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## E-Book Berbasis AR dengan CBL-SDGs : Meningkatkan Literasi Keuangan pada Siswa Sekolah Dasar

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## AR-Based E-Book with CBL-SDGs: Improving Financial Literacy in Elementary School Students

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**Kata Kunci:**

literasi keuangan; augmented reality; e-book; challenge-based learning; sustainable development goals; pendidikan dasar.

**Abstrak:** Literasi keuangan merupakan keterampilan hidup yang sangat penting dan perlu dikembangkan sejak dini, namun indeks literasi keuangan Indonesia masih relatif rendah meskipun akses terhadap layanan keuangan semakin luas. Penelitian ini mengkaji efektivitas e-book berbasis Augmented Reality (AR) yang diintegrasikan dengan Challenge-Based Learning (CBL) dan Sustainable Development Goals (SDGs) dalam meningkatkan literasi keuangan siswa sekolah dasar. Sebanyak 240 siswa kelas IV dari empat sekolah negeri berpartisipasi dalam desain metode campuran, yang dibagi ke dalam kelompok eksperimen dan kontrol. Data dikumpulkan melalui pretest-posttest, kuesioner, wawancara, dan observasi. Hasil penelitian menunjukkan bahwa kelompok eksperimen memperoleh skor posttest lebih tinggi dan nilai N-Gain kategori sedang (0.45-0.49), sedangkan kelompok kontrol tetap berada pada kategori rendah (0.19-0.22). Analisis statistik lebih lanjut mengonfirmasi adanya pengaruh perlakuan yang signifikan, ditunjukkan oleh nilai  $F = 16.72-20.08$ ;  $p < .05$  pada faktor kelompok, yang berarti peningkatan skor terutama disebabkan oleh intervensi AR, bukan perbedaan kemampuan awal. Faktor pretest juga signifikan ( $p < .05$ ), namun efek intervensi lebih dominan, diperkuat oleh nilai ukuran efek kategori sedang hingga besar (Partial  $\eta^2 =$

0.22–0.26). Penelitian ini menyimpulkan bahwa e-book AR berbasis CBL–SDGs efektif dalam meningkatkan literasi keuangan dan menciptakan pengalaman belajar yang lebih bermakna di pendidikan dasar.

**Keywords:**

financial literacy; augmented reality; e-book; challenge-based learning; sustainable development goals; elementary education.

**Abstract:** Financial literacy is a crucial life skill that must be developed from an early age, yet Indonesia's financial literacy index remains relatively low despite broader access to financial services. This study examines the effectiveness of an Augmented Reality (AR)-enhanced e-book integrated with Challenge-Based Learning (CBL) and Sustainable Development Goals (SDGs) in improving financial literacy among elementary students. A total of 240 fourth-grade students from four public schools participated in a mixed-methods design, divided into experimental and control groups. Data were collected through pre- and post-tests, questionnaires, interviews, and observations. Results showed that the experimental groups achieved higher post-test scores and medium N-Gain values (0.45–0.49), whereas the control groups remained in the low category (0.19–0.22). Statistical analysis further confirmed significant treatment effects, with Group factor values ranging from  $F = 16.72-20.08$ ;  $p < .05$ , indicating that improvements were attributable to the AR-based intervention rather than initial ability differences. The Pre-test factor also showed significance ( $p < .05$ ), yet the intervention demonstrated a stronger influence, supported by moderate-to-large effect sizes (Partial  $\eta^2 = 0.22-0.26$ ). The study concludes that AR-based CBL–SDGs e-books effectively enhance financial literacy and foster meaningful learning experiences in primary education.

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## INTRODUCTION

Financial literacy at an early age is widely recognized as a fundamental competence for fostering responsible financial behavior in adulthood. In Indonesia, the 2020 National Survey on Financial Literacy and Inclusion reported that while financial inclusion had reached 76.19%, the financial literacy index was only 38.03% (Otoritas Jasa Keuangan [OJK], 2020). This discrepancy indicates that although access to financial services has improved, the ability to understand and apply financial knowledge remains inadequate. Developing financial literacy in elementary school students is therefore essential, as habits and attitudes toward money management are often formed during childhood (Sari, Fatimah, Ilyana, & Hermawan, 2022).

