

The development of mobile learning based on augmented reality to strengthen student digital ethics



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Abstract Indonesia experiences low levels of digital civility, especially in Surakarta, where students are vulnerable to fake news and hate speech due to limited critical thinking skills. Digital ethics refers to safe, responsible, and ethical behavior by internet users. Incorporating augmented reality into Civic Education fosters digital ethics and promotes educational values among students. This research aims to develop augmented reality-based mobile learning tools suitable for Civic Education lessons. The research follows a 4D-development framework involving defining, designing, developing, and disseminating stages. The study involved 120 student participants and included validation by two academic experts, two media specialists, and four civic education teachers. Data collection methods encompassed observations, literature reviews, interviews, and questionnaires, with the questionnaire serving as the primary instrument. The results show that the augmented reality-based learning tool achieved excellent ratings: 85 from academic experts, 88 from media specialists, 86 from teachers, and 88 from students, categorizing it as very effective. The tool also improved students' digital ethics and is recommended for use in Civic Education programs.

Keywords: civic education, digital citizenship, e-learning

1. Introduction

The rapid advancement of information and communication technology in the 21st century has transformed the world and highlighted numerous cross-border challenges. These global issues include poverty, human rights, population growth, refugee crises, climate change, health concerns, energy resources, the global economy, and security (Hernandez-de-Menendez et al., 2020). John Cogan (Affandi & Nu'man Somantri, 2019) stated that such international problems are deeply connected to civic education, particularly concerning privacy and individual rights. Key challenges in this area involve balancing freedom of expression, demands for transparency, national and international security policies, and advancements in technology and data protection (Isdendi et al., 2023). According to Microsoft TRG (2021), Indonesia ranks 29th out of 32 countries in digital interaction on social media, placing it in Southeast Asia. The 2022 Indonesian Digital Literacy Index Survey for the Digital Ethics pillar reported a score of 3.76, revealing that most social media users still post content without obtaining permission. Additionally, many researchers struggle to verify the credibility of information, compare details from various sources, identify computer viruses, and differentiate between legitimate emails and those containing spam or malware. Social media interactions often involve decisions affected by ethnicity, religion, social status, and political views (Surya et al., 2021). A preliminary study conducted by researchers on digital ethics in Surakarta city, involving 90 respondents across 10 high schools, revealed that the majority fell into the low category, as shown in Table 1.

Table 1 Digital ethics of high school students in Surakarta.

Digital Ethics Category	Frequency	%
Low	83	92
Middle	6	7
High	1	1
Total	90	100

To overcome this problem, efforts are needed to develop ethical and responsible digital citizen behavior (Japar et al., 2024). The norms or values that need to be known to use technology appropriately and effectively in digital environments and online interactions are referred to as digital citizenship (Mossberger et al., 2008). Research Choi (2016) divides digital citizenship into four elements, namely, ethics, media and information literacy, critical resistance, and participation/engagement. "Awareness" is an important element in digital ethics, where digital citizens need to be aware of



political, social, cultural, economic and educational problems that originate from the use of digital technology and the internet. The topic of digital ethics needs to be added to the social science education curriculum to form ethical and responsible digital citizens (Longford, 2005; Vanfossen & Berson, 2008). Civic education aims to form citizens who are superior, responsible and have a noble character. From the current perspective, civic education has been considered to promote active and intelligent citizens in the digital world (Choi & Cristol, 2021; Erasmus+ Programme of the European Union, 2021).

