The effect of the Augmented Reality Accounting Mobile Learning App (AR-Counting App) on Achievement of Chinese University Students with Different Gender in Asset Learning

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In accounting education, mastery of accounting assets requires a profound understanding of abstract concepts and complex symbolic systems, which constitutes an indispensable component of accounting education. However, traditional teaching methods often fall short in helping students grasp these ideas, leading to decreased engagement and suboptimal learning outcomes. To tackle this issue, this study examines the impact of the Augmented Reality Accounting Mobile Learning App (AR-Counting App) on university students' achievement in learning about accounting assets. The study adopted a quasi-experimental design to test the efficacy of the AR-Counting app, involving sixty university students divided into the AR-Counting app group and the CAM app group. The findings revealed that AR technology significantly enhanced students' achievement underscoring its value in accounting education. This research reveals integrating the augmented reality technology in accounting education, with its findings offering constructive reference value for finance educators seeking to implement AR integration within authentic teaching scenarios.

Key words: *Augmented reality, Accounting education, Asset, Achievement, gender*

DOI : 10.5281/zenodo.21171089

Introduction

The need to achieve "Quality Education" in the United Nations' Sustainable Development Goal 4 (SDG4) which refers to holistic growth across all aspects of human development (United Nations, 2022). This growth encompasses comprehensive learning and progress in three key domains of learning, namely Cognition, Affection, and Psychomotor domains to ensure that students acquire the necessary skills for a meaningful career, a high quality of life, and life-long learning. The Cognition domain, which refers to the mental processes such as understanding and remembering the learning knowledge, serves as the foundation for the Affection domain, which pertains to emotions, and the Psychomotor domain, which refers to physical skills and practice (Prabhavathi et al., 2023). Both the Affection and psychomotor domains, in turn, reinforce cognition domain. Consequently, learning approach that prioritize cognition domain development provide a strong foundation for the growth of other domains. This emphasis on cognition is particularly crucial in Accounting education because Accounting education involves a significant amount of rule-based material, covering intricate technical concepts and legal regulations (Ade-Ibijola et al., 2025). In particular, Asset-related topics in Accounting requires extensive numerical and formula-based comprehension, which demand significant cognitive processes. If the cognition domain is not effectively developed, students' subsequent affection and psychomotor domains will also be negatively impacted. This is because these three domains were interconnected and could be reinforced effectively in integration (Yasmin, Farooq & Shah 2023).

Recognizing the importance of Asset-related topics in Accounting, many universities have adopted technological-enhanced learning to improve students' cognition domain development. A variety of technology tools are being applied in education, including augmented reality, virtual reality, mobile learning (Maketo et al., 2023), chatbots (Okonkwo & Ade-Ibijola, 2021), gamification (Musyafff et al., 2021), and virtual classrooms (Shonhe et al., 2023). Despite the widespread deployment of these technologies, accounting students in China continue to face challenges in learning Asset-related topics. These difficulties arise primarily because many learning technologies do not incorporate cognition-based learning theories tailored to students' cognitive abilities and needs (Lavrijsen et al., 2023). Although AR is increasingly adopted in educational contexts, its use often remains superficial. For example, in many implementations, AR is merely employed to play videos related to certain topics, rather than actively involving

students in meaningful cognitive processes. However, to truly foster cognitive development, educational technologies should be grounded in cognition-based learning theories, which emphasize active engagement, mental effort, and meaningful interaction with learning content. Specifically, within the scope of accounting education, there is still absence of research focusing on how AR can enhance core learning achievement. This highlights the need for more theory-driven and pedagogically sound applications of AR in accounting contexts. Currently, the three most influential cognition-based learning theories relevant to Accounting education are Constructivist, Cognitive load and Cognitive Theory of Multimedia Learning.