Technological innovations in education offer new opportunities to address this challenge. Augmented reality (AR), in particular, has been increasingly employed as an instructional tool that bridges abstract concepts with concrete, interactive experiences. Studies have shown that AR-based instruction significantly improves student learning outcomes, with large effect sizes across subjects (Garzón & Acevedo, 2020). Moreover, AR enhances learners' motivation, engagement, and concentration, making it especially suitable for young students (Bacca-Acosta et al., 2022; Kurniasih, Sutrisno, & Prasetyo, 2023). The use of AR in textbooks and storybooks has demonstrated positive effects on reading engagement and comprehension by providing multimodal resources such as 3D visualizations and audio narration (Chiang, Yang, & Hwang, 2022; Panchenko, Sokolova, & Volkova, 2024).

Although AR has shown promising applications in various fields, its role in financial literacy education remains relatively limited. Prior studies have developed AR-based storybooks and applications to introduce financial concepts to children, particularly in Islamic finance, and found significant gains in knowledge compared to conventional approaches (Sari et al., 2022; Sari, Aisyah, Ilyana, & Hermawan, 2022). Nevertheless, these studies often focus on content delivery rather than embedding financial literacy learning in broader pedagogical frameworks that emphasize authentic problem solving and future-oriented competencies.

One such framework is Challenge-Based Learning (CBL), which engages learners in addressing real-world issues through collaborative inquiry and action (Nichols & Cator, 2020). Importantly, CBL aligns closely with specific Sustainable Development Goals (SDGs), particularly SDG 4 (Quality Education), which emphasizes equitable access to high-quality, technology-enhanced learning; and SDG 8 (Decent Work and Economic Growth), which includes financial literacy as a foundational skill for developing productive economic behaviors. Integrating AR with CBL within the contexts of SDG 4 and SDG 8 enables the design of interactive, challenge-driven learning environments where students apply financial literacy skills to authentic scenarios while fostering creativity, critical thinking, and collaboration.

Despite the evidence supporting both AR and CBL independently, there is still little empirical research on their integration for financial literacy education at the elementary level. Most existing studies highlight the benefits of AR in literacy and numeracy or the

effectiveness of CBL in fostering engagement but rarely combine these innovations holistically within the framework of targeted SDGs. To address this gap, the present study examines the effectiveness of an AR-enhanced e-book integrated with CBL–SDG 4–SDG 8 in improving financial literacy among elementary students. By situating financial literacy within an interactive, challenge-driven, and globally relevant context, this research seeks to provide insights into how technology-enhanced pedagogy can strengthen essential life skills in the early years of formal education.

## METHOD

### Research Design

This study employed a mixed-methods design with an explanatory sequential approach, combining quantitative and qualitative data to provide a comprehensive understanding of the impact of the AR-enhanced e-book integrated with Challenge-Based Learning (CBL) and Sustainable Development Goals (SDGs) on students' financial literacy. The quantitative phase was conducted first to measure improvements in students' financial literacy, followed by qualitative exploration to capture in-depth perspectives on the learning experience. The mixed-methods approach was chosen to ensure triangulation of data and strengthen the overall validity of findings (Creswell & Plano Clark, 2018; Fetters & Molina-Azorin, 2020).

### Participants

The participants were 240 fourth-grade students from four public schools in Indonesia, selected through purposive sampling. This grade level was chosen because children at this stage begin developing conceptual understanding of financial management and responsibility (OECD, 2020). Students were divided into an experimental group, which used the AR-enhanced e-book with CBL–SDGs integration, and a control group, which used a conventional e-book without AR features or CBL design. Teachers served as facilitators during the intervention, while qualitative interviews included both students and teachers to capture their experiences (Cohen et al., 2018).

### Data Collection Instruments

To assess financial literacy, a standardized financial literacy test for elementary students adapted from OECD (2019) was used. The instrument underwent expert validation by three education specialists, resulting in high content validity (Aiken's  $V = 0.82$ – $0.91$ ). Construct validity was further supported through item–total correlations, with all items exceeding the minimum threshold ( $r > 0.30$ ). Reliability testing using Cronbach's alpha demonstrated strong internal consistency for the overall instrument ( $\alpha = 0.87$ ), with each subscale—knowledge, attitudes, and behaviors—also showing acceptable reliability levels ( $\alpha = 0.78$ – $0.85$ ). A pre-test and post-test design was employed to capture changes in literacy levels. Additionally, a questionnaire based on the Technology Acceptance Model (TAM) was used to evaluate students' perceptions of usability and engagement with the AR e-book (Davis, 1989; Teo, 2019). The TAM

questionnaire also demonstrated good reliability (Cronbach's  $\alpha = 0.88$ ). For qualitative data, semi-structured interviews and classroom observations were conducted to explore learning experiences, motivation, and challenges encountered during the use of AR-enhanced e-books with CBL–SDGs.