Civic education has long been considered boring, monotonous and devoid of practical content (Zheng et al., 2019). There is a need to change teaching in the classroom to suit the digital generation living in the digital era, who likes fast learning, does not have reading resistance, and is accustomed to receiving short information (Abdilah et al., 2023). Augmented reality, as one of the core technologies of the future, has potential implications and benefits in teaching and learning environments, especially in terms of skills, attitudes and knowledge (Billinghurst et al., 2003). AR encourages students to understand their everyday environment, encourages authentic learning, and has been proven to increase learning motivation and learning outcomes and reduce boredom (Abdilah et al., 2023; Lim & Lim, 2020; Yang & Hwang, 2014). Integrating mobile learning into civic education offers a valuable opportunity to address these challenges, as it aligns with the preferences and habits of digital natives. This approach can effectively introduce digital ethics and educational value to its users. A preliminary study involving four high school teachers in Surakarta highlighted the critical need for digital ethics education. The teachers observed that current learning media are inadequate in providing meaningful learning experiences with digital ethics outcomes and fail to meet students' needs. As a result, they recommended the development of interactive media focused on digital ethics through mobile learning. These findings are supported by Halimi et al. (2022), who emphasize that mobile learning integration enhances educational experiences, improves digital ethics comprehension, and sustains student engagement without compromising learning objectives. Mobile learning can be enhanced with augmented reality (AR) technology, which visualizes objects in two or three dimensions within a real-world setting, making it an engaging and effective tool for education (Hutagalung & Rachman, 2023). AR is recognized for improving motivation and learning outcomes and is suitable for various subjects (Dinayusadewi et al., 2020). Studies such as those by Hutagalung & Rachman (2023) highlight AR's potential in civic education topics such as "National Integration," whereas others, such as Nurholisa et al. (2022), applied AR to teach social phenomena, and (Halimah & Sungkono, 2021) used puzzle-based AR to instill Pancasila values. This research uniquely focuses on "observing the law" for 10th-grade civic education, aligning AR's ability to simplify complex concepts through interactive tools such as 3D illustrations, quizzes, and images, bridging the virtual and real worlds (Wannapiroon et al., 2021). It integrates knowledge of law-abiding behavior; fosters values such as honesty, cooperation, and openness to opinions; and improves creativity by encouraging problem-solving and innovative thinking (Hutagalung & Rachman, 2023). Augmented reality media, when integrated with mobile learning, offers compatibility across various devices, providing an authentic learning experience that helps students acquire knowledge, skills, and attitudes relevant to current developments (Astrid Savitri, 2019; Branson, 2007; Rusli et al., 2022; Silva et al., 2023).

This research aims to develop AR-based mobile learning media for the topic "Obeying the Law" to enhance students' digital ethics. The outcome seeks to diversify learning tools, enabling teachers to create engaging and interactive learning environments in civic education and making the subject more appealing and effective for students.

2. Materials and methods

This study adopts Research and Development (R&D) method, which is designed to create products that undergo testing, evaluation, and refinement until they meet the desired standards (Gal, 2005). The R&D approach is employed to develop AR-based mobile learning media via the four-dimensional (4D) model introduced by (Thiagarajan et al., 1974), which consists of four stages: define, design, develop, and disseminate. The following is a description of each step of the research.

This stage aims to capture the gaps that provide opportunities for the development of a product through a mixed-methods approach. Three types of analysis were conducted: needs analysis, curriculum analysis, and material analysis. The quantitative approach was implemented through an online survey involving 90 students from 10 high schools in Surakarta via a random sampling technique that gave each member of the population an equal chance of being selected (Connolly, 2021). The characteristics of the respondents can be found in Table 2 in the results section. The analysis was conducted via the partial least squares (PLS) method with SmartPLS software. PLS was utilized to examine the level of students' digital ethics and the factors influencing digital ethics through two submodels, namely, the outer model and the inner model.

2.1. Outer Model

The reliability level of the PLS model was assessed via Cronbach's alpha and composite reliability. The analysis results revealed that both values exceeded 0.70, indicating strong reliability. Thus, the research variables demonstrated high internal consistency. Convergent validity was evaluated through the average variance extracted (AVE), with a minimum threshold of 0.50. The analysis results revealed that all the AVE values were above 0.50, indicating that more than 50% of the variance in the indicators was successfully explained by their respective constructs, thereby confirming convergent validity.

After meeting the criteria for validity, reliability, and convergent validity in the measurement model evaluation, the next step was to assess discriminant validity. Discriminant validity ensures that each research variable is empirically and theoretically distinct from one another. This assessment was carried out via cross-loading and Hair's criteria (Hair et al., 2017). Cross-loading evaluates discriminant validity at the indicator level, whereas Hair's criteria assess discriminant validity at the construct level.

