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Enhancing Accounting Learning Through Mobile Augmented Reality: Effects on Student Learning Achievement and Cognitive Load

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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. Descriptive and inferential statistics were employed to analyze the collected data. ANCOVA was conducted to examine differences in learning achievement and cognitive load between the two 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 conventional multimedia learning. Overall, the findings suggest that MARA is an effective instructional tool that enhances learning achievement while reducing cognitive load in accounting asset education.

Key words: *Augmented Reality, Accounting Education*

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Introduction

The rapid development of mobile technology has profoundly shaped everyday life, with the current generation growing up as digital natives (Rebollo et al., 2022). Given that students are immersed in mobile technologies in their daily routines, the integration of these technologies into educational practices has become increasingly necessary (Trajkovik et al., 2018). Alongside the expansion of the digital economy, augmented reality (AR) has emerged as a prominent technology and is now widely adopted across multiple sectors, especially in higher education. It is commonly accepted that technology plays a significant role in shaping real-world experiences, and its influence on education is particularly profound. As an emerging technology, Augmented reality (AR) is a transformative technology that seamlessly integrates the real and virtual worlds (Akçayır et al., 2016). Since its introduction into education in 1995, AR has enriched the learning environment, offering numerous benefits to learners (Garzón, 2021). However, challenges such as poor interface design and fundamental differences between AR-based and traditional teaching methods may pose significant obstacles. These challenges highlight the importance of considering learners' cognitive processing when designing AR-based instructional environments. In this context, understanding the characteristics of the target discipline is essential when integrating emerging technologies into education.

Instructional design and content exceeding students' cognitive abilities may lead to excessive cognitive load, detrimentally affecting their learning interest and outcomes (Leahy & Sweller, 2016; Sweller, 1990). Cognitive load refers to the demands placed on working memory during the completion of cognitive tasks and comprises three primary components: intrinsic, extraneous, and germane cognitive load (Liao et al., 2019). Therefore, effective management of cognitive load is critical when implementing technologically enhanced learning environments such as AR.

This issue becomes particularly salient in the context of accounting education. Accounting has historically been perceived as a practical discipline rather than a purely theoretical one (Stevenson et al., 2018). It evolved into a learned profession before being formally incorporated into bookkeeping education (Evans & Paisey, 2018). Accounting was often viewed as a practical discipline rather than a purely theoretical one (Stevenson et al., 2018). It evolved into a learned profession before being officially integrated into bookkeeping education (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 research questions addressed in this study 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

Augmented Reality (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). Augmented Reality (AR) is considered an emerging technology. 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.

AR IN ACCOUTING EDUCATION

A new technological development in accounting education is augmented reality (AR) (Al-ansi et al., 2023). Research has found that AR has been successfully applied in accounting education. 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.

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 referred to the total amount of mental activity imposed on working memory at a given moment for processing information (Sweller, 1999; Cooper, 1998). Cognitive load described the working memory load required by students to complete a cognitive task. It comprised three primary components: intrinsic, extraneous, and germane cognitive load (Liao et al., 2019). According to Cooper (1998), there were two types of cognitive load: intrinsic cognitive load, due to the complexity of the content, which cannot be revised by instructional design. Extraneous cognitive load stemmed from the learning materials used to present information to learners, and its level could be adjusted by changing those materials.

Development of a *MARA*

MARA is primarily based on the Instructional Design (ATID) model of Alessi and Trollip (2001). This model employs a flexible and standards-based approach, incorporating a cycle of drafting, review, and revision during the design process. The methodology consists of three distinct phases: planning, design, and development, each step tailored to the needs of the development process. Alessi and Trollip also recommend its use in classroom environments, as it provides the technical means to design, develop, and integrate various multimedia components, including textual content, visual content, audio, video, and animation. Therefore, the ATID model is well-suited for the design and development of this research system.

During the planning phase, various factors need to be considered, such as hardware and software limitations. The two most commonly used software development platforms for Augmented Reality (AR) and Virtual Reality (VR) are Unity3D and Unreal Engine 4. Unity3D, developed by Unity Technologies, is known for its comprehensive and adaptable support tools, low learning curve, and suitability for lightweight AR projects. These advantages make Unity3D the development tool of choice for this project. To meet development requirements, a Software Development Kit (SDK) is essential. On the Unity3D platform, the most commonly used SDK options include ARToolkit, Easy AR, and Vuforia. Vuforia was considered a suitable choice for designing and developing lightweight augmented reality applications. Therefore, based on functional requirements, Vuforia was selected as the software development tool for the *MARA*'s (see Figure 1). Secondly, in the design phase, the research team first outlined the main goals and elements of the research in the preliminary program description. Subsequently, a prototype of the target program was created to assess its feasibility and functionality, and flowcharts and storyboards were generated to progressively depict the program flow and user interaction process. Furthermore, in the development phase, Microsoft Visual Studio was used for programming and coding. Visual Studio is an Integrated Development Environment (IDE) designed for creating various computer programs, such as web applications, websites, web services, and mobile applications. In this system, the researcher integrated audio functionality to enhance the user experience, including selecting soft music as background music to create a quiet atmosphere conducive to student learning. After extensive research and development, the *MARA* was finally designed and implemented. It is an innovative learning tool that can enhance students' learning experience in accounting asset learning content.