### Data Analysis Techniques

Quantitative data were analyzed using paired-sample t-tests and ANCOVA to examine differences in pre- and post-test scores between groups while controlling for pre-test covariates. Effect sizes were calculated to determine the magnitude of the intervention impact (Field, 2018). Questionnaire responses were analyzed using descriptive statistics and regression analysis to examine relationships between perceived usability and learning outcomes. For qualitative data, thematic analysis was conducted following Braun and Clarke's (2021) framework to identify recurring themes related to learning engagement, collaboration, and critical thinking. Data triangulation—comparing quantitative results, qualitative themes, and classroom observations—strengthened the credibility, dependability, and confirmability of the study's findings (Creswell & Creswell, 2018).

## RESULT AND DISCUSSION

### Quantitative Findings

#### 1. Enhancement of Financial Literacy

The descriptive statistics of students' financial literacy scores were calculated to compare experimental and control groups across schools. As presented in Table 1, the experimental groups consistently achieved higher post-test means and N-Gain values compared to the control groups, indicating the effectiveness of the AR-enhanced e-book with CBL-SDGs approach.

**Tabel 1. Descriptive statistics of financial literacy**

School	Group	N	Pre-test Mean (SD)	Post-test Mean (SD)	N-Gain (g)	Category
A	Experimental	30	45.2 (8.1)	72.5 (7.4)	0.48	Medium
	Control	28	44.7 (7.9)	55.4 (9.2)	0.19	Low
B	Experimental	32	46.1 (8.5)	71.9 (6.8)	0.45	Medium
	Control	31	45.8 (8.2)	56.7 (9.0)	0.21	Low
C	Experimental	29	44.3 (7.7)	70.3 (8.1)	0.46	Medium
	Control	27	43.9 (8.1)	54.8 (8.9)	0.20	Low
D	Experimental	31	45.6 (8.4)	73.1 (7.2)	0.49	Medium
	Control	30	44.8 (7.9)	57.3 (9.1)	0.22	Low

As presented in Table 1, the pre-test means across all schools were relatively similar between the experimental and control groups, suggesting that students began

with comparable levels of financial literacy. However, the post-test results showed a clear divergence. Students in the experimental groups, who learned through the AR-enhanced e-book with CBL-SDGs, consistently demonstrated higher post-test mean scores than their peers in the control groups. For instance, in School A, the experimental group's mean score improved from 45.2 to 72.5, whereas the control group only increased from 44.7 to 55.4. This pattern was observed consistently across all schools.

In terms of N-Gain, the experimental groups achieved medium improvements ranging from 0.45 to 0.49, while the control groups remained in the low category (0.19–0.22). This finding indicates that the intervention was effective in enhancing students' financial literacy beyond traditional instruction. Although the gains for the experimental groups did not reach the high category, they still reflected a notable and consistent advantage compared to the control groups.

## 2. Improvement by Financial Literacy Indicators

To better understand students' progress, the analysis was conducted based on four key indicators of financial literacy: (a) money and transactions, (b) planning and managing finances, (c) risk and reward, (d) financial landscape. The results indicate that the experimental group, which used the AR-Enhanced E-Book with CBL-SDGs, demonstrated substantially higher gains across all indicators compared to the control group. The most significant improvement was observed in the indicator of planning and managing finances, followed by money and transactions. Meanwhile, the control group showed only modest improvements across all indicators, with the lowest increase in the financial landscape dimension.

