load compared to students using CML.

Table 2. The t-test result of the two group's cognitive load

Group	N	mean	SD	t	d
Experimental Group	30	65.47	28.15	2.37*	0.61
Control Group	30	81.67	24.80		

** p < .05

Discussion

Discussion on the results of RQ1

The study's findings regarding the main effects on achievement align with many prior studies that

confirm the learning benefits of MARA. When multimedia teaching materials are used effectively, they can stimulate students' learning enthusiasm and thus improve their academic achievement (Heidig et al., 2015). Many studies have scrutinised the utility of AR in instruction to reinforce student achievement. Researchers have already investigated the applications of augmented reality in science, engineering, and medicine (Kaur et al., 2020). Conversely, a research gap exists regarding the application of Augmented Reality in accounting education, especially within asset accounting courses in China. The integration of 3D and video elements through AR facilitates a more engaging learning environment, which supports a variety of goal orientations. These findings align with previous studies by researchers such as Yilmaz (2020), who have highlighted the effectiveness of AR in facilitating the connection between new learning experiences and prior knowledge in an organized manner. AR learning, within the framework of the learning-by-doing methodology, provides students with the opportunity to actively engage in various learning activities. In a classroom environment, the knowledge and skills acquired through AR experiences can be used as a foundation for reflection and subsequent group discussions (Alnajdi et al., 2020).

Discussion on the results of RQ2

Research findings consistently demonstrate that students in 2D design courses incorporating augmented reality (AR) experience significantly less extrinsic cognitive load compared to those receiving traditional multimedia instruction (Krüger et al., 2022). Cognitive load refers to the mental effort an individual expends in processing and understanding information, and primarily includes three types (Klepsch & Seufert, 2020). Numerous studies have shown that applying AR technology in design education can reduce students' cognitive load compared to conventional learning strategies (Buchner et al., 2022). Furthermore, research confirms that the proximity principle in multimedia learning effectively reduces extrinsic cognitive load (Mutlu-Bayraktar et al., 2019; Dirkx et al., 2021). External cognitive load, caused by inappropriate information presentation and instructional activity organization, increases additional cognitive pressure on students during the learning process. Since this type of load is influenced by instructional design factors, it can be controlled and reduced by optimizing the presentation of instructional content and improving the arrangement of instructional activities (Atiomo, 2020).

Limitations

In terms of generalization, the study is conducted within the following limitations.

Firstly, this study is also limited to multimedia design students taking accounting subjects at the university from Shandong province. Thus, the findings cannot be generalized to mathematics, history, art, medicine, and biology.

Secondly, the study's age range was restricted to university students aged 18-20. Due to the narrow age range, the findings may not be entirely applicable to younger or older students.

Significance of the Research

Firstly, this study delivers a prototype of Accounting Asset learning app that manifested the cognition-based learning environment for university students. The successful development of such prototype demonstrated an innovative way to learning to attain knowledge in Accounting Asset among undergraduate students in China.

Secondly, the study also marks a significant advancement in mobile learning by integrating AR technology into Accounting Asset education. By assessing the effect of such AR technology on Accounting Asset learning, this study provides valuable insights for educators and policymaker, which highlighting the feasibility of combining AR technology with Accounting Asset in educational setting.

Thirdly, this study provides a valuable cognition-based framework, which is exemplified by the MARA to guide researchers and educators in understanding how AR can enhance learning achievement.

Implications of the Research

Implications for Future Research

Considering the significant effectiveness of the AR learning model discovered in this study, future research could further explore its application across different subjects and age groups or examine how specific design elements of the MARA influence various types of students. Moreover, future studies may employ longitudinal or mixed-method approaches to gain deeper insights into how AR-based learning affects students' cognitive load, and learning achievement over time.

Furthermore, considering that augmented reality (AR) has effectively enhanced students' achievement and cognitive load, it is necessary to explore integrating artificial intelligence (AI) in the future, in order to innovate the educational model of accounting course design. An adaptive learning platform based on artificial intelligence can provide personalized instructional content for each learner, while continuously monitoring learning progress and adjusting teaching methods in real time (Vittorini et al., 2021). AI-based data analytics systems can accurately interpret learning behavior patterns, assisting educators in refining targeted teaching plans to effectively enhance learning outcomes. The synergistic application of AI and AR technologies can further create a highly immersive interactive learning environment, promoting the development of students' creativity and deepening their grasp of accounting asset concepts.

Recommendations for Future Research

The study identifies specific potential areas, directions, and foci warranting further investigation, including addressing gaps highlighted by the study's limitations. It is worthwhile to outline precise research works that could directly lead to overcoming these limitations.

Firstly, to further refine and revise this design and development framework, the key lies in developing additional types of AR applications based on it. Only in this way can a more robust and comprehensive framework for AR-based learning environments be established.

Secondly, this study did not employ formal qualitative methods, such as observations or interviews. A particularly valuable avenue for future research would be to explore individual experiences with the two treatment modalities, as this could yield valuable insights into their personal application and impact.

Thirdly, this research should be repeated with a larger sample size across a wider range of locations, given that it was conducted with only 60 students from two universities in Shandong province. In the future, it can be widely used in provinces such as Henan, Hebei, Yunnan, and Guangdong.

Conclusion

Overall, this study developed the MARA for accounting education, designed around asset-related accounting concepts and knowledge to enhance students' understanding of accounting theory and improve learning outcomes. The application of augmented reality technology helps establish connections between abstract knowledge and real-world contexts, effectively improving student performance and reducing cognitive load. Furthermore, MARA plays a positive role in reducing external cognitive load, creating a more intuitive, interactive, and efficient learning environment for students.

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Author Declaration

The authors declare that this manuscript is original, has not been published previously, and is not under consideration for publication elsewhere.

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