In 2016, AR was identified as innovative and substantial strategic technology by the State Council in China in the "13th Five-Year National Science and Technology Innovation Plan" (2016). Apart from that, the National People's Congress incorporated AR into the "Construction of Digital China" under the policy entitled "14th Five-Year Plan and the Long-Range Objectives Through the Year 2035" as the key of digital transformation and economic growth in 2021. Ministry of Education of China (2019) had also taken initiatives to urge all schools and universities to integrate AR and other emerging technologies into education through the "Outstanding Teacher Training Program 2.0". As a result of these initiatives, AR has been started to be widely deployed across disciplines in university (Moro et al., 2021; Tarmizi & Yasak, 2022). Amongst others, AR is applied in physical education (Ariffin et al, 2022), science (Arici et al., 2019), STEM (Sırakaya & Sırakaya, 2022), mathematics (Aldalalah et al., 2019), history (Martin et al., 2012), and medicine (Liao et al., 2024). However, in Accounting education, AR implementation remains limited, and its learning achievement have been unsatisfactory due to the lack of alignment with cognition-based learning theories.

In response to government's push for innovation educational technologies as well as addressing the aforesaid obstacles in accounting education, the researcher attempts to develop and investigate an AR-based learning system for Accounting Asset education based on three cognition-based learning theories, Constructivist, Cognitive Load and Cognitive Theory of Multimedia Learning (CTML). The proposed system is termed as "the Augmented Reality Accounting Mobile Learning App", or in short, *AR-Counting* app.

2. Literature review

2.1 AR in Education

Azuma (1997) identified three core technological elements of augmented reality: the fusion of virtual and real elements, real-time interaction, and three-dimensional registration. Its technical implementation pathways are primarily categorized into marker-based and markerless approaches (Boonbrahm et al., 2020). the former relies on physical markers to activate virtual content, while the latter employs positioning technologies such as GPS to achieve scene embedding (Yoon & Lee, 2023). At the interaction level, users can engage in real-time interaction with virtual objects through diverse terminals such as smartphones and AR glasses (Chen et al., 2019; Goh et al., 2019).

The key technological distinction between the two lies in the construction of their interactive spaces. VR generates fully immersive digital environments, whereas AR does not require the creation of such enclosed interactive settings. Instead, it achieves interaction by merging the digital (virtual) realm with the physical (natural) environment (Garrett et al., 2018). The three fundamental concepts constituting augmented reality (AR) are immersion, interaction, and engagement (Da Silva et al., 2017). Immersion pertains to the user's perceptual experience within the environment. With the rapid global proliferation of AR technology, its educational potential is being increasingly unlocked (Mokmin et al., 2023). Research indicates that integrating technological innovation with the educational ecosystem is a key pathway to stimulating learning engagement (Ghory & Ghafory, 2021). In the digital age, the application of augmented reality (AR) is an option worth considering in all areas of education. Arena et al. (2022) contend that augmented reality (AR) can integrate the real environment with digital information, a fusion that may occur automatically or be triggered through user-device interaction. Consequently, AR delivers novel enhanced experiences for humans across both perceptual and cognitive dimensions.

Despite its numerous advantages in education, augmented reality (AR) still faces challenges. Poor interface design often makes it difficult for students to master AR technology. Usability issues such as tracking accuracy, device calibration, and unstable content presentation can hinder learning outcomes. Promoting AR technology requires investments in supporting infrastructure (such as compatible devices) and systematic training for educators. This training should cover effective use of AR tools, instructional design methodologies, and enhanced classroom interaction techniques (Mascareñas et al., 2021). However, as AR technologies tailored for specific audiences continue to advance (Tuli & Mantri, 2021), this technology holds promise to become an indispensable tool in educational practice.

2.2 Augmented Reality in Accounting Education

Accounting education is undergoing a pedagogical revolution spearheaded by augmented reality (AR) technology (Al-ansi et al., 2023). Leveraging its ability to overlay virtual elements onto the physical world, this technology creates highly immersive learning environments (Liang et al., 2023). It excels particularly in presenting abstract concepts through three-dimensional visual demonstrations, significantly enhancing teaching engagement and comprehension (Shiue et al., 2023). The continuous growth in academic research findings serves as compelling evidence of this technology's profound empowerment within the educational sphere (Garzón, 2021). Numerous scholars have thoroughly examined how different types of learners perceive the benefits of integrating AR technology into the classroom. The most often cited affordances are related to student enjoyment (Savela et al., 2020), engagement (Dirin & Laine, 2018)., increased motivation (Kaur, Mantri & Horan, 2020), and enhanced interaction

(Gudoniene & Rutkauskiene). Therefore, the study explores the augmented reality technology which demonstrates significant application effectiveness in accounting education settings.