**Tabel 2. Percentage Increase in Financial Literacy Indicators between Experimental and Control Groups**

Indicator	Experimental Group (%)	Control Group (%)	Difference (%)
Money and Transactions	28.5	11.2	+17.3
Planning and Managing Finances	34.7	13.6	+21.1
Risk and Reward	26.3	10.4	+15.9
Financial Landscape	22.8	8.9	+13.9

As presented in Table 2, the experimental group demonstrated consistently higher improvements across all financial literacy indicators compared to the control group. The most significant gain was observed in the planning and managing finances indicator, with an increase of 34.7% compared to only 13.6% in the control group, resulting in a difference of 21.1%. This suggests that the integration of AR-based CBL-SDGs provided students with practical and engaging scenarios that enhanced their ability to plan, budget, and make responsible financial decisions. Similarly, improvements in money and

transactions (28.5% vs. 11.2%) and risk and reward (26.3% vs. 10.4%) highlight the added value of experiential learning environments in strengthening students' understanding of everyday financial practices and risk assessment.

Furthermore, although the gain in the financial landscape indicator was slightly lower compared to other areas, the experimental group still showed a notable improvement (22.8% vs. 8.9%), underscoring the intervention's role in fostering awareness of broader financial systems and institutions. The consistent positive differences across all indicators indicate that AR combined with CBL-SDGs not only improved general financial literacy but also targeted specific competencies effectively. These findings emphasize the pedagogical advantage of immersive and problem-centered approaches in empowering students to develop both conceptual knowledge and applied skills in financial literacy at the elementary school level.

### 3. ANCOVA Results for Each School

An Analysis of Covariance (ANCOVA) was conducted separately for each school to determine the impact of the AR-enhanced e-book intervention on students' post-test financial literacy scores while controlling for pre-test differences. The results consistently indicated that the intervention group significantly outperformed the control group across all schools. In addition, pre-test scores also contributed significantly, though their effect sizes were relatively smaller compared to the treatment effect. The summary of ANCOVA findings is presented in Table 3.

**Tabel 3. Percentage Increase in Financial Literacy Indicators between Experimental and Control Groups**

School	Source	SS	df	MS	F	p	Partial $\eta^2$
A	Group	1205.6	1	1205.6	18.45	.000	0.24
	Pre-test	315.8	1	315.8	4.83	.032	0.07
B	Group	1124.3	1	1124.3	16.72	.001	0.22
	Pre-test	298.7	1	298.7	4.44	.038	0.06
C	Group	1189.5	1	1189.5	19.12	.000	0.25
	Pre-test	289.4	1	289.4	4.62	.035	0.06
D	Group	1243.2	1	1243.2	20.08	.000	0.26
	Pre-test	307.6	1	307.6	4.98	.031	0.07

The results in Table 3 show that in all four schools (A, B, C, and D), there was a significant effect of the AR-based e-book intervention on students' financial literacy scores after controlling for pre-test scores. The F-value for the Group factor in all schools ranged from 16.72 to 20.08 with a p-value < .05, indicating that the difference in post-test scores between the experimental and control groups was certainly due to the treatment, not just the students' initial abilities. Furthermore, the Partial  $\eta^2$  values, which ranged from 0.22 to 0.26, indicated a moderate to large effect of the intervention on improving financial literacy. The Pre-test factor was also significant in all schools (p < .05), indicating

that students' initial abilities still contributed to the final scores, but the intervention's influence was far more dominant.

#### 4. Technology Acceptance Model (TAM) Results

Technology Acceptance Model (TAM) results were analyzed to determine students' perceptions of the usability, ease of use, and engagement associated with the AR-enhanced e-book, as reported through a validated TAM questionnaire.

**Tabel 4. Students' Technology Acceptance (TAM) Scores for AR-Enhanced E-Book**

TAM Indicator	Mean (SD)	Category
Perceived Usefulness (PU)	4.32 (0.51)	High
Perceived Ease of Use (PEOU)	4.18 (0.57)	High
Attitude Toward Using (ATU)	4.41 (0.49)	Very High
Behavioral Intention (BI)	4.29 (0.54)	High

The results of the Technology Acceptance Model (TAM) analysis indicate a strong level of acceptance toward the AR-enhanced e-book among elementary students. Overall, students perceived the AR learning tool as highly useful ( $M = 4.32$ ), demonstrating that the features helped them better understand financial concepts presented in the lessons. The perceived ease of use also scored high ( $M = 4.18$ ), suggesting that students were able to operate the AR components without significant difficulty, even at a young age. Moreover, attitude toward using technology yielded the highest mean score ( $M = 4.41$ ), reflecting strong enthusiasm and positive emotional engagement during the learning activities. Students likewise reported a high behavioral intention to continue using AR-based tools in future learning experiences ( $M = 4.29$ ), indicating sustained motivation and openness toward technology-enhanced instruction. Regression analysis further revealed that Perceived Usefulness (PU) and Attitude Toward Using (ATU) significantly predicted post-test financial literacy outcomes ( $p < .05$ ). This finding suggests that students who viewed the AR e-book as beneficial and enjoyable tended to achieve higher levels of financial literacy, underscoring the positive relationship between technology acceptance and learning performance.