According to Hair's criteria, discriminant validity is considered fulfilled if the square root of the AVE of a construct is greater than its correlation with other constructs. The analysis results showed that the square root of the AVE was greater than their correlations with other variables, thus confirming discriminant validity, as outlined in Table 2 below.

Table 2 Cronbach's alpha, composite reliability, and average variance extracted.

Variables	Cronbach's alpha	Composite realibility	Average Variance Extracted (AVE)
Internet Self Efficacy	0,920	0,899	0,623
Internet Anxiety	0,965	0,959	0,751
Digital Ethics	0,923	0,901	0,668

2.2. Inner Model

R-square (R^2) is used to assess the validity and prediction of the model with the following interpretations: 0.19 (low), 0.33 (moderate), and 0.66 (high). The R-square (R^2) analysis results show a value of 0.646, indicating a moderate influence of internet self-efficacy and internet anxiety on digital ethics, accounting for 64.6%. Hypothesis testing to examine the influence of internet self-efficacy and internet anxiety on digital ethics was conducted by analyzing the t statistic and p value. A relationship between variables was considered significant if the t statistic was ≥ 1.96 or if the p value was less than 5% (0.05), indicating rejection of the null hypothesis (H_0). Table 3 provides a summary of the hypothesis testing results, outlining the significance of the proposed relationships between the variables.

Table 3 Hypothesis testing.

Hypothesis	Coefficient	T Statistics	P Values	Decision
H1: Internet Self Efficacy -> Digital Ethics	0,325	2,769	0,006	Significant
H2: Internet Anxiety -> Digital Ethics	0,532	4,179	0,000	Significant

The analysis reveals that internet self-efficacy positively and significantly impacts students' digital ethics, with a coefficient value of 0.325, a t statistic of 2.679 (≥ 1.96), and a p value of 0.006 (< 0.05). Similarly, internet anxiety also has a positive and significant effect, as indicated by a coefficient value of 0.532, a t statistic of 4.179 (≥ 1.96), and a p value of 0.000 (< 0.05).

To complement and strengthen these findings, qualitative research was conducted *in-depth* with four civic education teachers from different schools in Surakarta. Data collection was carried out directly through a semistructured interview approach. The data obtained were analyzed via the model by (Miles & Huberman, 1994), which includes data condensation, data presentation, and conclusion drawing.

Design aims to develop the design for product creation and the product prototype, including the following:

The lesson plan, teaching materials, and assessment instruments for the Law-Abiding Citizens topic in the Civic Education subject, as well as feasibility instruments for media experts, subject matter experts, teachers, and students, are designed.

Media selection, which is based on the results of the define phase (needs analysis, curriculum analysis, and material analysis), is a mobile learning method based on augmented reality.

Format selection enhances the learning media through two-dimensional and three-dimensional formats.

Prototype design, where the initial design phase involves creating a product prototype via the T3 Turbo tech stack software.

Develop, aims to produce a developed product, including:

For expert appraisal, the product undergoes feasibility testing and is revised based on feedback from 2 academic experts and 2 media experts.

2.3. Developmental testing

Limited testing was conducted to obtain direct feedback in the form of responses, reactions, and comments from 120 students and 4 civic education teachers.

2.4. Disseminate

The Disseminate stage focuses on introducing the product to the public. The augmented reality-based mobile learning media, developed for the subtopic "Obeying the Law," was distributed to schools for integration into the civic education curriculum.



3. Results

The research and development of AR-based mobile learning media focused on the content "Obey the Law" within the Civic Education subject for phase E, class X high school students. The process began with the Define stage, aimed at identifying gaps that could justify product development. This stage included several analyses: front-end analysis to understand general learning challenges, learner analysis to pinpoint students' constraints and needs, task analysis to assess their initial and required skills, and concept analysis to determine the core material to be taught and specify instructional objectives to set clear learning goals (Thiagarajan et al., 1974). A mixed-method approach was employed at this stage, combining qualitative and quantitative research methods to ensure comprehensive insights and robust findings throughout the study.

The quantitative research in this study draws on (Choi et al., 2018) findings that digital ethics is influenced by demographic factors, internet self-efficacy, and internet anxiety. Data analysis was conducted via the partial least squares (PLS) method via SmartPLS software. An online questionnaire was distributed to 90 respondents from 10 senior high schools in Surakarta to collect data. The demographic data of the respondents are summarized in Table 4.