Experiment

Experiment design

A quasi-experimental design was carried out in this study. One class of students was assigned to the experimental group and received instruction using the *MARA*, while the other class was assigned to the control group and received traditional instruction. It is significant to note that both groups were taught by the same experienced instructor with over eight years of experience teaching design accounting courses.

Experiment participants

The participants in this research comprised two classes of first-year undergraduate students at a university in Shandong province, China, who are enrolled in a design program. Two classes consisted of a total of 60 students. All students are no 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. Each test lasted 20 minutes. The pre-test was conducted two weeks before the experimental treatment, and the post-test was conducted after the experimental treatment. Both the pre-test and post-test contained 20 multiple-choice questions covering basic knowledge related to assets. 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.

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.

In the second week, participants begin a 20-minute self-directed exploration of the system. 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. 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 Statistical Package for the Social Sciences (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 RQ_1: Impact on learning achievement

To examine the effectiveness of MARA on students' learning performance, this study employed one-way analysis of covariance (ANCOVA). The dependent variable was students' post-test scores, and the independent variables were two different groups used in the learning activities. To control for differences in students' initial knowledge levels, pre-test scores were included as covariates in the analysis. To verify the applicability of ANCOVA, the hypothesis of homogeneity of regression was first tested. The results showed that the hypothesis of homogeneity of regression was not violated ($F = 3.16$, $p > 0.05$). Subsequently, ANCOVA analysis was performed. As shown in Table 2, the use of *MARA* had a significant impact on learning performance ($F = 21.26$, $p < 0.01$, $\eta^2 = 0.51$), indicating a significant difference in post-test scores between the two groups of students. Therefore, the results show that accounting education integrating augmented reality technology significantly improved students' learning performance, and the effect size was relatively large ($\eta^2 = 0.51$).

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

Group	N	mean	SD	F	η^2
Experimental Group	30	55.17	18.35	21.26*	0.510
Control Group	30	30.33	15.7		

$^{**}P < 0.01$

Results for RQ_2: Impact on cognitive load

To answer research question 2, this study analyzed the impact of integrating MARC into the learning system on students' cognitive load using a t-test. As shown in Table 3, the results revealed a significant difference between the two groups ($t = 2.37$, $p < 0.05$). The results indicate that the learning system integrating MARA has a significant impact on students' learning cognitive load. Specifically, the experimental group had a mean score of 65.47 (SD = 38.15), while the control group had a mean score of 81.67 (SD = 24.80). This suggests that students using the learning system integrating *MARA* experienced a lower cognitive load during the learning process compared to students using traditional multimedia learning materials.

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 RQ_1

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 experences 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 RQ_2

Research findings consistently indicate that students experiencing significantly lower extrinsic cognitive load in 2D design courses incorporating augmented reality (AR) compared to those in traditional multimedia courses (Krüger et al., 2022). Cognitive load refers to the mental effort an individual expends in processing and understanding information, and mainly includes three types: intrinsic cognitive load, extrinsic cognitive load, and related cognitive load (Klepsch & Seufert, 2020).

Numerous studies (Buchner et al., 2022) have shown that using augmented reality (AR) in design education reduces students' cognitive load compared to traditional learning strategies. Furthermore, research findings validate the role of the proximity principle in multimedia learning in effectively reducing extrinsic cognitive load (Mutlu-Bayraktar et al., 2019; Dirkx et al., 2021). Extrinsic cognitive load interferes with student learning, primarily influenced by the presentation of learning materials and the organization of learning activities, factors that can be adjusted and optimized (Atiomo, 2020).

Implications of the Research

The results have four meaningful implications for the integration of *MAR* learning in accounting assets, particularly in enhancing university students' achievement, reducing cognitive load to learn accounting asset materials in a classroom setting.

Pedagogical Implications

Educators should consider redesigning lesson activities to include AR features that can enhance students' engagement, promote active participation, and increase retention of accounting asset concepts. Additionally, given these constraints, providing university teachers with a comprehensive set of guidelines and a ready catalogue of best practices for existing AR applications may not be feasible. Consequently, both teachers and students likely require further professional development to effectively implement AR (Petrovych et al., 2021).

It is recommended that curriculum designers incorporate AR features into accounting educational resources, including textbooks and digital learning platforms. Integrating AR technology can transform abstract accounting concepts into more concrete and interactive representations, thereby enhancing students' conceptual understanding and employment prospects. Additionally, AR-based materials could be embedded in both traditional printed textbooks and digital applications to support blended learning methodologies. For instance, 3D visualisation of accounting processes, such as journal entries or financial statement preparation, can help students better grasp the logical relationships among accounting elements.

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.

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