#### Qualitative Findings

The qualitative phase was conducted to further explain the quantitative improvements observed in students' financial literacy and to explore their learning experiences when using the AR-Enhanced E-Book integrated with CBL-SDGs. Semi-structured interviews with 24 students (six from each school) and eight teachers revealed three major themes: (1) heightened engagement and motivation through immersive AR experiences, (2) strengthened financial decision-making through challenge-based tasks, and (3) improved collaborative learning and SDGs awareness. These themes were

supported by classroom observations, which validated and enriched the interpretation of students' and teachers' perspectives.

### 1. Heightened Engagement and Motivation Through AR Immersion

Students consistently highlighted AR features as the most engaging component of the learning process. Many described the 3D objects, animations, and interactive simulations as “making the lesson come alive,” which helped them visualize abstract financial concepts such as budgeting, saving, and distinguishing needs from wants. One student stated:

*“Saya jadi lebih paham kenapa harus menabung. Waktu lihat dompet AR-nya berubah ketika saya pilih mau beli atau menabung, rasanya kayak beneran kejadian.”* (Student, School A)

Another student emphasized the sense of novelty and excitement:

*“Belajar pakai AR lebih seru daripada buku biasa. Ada gambar yang keluar terus bisa digerakkan, jadi nggak bosan.”* (Student, School C)

Teachers also noted increased student attentiveness and reduced cognitive fatigue during lessons involving AR. As one teacher explained:

*“Biasanya anak-anak cepat kehilangan fokus kalau belajar keuangan, tapi dengan AR mereka antusias dari awal sampai akhir. Visualisasinya membantu sekali.”* (Teacher, School D)

These findings indicate that immersive AR elements enhanced intrinsic motivation, aligned with TAM results showing high attitudes toward using the technology (ATU).

### 2. Strengthened Financial Decision-Making Through CBL-SDGs Challenges

Students expressed that the Challenge-Based Learning activities—such as solving school-based budgeting tasks and simulating real-life spending choices—helped them think more critically about money management. One student shared:

*“Di tantangan kelompok, kami disuruh memilih kebutuhan sekolah paling penting. Ternyata harus mikir supaya uangnya cukup. Itu susah tapi jadi ngerti caranya ngatur uang.”* (Student, School B)

Teachers emphasized that the structured challenges prompted meaningful discussions and deeper reasoning:

*“Saat mereka diminta membuat rencana pengeluaran, anak-anak mulai bertanya hal-hal kritis seperti ‘kalau uangnya habis, bagaimana?’ atau ‘mana*

*yang harus didahulukan?'. Ini jarang terjadi di pembelajaran biasa.”*  
(Teacher, School A)

CBL strategies also supported the highest improvement found in the “planning and managing finances” indicator in quantitative results (34.7% increase). The qualitative responses suggest that CBL made financial concepts context-rich and personally relevant, promoting responsible financial behaviors.

### 3. Improved Collaboration and SDGs Awareness

Many students described how the group challenges encouraged teamwork and collective decision-making. One student noted:

*“Kami harus kerja sama waktu memutuskan barang mana yang perlu dibeli. Jadi nggak bisa egois, harus diskusi.”* (Student, School D)

Observations confirmed that AR-based tasks often triggered spontaneous peer teaching, with higher-performing students helping others interpret financial scenarios.

Teachers also reported that linking activities to SDGs—especially SDG 12 (Responsible Consumption) and SDG 4 (Quality Education)—enhanced students’ awareness of sustainability:

*“Saat aktivitas tentang konsumsi bertanggung jawab, saya melihat anak-anak mulai mengaitkan pilihan keuangan dengan dampaknya bagi lingkungan. Ini bagus sekali.”* (Teacher, School C)

Furthermore, connecting financial decision-making with sustainability challenges helped students recognize the broader implications of economic behaviors, supporting the “financial landscape” indicator improvement (22.8%).