Table 4 Respondents' demographic information

Respondents	Frequency
Male Students	26
Female Students	64
Total	90

The demographic breakdown included 26 male and 64 female participants aged 15 (48 respondents), 16 (32 respondents), and 17 (10 respondents). Daily internet use ranged from 1--3 hours (7 respondents), 4--6 hours (23 respondents), 7--9 hours (36 respondents), and more than 9 hours (24 respondents). The devices used to access the internet included computers (4 respondents), laptops (6 respondents), smartphones (74 respondents), and tablets (6 respondents). The findings revealed that 33 students used the internet for entertainment, 2 for reading news, 26 for completing assignments, and 29 for accessing social media.

To complement and strengthen these findings, qualitative research was conducted with four civic education teachers from different schools in Surakarta (Connolly, 2021). The qualitative results highlight students' lack of understanding of digital ethics in schools. Students often show limited awareness of issues such as fake news in social, political, and academic contexts; overshare personal information; depend on social media; engage in plagiarism; and experience inferiority due to online social comparisons. Furthermore, civic education lessons are described as monotonous and uninspiring, failing to address these issues effectively.

In addition, the current learning media fails to align with students' characteristics and learning styles, and the material does not adequately meet the learning objectives. This gap underlines the importance of developing AR-based mobile learning media for the civic education subtopic "Obeying the Law." The design stage focuses on initial product creation, beginning with the construction of criterion-referenced tests based on the basis of the analysis of learning objectives and student needs. These tests include essays, multiple-choice questions, and case studies. The second step involves media selection, which is informed by the Define stage, to guide the development of AR-based mobile learning. The third step is format selection, which enhances the learning media through two-dimensional and three-dimensional formats. Finally, the initial design phase involves creating a product prototype via T3 Turbo tech stack software. In the development stage, the product undergoes feasibility testing and is revised based on feedback from two academic experts and two media experts, with the results detailed in Table 5.

Table 5 Material Expert Validation I.

No	Validator	Mean	Category
1	Content Suitability	78	Very Feasible
2	Content Language	80	Very Feasible
3	Learning Support	70	Very Feasible

The results of the material suitability test by the first validator showed that the content suitability category received an average score of 78%, placing it in the feasible category. The content language category achieved an average score of 80%, which was also categorized as feasible. In the learning support category, the average score was 70%, falling into the feasible category as well. Overall, the average content feasibility score from the first validator was 76%, indicating that the material is feasible and suitable for use in research with revisions, as presented in Table 6.

Table 6 Material Expert Validation II.

No	Validator	Mean	Category
1	Content Suitability	82	Very Feasible
2	Content Language	100	Very Feasible
3	Learning Support	100	Very Feasible



The content suitability test results from the second validator showed an average score of 82% in the content suitability category, which was classified as very feasible. The content language category achieved a perfect score of 100%, which was also classified as very feasible. Similarly, the learning support category received a score of 100%, which falls into the very feasible category. The overall average content feasibility score was 90%, indicating that the material is very feasible and suitable for use in research without requiring any changes, as detailed in Table 7.

Table 7 Media Expert Validation I.

No	Validator	Mean	Category
1	Media Visualization	86	Very Feasible
2	Media Programming	90	Very Feasible

The media feasibility test results from the first validator indicated that the media display category received an average score of 86%, which was classified as very feasible. The media programming category achieved an average score of 90%, which was also categorized as very feasible. Overall, the media was deemed suitable for use in research with only minor revisions, as detailed in Table 8.

Table 8 Media Expert Validation II.

No	Validator	Mean	Category
1	Media Visualization	86	Very Feasible
2	Media Programming	90	Very Feasible

The media feasibility test results from the second validator showed that the media display category achieved an average score of 86%, which was classified as very feasible. The media programming category also received an average score of 90%, categorized as very feasible, making it suitable for use in research with minor adjustments. Learning media deemed appropriate by academic and media experts was subsequently tested in schools to gather feedback from civic education teachers and students. Civic education teachers rated the augmented reality-based mobile learning media with a score of 86, which was categorized as very feasible. Testing was conducted with 120 students from 4 senior high schools in Surakarta, resulting in an average score of 88, which was also classified as very feasible (see Table 9 and Table 10 for details).