2.3 Research Gap

AR is an emerging technological development in the field of accounting education (Al-ansi et al., 2023). Existing literature shows that augmented reality technology has been gradually applied to accounting education practice and has achieved positive results (Hadi et al., 2022).

Table 2.2 Research Gaps in AR-Based Accounting Education Studies

Author	Year	Research Design	Variables Investigated
Zainuddin	2021	Mixed-method approach	Students' learning experiences; course design; lecturer factor; infrastructure/facilities.
Hadi et al.	2022	Development research using SCRUM method; quantitative usability testing.	Perceived usability, perceived usefulness, perceived ease of use, attitude
Omar et al.	2023	Descriptive research design using a quantitative survey approach.	Perceived Usefulness Perceived Ease of Use Perceived Enjoyment Attitude.
Mulyono et al	2023	Quantitative experimental research design using an experimental group and a control group.	AR-based learning / AR-assisted learning, Students' learning outcomes Knowledge acquisition in public sector accounting.
Ade-Ibijola, Sukhari, & Oyelere	2025	quantitative evaluation using questionnaires and experimental testing.	Usability of ZART, students' perceptions, pedagogical experiences, language translation functionality, engagement with AR avatars.

3. Research Questions

This study developed an application named "*AR-Counting* App" for learning accounting courses. To validate the impact of this application on university students' achievement, the paper conducted a quasi-experimental study primarily addressing the following research questions:

RO_1: To investigate whether there is a significant difference in accounting asset achievement between students using the *AR-Counting* App and those using the *CAM* app.

RO_2: To investigate whether there is a significant difference in accounting asset achievement between students of different genders when using the *AR-Counting* app and *CAM* app.

4.Research Hypotheses

As a novel *AR-Counting* app, it is hypothesised that the study has null effects on the university students. The statistical significance test typically adopts a probability level of 0.05 as the benchmark.

$H_0$1: There is no significant difference in accounting asset achievement between students using *AR-Counting* app and those using *CAM* app.

$H_0$2: There is no significant difference in accounting asset achievement between students of different genders when using *AR-Counting* App and *CAM* app.

$H_0$2.1: There is no significant difference in accounting asset achievement assessments between male and female students using *AR-Counting* app.

5. Research Framework

This study established three categories of variables: independent variables, dependent variables, and moderator variables. The independent variables comprised AR counting applications versus *CAM* app, while the dependent variable was achievement. Previous research (Dirin et al., 2024) indicated that achievement differed between male and female students when utilizing AR technology. Therefore, to further investigate the achievement differences between male and female students when using *AR-Counting* app, this study incorporates student gender as a moderate variable (MV), as shown in Figure 1.

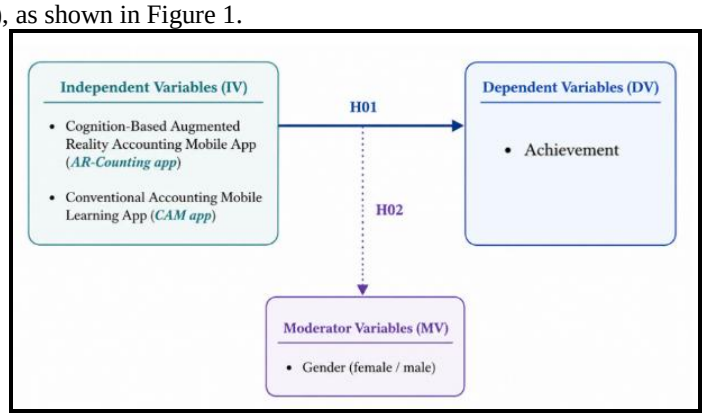

Figure 1. Research framework adopted in this study

6. Theoretical Framework

Three theories adopted in this study, that is the Constructivist Theory (Piaget, 1972), Cognitive Theory of Multimedia Learning (CTML) (Mayer, 2009), Cognitive Load Theory (Sweller, 1994). The combination of CTML, Constructivist and Cognitive Load Theories categorized under the Learning Theory is the underlying basis for designing the instructional *AR-Counting* app, as shown in Figure 1.6. Grounded in these theories, this study seeks to examine how the *AR-Counting* app affects university students on achievement.