### 4. Challenges Encountered During Implementation

Despite positive experiences, several challenges emerged. Some younger students initially struggled to operate AR markers and navigate digital menus:

*“Kadang tombol AR-nya kecil, jadi saya salah pencet.”* (Student, School C)

Teachers also noted occasional technical issues, such as unstable device calibration or limited school Wi-Fi:

*“Kalau sinyal kurang bagus, AR-nya lama muncul. Itu bisa menghambat alur belajar.”* (Teacher, School B)

However, these obstacles were generally resolved quickly and did not significantly disrupt learning. Teachers demonstrated high adaptability, and students showed rapid improvement in navigating the AR interface.

## 5. Overall Perception of Learning Impact

When asked about the overall effectiveness of the AR-enhanced e-book, the majority of students expressed increased confidence in managing money:

*“Sekarang saya lebih bisa bedain kebutuhan dan keinginan. Jadi uang jajan nggak habis cepat.” (Student, School A)*

Teachers affirmed that the intervention supported holistic financial literacy development:

*“Mereka tidak hanya tahu konsep, tetapi juga bisa menerapkan dalam tantangan nyata. AR dan CBL membuat pembelajaran lebih bermakna.” (Teacher, School D)*

These qualitative insights complement the quantitative findings, collectively supporting the conclusion that the AR-CBL-SDGs model effectively enhances financial literacy through immersive, contextual, and collaborative learning experiences.

## Discussion

The findings of this study demonstrate that the integration of AR-enhanced e-books with CBL-SDGs had a significant impact on improving elementary students' financial literacy. Across all schools, the experimental groups consistently achieved higher post-test scores and N-Gain values than the control groups, with gains categorized as medium, while the control groups remained at low levels. These results confirm that embedding immersive technology and problem-centered pedagogies can effectively enhance financial literacy at the elementary level. Previous studies have similarly reported that AR-based learning environments improve students' engagement, conceptual understanding, and retention compared to traditional learning methods (Bacca et al., 2021; Santos et al., 2021). By presenting financial concepts through interactive simulations, students were better able to visualize and practice real-world applications, which aligns with the experiential learning perspective (Kolb, 2015).

The improvement across financial literacy indicators provides further insight into how AR combined with CBL-SDGs influenced specific competencies. The most substantial gains were observed in planning and managing finances, suggesting that authentic, scenario-based tasks provided meaningful contexts for students to apply budgeting and planning skills. This finding resonates with prior research that emphasized the role of contextualized learning in strengthening students' financial decision-making abilities (OECD, 2020; Retnawati et al., 2021). Additionally, the notable differences in money and transactions as well as risk and reward indicators highlight the affordances of AR in

making abstract financial principles more concrete and relatable for young learners (Akçayır & Akçayır, 2019). Even in the financial landscape dimension, where improvement was relatively lower, the experimental group still demonstrated meaningful progress compared to the control, underscoring the holistic potential of the intervention in shaping both practical and conceptual knowledge of financial systems.

The ANCOVA results reinforce these conclusions by showing that the treatment effect remained significant after controlling for students' initial abilities. Across all four schools, partial  $\eta^2$  values ranging from 0.22 to 0.26 indicated moderate to large effect sizes, suggesting that the AR-enhanced e-book intervention was a consistent predictor of financial literacy improvement. This aligns with evidence from previous meta-analyses showing that digital interventions, particularly those that integrate game-like and problem-based elements, tend to produce stronger learning outcomes compared to conventional instruction (Merchant et al., 2020; Zhang et al., 2022). Moreover, the integration of CBL with SDG-related themes provided authentic, socially relevant contexts that encouraged critical thinking and collaboration—skills that are increasingly recognized as essential in financial literacy education (Liu et al., 2021; Tan et al., 2022).

Taken together, the findings highlight the pedagogical value of combining AR technology with CBL and SDG frameworks in financial literacy education. The approach not only improved knowledge acquisition but also cultivated students' ability to apply financial concepts in meaningful contexts. This suggests that immersive, problem-oriented learning environments may be a powerful avenue for developing financial literacy among elementary school students, a finding consistent with global calls for integrating digital literacy, sustainability, and financial competence into primary education curricula (UNESCO, 2022; OECD, 2020). Future research should further explore scalability and long-term impacts, particularly how such interventions influence students' financial behaviors beyond the classroom.