Table 9 Trial to Students.

No	Trials	Mean	Category
1	Application Attractiveness	88	Very Feasible
2	Content	86	Very Feasible
3	Language	90	Very Feasible

Table 10 Trial to Teacher.

No	Trials	Mean	Category
1	Application Attractiveness	86	Very Feasible
2	Content	86	Very Feasible
3	Language	86	Very Feasible

The feasibility tests for content, media, teacher, and student validation confirm that augmented reality-based mobile learning media is suitable for use in civic education learning. The Disseminate stage focuses on introducing the product to the public. The augmented reality-based mobile learning media, developed for the subtopic "Obeying the Law," was distributed to schools for integration into the civic education curriculum.

4. Discussion

4.1. Development of augmented reality-based mobile learning media to strengthen students' digital ethics in Surakarta city

AR-based mobile learning media was selected following an analysis of students and teachers, which revealed a low level of digital ethics among students, influenced by internet self-efficacy and internet anxiety factors (Choi, 2015). Internet self-efficacy, defined as an individual's belief in his or her ability to manage and execute internet-related behaviors effectively, is a crucial psychological factor for productive internet use (Choi et al., 2017). It has a significant correlation with digital ethics, as demonstrated by research in Surakarta city, which revealed that internet self-efficacy accounts for 47.786% of the variance in students' digital ethics. Previous studies have shown that individuals with greater internet self-efficacy exhibit stronger digital ethics (Baylor et al., 2002). Therefore, it can be concluded that increased internet self-efficacy leads to a greater likelihood of developing robust digital ethics. Increasing internet self-efficacy can be achieved through the integration of technology in learning, particularly mobile learning. Mobile devices support compatibility with augmented reality (AR) and offer opportunities to be integrated into every topic of civic education. (Abdilah et al., 2023). Mobile learning media based on augmented reality, as one of the core technologies of the future, has potential implications and benefits in teaching and



learning environments, particularly in the areas of skills, attitudes, and knowledge (Billinghurst et al., 2003). The media encourage students to understand their everyday environment and encourage authentic learning, and has been shown to improve learning motivation, learning outcomes and reduce boredom (Abdilah et al., 2023; Lim & Lim, 2020; Yang & Hwang, 2014). (Halimi et al., 2022) noted that integrating mobile learning into education creates a more interactive and engaging experience, which positively affects students' digital ethics. Students in the civic education class, assisted by mobile learning media based on augmented reality, expressed satisfaction with this learning media, as evidenced by a media feasibility score of 88%, measured through application attractiveness, content, and language. The correlation between internet self-efficacy and digital ethics was statistically significant. This study shows that the more confident students are in using technology, the more likely they are to exhibit ethical behavior in the digital world. The motion-recognition-based interaction system offers a unique experience for students, with characters and 3D models supporting self-directed learning, encouraging topic exploration based on personal interests, developing digital skills in a flexible and adaptive environment, and providing more interactive and engaging learning, all of which positively impact students' digital ethics. Students can change perspectives or directions by scanning a special barcode, where the generated content displays 3D model case studies, offering an intuitive impression of the presented items and enabling effective participation. Our findings also support the research of Zheng (Zheng et al., 2019), which states that AR helps reduce student boredom and strengthens their curiosity. These findings are in line with other technology integration education programs that aim to enhance students' learning skills in the civic education subject. The results of this study also confirm previous findings showing that integrating technology into traditional classrooms substantially improves communication, expands access to internet resources, and correlates with ethical behavior in the digital world. (Choi & Cristol, 2021; Zhao et al., 2022)

The second factor is internet anxiety, a condition in which individuals feel fear or discomfort when using the internet, which affects how they engage in the digital world. According to (Choi et al., 2018), internet anxiety is closely linked to a person's level of digital ethics. The greater the level of anxiety experienced, the lower their adherence to digital ethics. Research on students in Surakarta city indicates that internet anxiety affects 52.214% of students. This anxiety stems from various causes, such as a limited understanding of digital technology, privacy concerns, or negative online experiences such as cyberbullying (Choi et al., 2017). People with high internet anxiety often avoid complex online activities and are more prone to errors in practicing digital ethics principles.