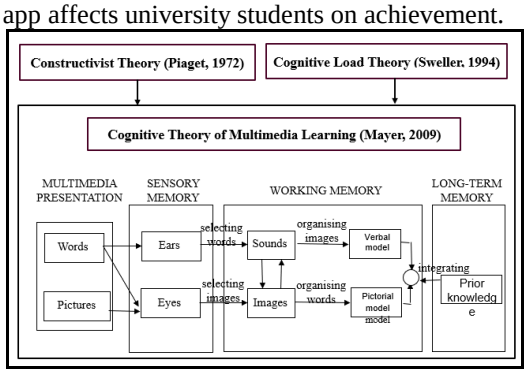

Figure 2. Theoretical framework adopted in this study

7. Methodology

7.1 Research Design

This quasi-experimental study systematically compared the differing effects of *AR-Counting* app and *CAM* app on university students' asset-related grades in accounting courses.

7.2 Participants

This study selected 60 first-year students (aged 18-20) from two classes at a university in Shandong Province as research subjects. The participants were randomly assigned to the experimental group (using the *AR-Counting* app, n=30) and the control group (using the *CAM* app, n=30). These students were accustomed to using multimedia materials in their daily studies.

7.3 Measuring tools

Pre-test and Post-test in the study are used to assess participant achievement. They are designed and developed by the researcher. The duration of both tests are 25 minutes. The pre-test and post-test were scheduled to take place two weeks prior to the commencement of the intervention and immediately following its conclusion, respectively.

Both pre-test and post-test consist of a total of twenty multiple choice questions, ranging from basic knowledge covering Asset related topics. There are 20 questions in these pre-test and post-test. The first four questions ask about the definition of assets. The subsequent four questions ask about the classification of Assets. Questions 9 to 12 address asset borrowing. Questions 13 to 16 ask about to asset management, and the questions 17 to 20 ask about Asset Depreciation.

The questions in pre-test and post-test are the same. Participants are asked the same contents and the same number of lessons they learn. The difference between the pre-test and post-test are that the order of the questions are different. The questions are randomized to ensure the participants will not remember the questions in the pre-test.

For the 20 multiple-choice questions, the participants are required to circle the correct option. Each correct answer earns 5%, while incorrect answers receive 0%. The validity has also been conducted by two experts in Asset Accounting. The two experts had reviewed both pre-test and post-test. The experts are teachers who have 10 years teaching Accounting, including Asset. The experts had given minor comments on the tests, and the researcher had made corrections and adjustments based on their comments.

7.4 Experimental procedure

The researcher followed strict procedure to conduct treatment and collect data from the target participants. One week before the execution of the treatment, the researcher sought official permission to conduct the study from the principals of the two universities. The researcher targeted to conduct study in two universities in Shandong province. Together with the permission letter, general information was given to them on what the study was regarding without informing them about *AR-Counting* and *CAM*. They were only informed about their contribution to this study, that is, they are contributing to new Accounting Knowledge in multimedia education. After obtaining approval, the researchers then asked each principal to fill out an informed consent form. Thereafter, all participants were requested to sit for pre-test in the classroom.

In the first week of study, the participants were randomly assigned to use two different groups of treatments, that is the experimental group were engaged with the *AR-Counting* whereas the control group with the *CAM*. The duration of this treatment was seven weeks. The treatment for these two groups was conducted in the classrooms arranged by the principals in the two universities. Each lesson lasted for 15 minutes per week, and the overall treatment was held for seven weeks consecutively. The study was carried out from September to October 2025. The study was designed to last seven weeks to ensure participants had sufficient time to engage with the

learning materials and for measurable changes in learning outcomes to become apparent. This timeframe was considered suitable for capturing the cognitive processing and memory retention effects of *AR-Counting* and *CAM* learning interventions.