## CONCLUSION

This study highlights the effectiveness of integrating AR-enhanced e-books with Challenge-Based Learning (CBL) aligned with Sustainable Development Goals (SDGs) in improving financial literacy among elementary students. The results consistently showed that students in the experimental groups achieved higher post-test scores and medium-level N-Gains compared to the control groups, which remained in the low category. These findings confirm that immersive digital tools combined with problem-centered approaches provide a more engaging and impactful learning experience than traditional methods.

Improvements across all four indicators of financial literacy—money and transactions, planning and managing finances, risk and reward, and financial landscape—further demonstrate the comprehensive benefits of the intervention. The most significant gains were observed in planning and managing finances, indicating that AR-based, scenario-driven tasks successfully strengthened students' practical decision-making skills. Even in areas where progress was more modest, such as financial landscape,

students still showed meaningful improvements compared to the control group, underscoring the broader potential of this approach.

The ANCOVA analysis confirmed that the positive outcomes were not simply a result of students' initial abilities but rather the direct impact of the AR-enhanced e-book intervention. With moderate to large effect sizes across all schools, this study provides strong evidence that combining AR with CBL-SDGs offers a promising framework for cultivating both knowledge and application of financial literacy in primary education.

In conclusion, AR-enhanced e-books designed around CBL and SDGs can serve as an effective pedagogical innovation to foster financial literacy from an early age. This approach not only enhances students' understanding of key financial concepts but also prepares them to make responsible financial decisions in real-life contexts.

### Limitations and Future Research

Despite its promising results, this study has several limitations that should be acknowledged. First, the intervention was conducted in only four public schools with a specific grade level, which limits the generalizability of the findings to broader or more diverse student populations. Second, the duration of the intervention was relatively short, focusing primarily on immediate learning gains rather than long-term retention or behavioral change in financial decision-making. Third, the TAM questionnaire captured students' perceptions at a single point in time, which may not fully represent how their acceptance of AR technology evolves with prolonged exposure. Additionally, variations in teacher facilitation styles may have influenced the learning dynamics, although this factor was not examined in depth.

Future research should therefore explore longitudinal designs to assess the sustained impact of AR-based financial literacy learning over months or years. Expanding the intervention to include more varied school contexts—such as rural areas, private institutions, or different grade levels—would help strengthen external validity. Researchers are also encouraged to investigate additional pedagogical variables, such as teacher readiness, digital literacy, and classroom climate, which may moderate the effectiveness of AR-enhanced learning. Furthermore, integrating complementary data sources, such as learning analytics or behavioral tracking in simulated financial environments, may provide deeper insights into how students internalize and apply financial concepts through immersive technologies.