Another study by (Halimi et al., 2022) reported that students experiencing internet anxiety often lack the confidence to engage in technology-based learning. Consequently, they struggle to fully utilize information and communication technology in the teaching-learning process. To enhance digital ethics, it is essential to reduce internet anxiety through educational and training programs aimed at building students' skills and confidence in internet use. Research by Crompton (2013) supports mobile learning as a solution to address internet anxiety. Crompton highlighted that mobile learning encourages students to be more active and independent in the learning process, increasing their confidence in using technology. By overcoming their fear of the internet, students can develop the skills needed to participate ethically in the digital world. The analysis of student needs revealed that the low level of digital ethics among students in Surakarta city stems from low internet self-efficacy and high internet anxiety. Addressing this issue requires an educational strategy focused on building students' confidence in using the internet while reducing their anxiety.

One effective way to improve internet self-efficacy is through training programs designed to improve students' digital skills. Halimi et al. (2022) emphasized the importance of integrating information and communication technologies, such as mobile learning, into education to increase student engagement and foster digital ethics. Providing students with safe and supportive opportunities to interact with technology helps them gain confidence and apply ethical behavior in digital contexts.

In addition, an inclusive and supportive learning approach is crucial for reducing internet anxiety. By fostering a learning environment that encourages exploration of technology and offers emotional support, students can overcome their fears and become more active participants in digital learning. Consequently, enhancing digital ethics in Surakarta city requires a dual approach that strengthens internet self-efficacy while minimizing internet anxiety.

The development of AR-based mobile learning media was driven by in-depth interviews with four Civic Education teachers in Surakarta city, who emphasized the need for engaging, varied, and enjoyable learning tools that suit the diverse characteristics and learning styles of students while aligning with the material, design, and learning objectives. Variations in how students comprehend material underscore the importance of creative and innovative learning media to foster an interactive and effective learning environment (Sayu Putri Ningrat et al., 2018). A significant obstacle to achieving this goal is the reliance on traditional methods, such as textbooks and PowerPoint presentations, which often create teacher-centered instruction and fail to engage students actively. Moreover, the need for resources that incorporate visual, audio, and kinesthetic elements, in line with modern technological advancements, remains unmet owing to outdated and unsuitable learning media.

The development of AR-based mobile learning media for the civic education subject "Obeying the Law" aims to provide students with a contextual learning experience by visualizing concepts in a real-world environment (Pekkala & van Zoonen, 2022). Augmented reality simplifies complex learning materials, making them concrete, engaging, and easier to understand,

and its use has been shown to improve student learning outcomes (Andriani, 2020; Sapulette, 2023). Integrating augmented reality into education enhances the learning experience, supports the development of digital ethics, and sustains student interest without compromising the subject's objectives (Halimi et al., 2022). This approach combines knowledge, attitudes, and skills (Maulidiah et al., 2023) by presenting the "Obeying the Law" material in a structured way with images, quizzes, and 3D illustrations that blend the virtual and real worlds. It fosters values such as cooperation, honesty, enthusiasm for learning, and openness to opinions while encouraging idea generation. Students actively engage with the material in a manner suited to their learning styles, gaining direct experience (Andriani, 2020). This aligns with Bruner's theory, which highlights the interplay of abstract, pictorial, and direct experiences to create a comprehensive learning process that develops knowledge, attitudes, and skills over time (Harahap et al., 2018). The validity of the augmented reality-based mobile learning media intervention has an impact on students' digital ethics attitudes, as evidenced by the posttest results, which increased from 82.5 to 89.5. The results of this study support Bruner's theory; abstract experience involves presenting concepts, facts, data, and quizzes in symbolic forms. In this learning media, abstract experience is achieved by understanding the concept of obeying the law through textual materials enhanced with graphics, real-world examples, and quizzes that measure students' initial and final comprehension through assessment activities. Pictorial experience, as defined by Bruner, focuses on grasping concepts through visual representations. This is realized in the learning media through augmented reality, which uses three-dimensional (3D) illustrations to depict real behaviors associated with obeying the law. Moreover, direct experience refers to the physical interaction or manipulation of real objects. Within this learning media, direct experience is reflected in a comprehensive exploration of the "Obeying the Law" material, which is designed to inspire behavioral changes that foster good citizenship and intelligent decision-making (Schunk, 2012).