In the second week, the participants began to explore the *AR-Counting* by themselves for 25 minutes. After the practice in demonstration session in the previous week, the participants had already become familiar with the *AR-Counting*. Therefore, they were allowed to be self-directed to navigate the whole lessons in the app by themselves without guidance from the teachers. They operated the *AR-Counting* app smoothly because they had been trained in the first week. They started the lesson by using their mobile phone and scanning the *AR-Counting* app referenced book with image. After successful scanning, the participants jumped into screen which showed the learning topic. After entering the task session, the learning started.

Such learning process in each session proceeded similarly for five weeks subsequently. To revise the topics that they had learned, each topic was equipped with the quiz sessions. When participants encountered the problems during the treatment, the researcher highlighted them to what could be done and what could not be done without providing guidance for participants whatever any reasons. The purpose of doing this was to avoid the bias in the learning process. After completing treatment, the participants of both groups were subjected to post-assessment, namely accounting asset knowledge.

8.Data Analysis

To test Hypothesis 1 ($H_0$1), namely that "there is no significant difference in achievement between students using the AR counting application and those using the CAM application," this study employed analysis of covariance (ANCOVA). Previously, pre-test achievement were employed as covariates to control for baseline differences between groups in statistical analyses.

To test Hypothesis 2 ($H_0$2), this study employed a two-way analysis of covariance. This analysis included an interaction term between the two apps (*AR-Counting* app and *CAM* app) and gender (male/female) to investigate the effect of gender.

To test the null hypotheses $H_0$2.1, which aim to investigate whether significant differences exist in accounting asset achievement assessments between male and female students across different groups. This study conducted separate analyses of covariance (ANCOVA). Specifically, one analysis compared the accounting asset achievement of male and female students using the *AR-Counting* app, while another compared the accounting asset achievement of male and female students using the *CAM* app. In both analyses, pretest scores were included as covariates.

9. Results

9.1 ANCOVA Results for $H_0$1:

This study posits the null hypothesis $H_0$1 that "there is no significant difference in accounting asset achievement between the two groups of university students", and statistically tests this through analysis of covariance (ANCOVA). This analysis used pretest as a covariate to control for differences in the initial accounting knowledge levels between the *AR-Counting* app and *CAM* app students. The Levene's test for homogeneity of variances failed to reach statistical significance ($F(1, 58) = 0.780$, $p = .381$), supporting the hypothesis that the dependent variables satisfy homogeneity of variances.

Table 1. Tests of Between-Subjects Effects

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	η^2
Corrected Model	5436.476[a]	2	2178.3238	9.484	.000	0.250
Intercept	3758.504	1	3728.504	13.009	.001	0.186
Pretest	3029.809	1	3029.809	10.571	.002	0.156
Group	2077.840	1	2077.840	7.250	.009	0.113
Error	16336.858	57	286.612			
Total	114600.000	60				
Corrected Total	21773.333	59				

a. R Squared =.250 (Adjusted R Squared = 0.223)

The group results are $F(1, 57) = 7.250$, $p = 0.009 < 0.05$. The adjusted means further indicated that students using *AR-Counting* demonstrated significantly higher accounting asset achievement than those using *CAM* app. Therefore, $H_0$1 is rejected.

9.2 Two-Way ANCOVA Results for H02

To test $H_0$2, namely that there is no significant difference accounting asset knowledge achievement between students of different gender. The Levene's test for homogeneity of variances failed to reach statistical significance ($F(3, 56) = 0.286$, $p = .835$), supporting the hypothesis that the dependent variables satisfy homogeneity of variances.