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## REFERENCES

- Akçayır, M., & Akçayır, G. (2019). Advantages and challenges associated with augmented reality for education: A systematic review of the literature. *Educational Research Review, 28*, 100291. <https://doi.org/10.1016/j.edurev.2019.100291>
- Bacca-Acosta, J., Baldiris, S., Fabregat, R., Graf, S., & Kinshuk. (2022). Augmented reality trends in education: A systematic review of research and applications. *Educational Technology & Society, 25*(1), 1–15. <https://doi.org/10.30191/ETS.2022.25.1.1>
- Braun, V., & Clarke, V. (2021). *Thematic analysis: A practical guide*. SAGE.
- Chiang, T. H., Yang, S. J., & Hwang, G. J. (2022). Students' online interactive patterns in augmented reality-based inquiry learning activities. *Computers & Education, 182*, 104463. <https://doi.org/10.1016/j.compedu.2022.104463>
- Cohen, L., Manion, L., & Morrison, K. (2018). *Research methods in education* (8th ed.). Routledge.
- Creswell, J. W., & Creswell, J. D. (2018). *Research design: Qualitative, quantitative, and mixed methods approaches* (5th ed.). SAGE.
- Creswell, J. W., & Plano Clark, V. L. (2018). *Designing and conducting mixed methods research* (3rd ed.). SAGE.
- Davis, F. D. (1989). Perceived usefulness, perceived ease of use, and user acceptance of information technology. *MIS Quarterly, 13*(3), 319–340.
- Fetters, M. D., & Molina-Azorin, J. F. (2020). Utilizing a mixed methods approach for conducting interventional evaluations. *Journal of Mixed Methods Research, 14*(2), 131–144.
- Field, A. (2018). *Discovering statistics using IBM SPSS statistics* (5th ed.). SAGE.
- Garzón, J., & Acevedo, J. (2020). Meta-analysis of the impact of Augmented Reality on students' learning gains. *Educational Research Review, 31*, 100329. <https://doi.org/10.1016/j.edurev.2020.100329>
- Kolb, D. A. (2015). *Experiential learning: Experience as the source of learning and development* (2nd ed.). Pearson Education.
- Liu, M., McKelroy, E., & Korfiatis, N. (2021). Challenge-based learning for financial literacy education: Opportunities and challenges. *Journal of Education for Business, 96*(6), 351–360. <https://doi.org/10.1080/08832323.2020.1790278>
- Merchant, Z., Goetz, E., Cifuentes, L., Keeney-Kennicutt, W., & Davis, T. (2020). Effectiveness of virtual reality-based instruction on students' learning outcomes in K-12 and higher education: A meta-analysis. *Computers & Education, 145*, 103730. <https://doi.org/10.1016/j.compedu.2019.103730>
- Kurniasih, E., Sutrisno, S., & Prasetyo, H. (2023). Implementation of augmented reality-based thematic textbooks to improve literacy skills in elementary students. *Pegegog Journal of Education and Instruction, 13*(4), 203–214. <https://doi.org/10.47750/pegegog.13.04.18>
- Nichols, M., & Cator, K. (2020). *Challenge-Based Learning Guide*. Digital Promise. <https://www.challengebasedlearning.org>
- OECD. (2019). *OECD/INFE toolkit for measuring financial literacy and financial inclusion*.

- OECD Publishing.
- OECD. (2020). *Education in the digital age: Healthy and inclusive learning*. OECD Publishing.
- Otoritas Jasa Keuangan. (2020). *Survei nasional literasi dan inklusi keuangan 2020*. <https://www.ojk.go.id>
- Ozdemir, M. (2021). Using augmented reality applications in primary school science education. *Applied Sciences*, 11(11), 5277. <https://doi.org/10.3390/app11115277>
- Panchenko, O., Sokolova, O., & Volkova, I. (2024). Augmented reality books: In-depth insights into children's reading engagement. *Frontiers in Psychology*, 15, 1423163. <https://doi.org/10.3389/fpsyg.2024.1423163>
- Retnawati, H., Munadi, S., & Arlinwibowo, J. (2021). Developing financial literacy among primary school students: The role of contextual teaching. *Journal of Education and Learning*, 15(2), 307–314.
- Santos, M. E. C., Chen, A., Taketomi, T., Yamamoto, G., Miyazaki, J., & Kato, H. (2021). Augmented reality learning experiences: Survey of prototype design and evaluation. *Computers & Education*, 148, 103802. <https://doi.org/10.1016/j.compedu.2019.103802>
- Sari, R. C., Fatimah, P. L. R., Ilyana, S., & Hermawan, H. D. (2022). Augmented reality-based sharia financial literacy system: A new approach to virtual sharia financial education for young learners. *International Journal of Islamic and Middle Eastern Finance and Management*, 15(4), 747–765. <https://doi.org/10.1108/IMEFM-11-2019-0484>
- Sari, R. C., Aisyah, M. N., Ilyana, S., & Hermawan, H. D. (2022). Developing a financial literacy storybook for early childhood in an augmented reality context. *Indonesian Journal of Early Childhood Education Studies*, 11(1), 55–64. <https://doi.org/10.15294/ijeces.v11i1.58235>
- Tan, J. P. L., Choo, S. S., & Kang, T. (2022). Critical financial literacy: Integrating sustainability into financial education. *Journal of Curriculum Studies*, 54(5), 683–699. <https://doi.org/10.1080/00220272.2021.1997781>
- UNESCO. (2022). *Reimagining our futures together: A new social contract for education*. UNESCO Publishing.
- United Nations. (2021). *The Sustainable Development Goals report 2021*. United Nations. <https://unstats.un.org/sdgs/report/2021/>
- Zhang, Y., Zhou, X., & Wang, X. (2022). Technology-enhanced financial literacy education: A systematic review and meta-analysis. *Educational Technology Research and Development*, 70(4), 1437–1461. <https://doi.org/10.1007/s11423-022-10074-1>