4.2. Effectiveness of augmented reality-based mobile learning media in strengthening students' digital ethics in Surakarta city

The augmented reality-based mobile learning media developed for civic education was rated as very feasible and very interesting. The very feasible category was supported by validation test results from material experts (85). The main objective of material expert validation is to determine whether the material contained in the learning media is appropriate. 1) The suitability of the content suitability is as follows: learning achievements in the independent learning curriculum; phase E of Pancasila education; digital ethics material on elements of the Indonesian constitution; learning objectives; reference suitability; suitability of pictures and illustrations; and systematic writing. 2) Content language includes similarity to correct spelling, appropriateness of language and terms, and ease of understanding. 3) Learning support includes making students more active and helping them understand learning. The very feasible category was supported by validation test results from media experts (88). The main objective of media expert validation is to determine whether the resulting learning media can improve students' digital ethics through 1) application attractiveness, including creative and innovative media produced, the suitability of font sizes and models, layout, color combinations, and sound effects, and 2) media programming, including media responsiveness, media maintenance and media operations. Learning media deemed appropriate by academic and media experts was subsequently tested in schools to gather feedback from civic education teachers and students. 4) Civic education teachers rated augmented reality-based mobile learning media with a score of 86 as very feasible. The very interesting category was based on student assessments, which scored the media at (88). Additionally, testing with 120 students in Surakarta city demonstrated considerable improvement in knowledge after they used media. The average pretest score was 82.5, which increased to 89.5 in the posttest, indicating the effectiveness of the augmented reality-based mobile learning media. This learning media not only is effective in improving students' understanding of the material but also serves as an innovative tool to support character building, particularly in applying digital ethical values in daily life. It is expected to assist civic education teachers in creating more interactive and relevant learning experiences that align with technological developments.

AR-based mobile learning media have been deemed feasible for use in civic education classrooms, helping to improve students' digital ethics and adapt learning to modern educational needs (Halimi et al., 2022). This research makes novel contributions compared with previous studies, which have focused primarily on augmented reality learning media for subjects such as chemistry and social studies across universities, elementary schools, and high schools (Carolina, 2022). Until now, no AR-based mobile learning media has been developed specifically for the Civic Education subject on the material of "Obeying the Law." This development aligns with Bruner's theory (1973), emphasizing the active involvement of students in the learning process through the integration of abstract experiences, image experiences, and direct experiences. These interconnected elements provide a comprehensive learning experience, fostering knowledge, attitudes, and skills relevant to contemporary educational needs. Augmented reality-based mobile learning media is highly compatible with and feasible for application in civic education, particularly for teaching the material "Obeying the Law." Future research will focus on evaluating the effectiveness of this media in enhancing students' digital ethics. In the current digital era, teachers need to be adaptive, technologically competent, and able to integrate technology into their teaching practices to meet the demands of 21st-century education (Hasanah, 2023).

5. Conclusions

Based on the research findings, augmented reality-based mobile learning media for the material "Obeying the Law" has been declared highly feasible for use in civic education. This conclusion is supported by evaluation results from material experts, media experts, civic education teachers, students, and classroom experiment outcomes, all of which affirm its suitability and effectiveness in enhancing the learning process. This research recommends that schools, teachers, and students optimally utilize this learning media with a focus on promoting digital ethics. The integration of information and communication technology (ICT), especially through augmented reality-based mobile learning media, is expected to enhance classroom learning effectiveness and contribute to improving students' digital ethics.

Ethical considerations

We confirm that we have obtained all the consent required by the applicable law to publish any personal details or images of patients, research subjects, or other individuals used. We agree to provide the Multidisciplinary Science Journal with copies of the consent or evidence that such consent has been obtained if requested

Conflict of interest

The authors declare that they have no conflicts of interest.

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