Table 2. Tests of Between-Subjects Effects

Source	ɔe III Sum of Squares	df	Mean Square	F	Sig.	η²
Corrected Model	**6980.420[a]**	**2**	**1745.105**	**6.488**	**.000**	**. 321**
Intercept	**3327.448**	**1**	**3327.448**	**12.371**	**.001**	**.184**
Pretest	**3317.086**	**1**	**3317.086**	**3.352**	**.001**	**.183**
Group	**2060.301**	**1**	**2060.301**	**6.504**	**.008**	**.122**
Gender	**223.404**	**1**	**223.404**	**2.118**	**.366**	**.015**
Group* Gender	**1310.860**	**1**	**1310.860**	**6.389**	**.031**	**.081**
Error	**14792.914**	**55**	**268.962**			
Total	**114600.000**	**60**				
Corrected Total	**21773.333**	**59**				

a. R Squared =.321 (Adjusted R Squared = .271)

The main effect F (1, 55) = 6.504, p = 0.008, suggesting that the type of learning app had a significant effect on students' accounting asset achievement. The main effect of gender (1, 55) = 2.118, p = 0.366. the Group* Gender results are F (1, 55) = 6.389, p = 0.031, indicating that the effectiveness of the learning apps differed by gender. Therefore, $H_0$2 is rejected.

9.3 Separate ANCOVA Results for $H_0$2.1

9.3.1 Results for $H_0$2.1

To test Hypothesis $H_0$2.1, there is no significant difference in accounting asset achievement assessments between male and female students using *AR-Counting* app. The Levene's test for homogeneity of variances failed to reach statistical significance (F (1, 28) = 1.128, p = 0.297), supporting the hypothesis that the dependent variables satisfy homogeneity of variances.

Table 3. Tests of Between-Subjects Effects

Source	ɔe III Sum of Squares	df	Mean Square	F	Sig.	η²
Corrected Model	**6840. 333[a]**	**2**	**3130.667**	**13.890**	**0.000**	**0.507**
Intercept	**1122.717**	**1**	**1122.717**	**4.981**	**0.034**	**0.156**
Pretest	**5408.000**	**1**	**5408.000**	**23.995**	**0.000**	**0.471**
Gender	**1010.058**	**1**	**1010.058**	**4.482**	**0.044**	**0.142**
Error	**6085.333**	**27**	**225.383**			
Total	**72200.000**	**30**				
Corrected Total	**12346.667**	**29**				

a. R Squared = 0.529 (Adjusted R Squared = 0.494)

The pretest results showed a significant effect, F (1, 27) = 23.995, p < .001, indicating that initial achievement levels were a strong predictor of final achievement. For gender, the results also revealed a significant difference, F (1, 27) = 4.482, p = .044, suggesting that male and female students in the *AR-Counting* app group differed significantly in their accounting asset achievement. Therefore, the null hypothesis ($H_0$2.1) was rejected.

Discussion

The analysis of accounting asset achievement of students using *AR-Counting* app and *CAM* app revealed lots of findings. Firstly, the results of the hypothesis $H_0$1 showed a significant difference in accounting asset achievement between university students using *AR-Counting* app and those using *CAM* app. This demonstrates that *AR-Counting* app accounting asset achievement effectively than *CAM* app.

The results of testing Hypothesis $H_0$2 reveal significant gender differences. Specifically, the ANCOVA analysis for $H_0$2.1 confirms that female users of the AR counting application significantly underperformed males in accounting asset grades, indicating that the application's inherent limitations disproportionately disadvantaged female users.

Conclusions

This study demonstrates that the *AR-Counting* App can significantly improve university students' achievement in learning accounting assets compared with the conventional accounting mobile learning application (*CAM* App). Grounded in Constructivist Theory, Cognitive Load Theory, and the Cognitive Theory of Multimedia Learning, the *AR-Counting* App provides learners with interactive and visually enhanced learning experiences that facilitate the understanding of abstract accounting concepts. The findings suggest that augmented reality has considerable potential to support accounting education by improving students' comprehension and academic performance. Furthermore, the study reveals that gender may influence students' learning outcomes when using AR-based learning environments, highlighting the need for future research to explore gender-sensitive instructional design strategies.

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