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TikTok Filter-Based Educational Game to Improve Elementary Students' Conceptual Understanding

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ABSTRACT

The integration of digital technology into elementary education has created opportunities for developing interactive learning media that can enhance students' engagement and understanding. However, conceptual learning in integrated science and social studies (IPAS) remains challenging for many elementary students, highlighting the need for innovative instructional approaches. This study aimed to develop a TikTok filter-based educational game utilizing Augmented Reality (AR) technology to improve students' conceptual understanding. The study employed a Research and Development approach based on the 4D model (Define, Design, Develop, and Disseminate). The product was evaluated through expert validation, user response questionnaires, and a one-group pretest–posttest design involving 26 sixth-grade students. The results indicated that the developed game was feasible for implementation, with content expert and media expert validation scores of 83% and 94.79%, respectively. Teacher and student responses were highly positive, reaching 84.6% and 88%. In addition, the Wilcoxon Signed-Ranks Test revealed a significant improvement in students' conceptual understanding, while the N-Gain score of 0.56 indicated a moderate level of learning improvement. These findings demonstrate that TikTok filter-based AR educational games are practical and effective for supporting conceptual learning. This study contributes to AR-enhanced learning research by demonstrating the educational potential of social media-based technologies as curriculum-aligned learning media in elementary education.

INTRODUCTION

The rapid advancement of digital technology continues to reshape education, creating opportunities to develop learning media that are more engaging, interactive, and student-centered (Ifenthaler et al., 2023). Social media, in particular, has evolved beyond entertainment into a viable platform for delivering educational content effectively (Sikumbang et al., 2024).

In recent years, Augmented Reality (AR) has emerged as a promising approach in education. Liu et al. (2024) demonstrate that AR-based educational games can

significantly improve children's understanding of scientific concepts through interactive visualization. Similarly, (Nevrelova et al., 2024). argue that AR enhances digital literacy and supports meaningful learning experiences in primary education. At the elementary level, (Lestari & Setyasto, 2025) found that AR-assisted learning materials can improve students' learning outcomes, while (Aini et al., 2021) highlight the effectiveness of AR in presenting abstract science concepts in a more concrete and engaging manner. Theoretically, these outcomes can be explained through (Mayer, 2001) Cognitive Theory of Multimedia Learning, which posits that learning is most effective when visual and auditory channels are simultaneously activated, and through (Sweller, 1988) Cognitive Load Theory, which argues that well-designed visual media reduces extraneous cognitive load and enhances schema formation.

The implementation of the Merdeka Curriculum in Indonesia introduced IPAS (Ilmu Pengetahuan Alam dan Sosial) as an integrated subject combining Natural Science (IPA) and Social Science (IPS) at the elementary school level. This integration aims to develop students' holistic understanding of natural and social phenomena (Kemendikbudristek, 2022). However, the implementation of IPAS presents significant challenges. Studies indicate that low student interest is often caused by non-contextual teaching approaches (Anggita et al., 2023), while the dominance of lecture-based methods contributes to low student engagement (Izzatuna Dauly et al., 2024). Furthermore, the abstract nature of many IPAS concepts demands concrete visualization and game-based approaches to improve students' conceptual understanding (Ilham et al., 2024).

Alongside AR, game-based learning has gained attention as an effective instructional approach. (Li et al., 2024) explain that digital educational games can enhance students' motivation through increased engagement, which subsequently impacts learning outcomes. This is further supported by (Rodríguez-Ferrer et al., 2023), who show that game-based learning contributes to better classroom interaction and participation in primary education contexts. From a motivational perspective, (Deci & Ryan, 1985) Self-Determination Theory provides a relevant explanatory framework: game-based AR environments simultaneously support students' need for autonomy (self-directed head-movement interaction), competence (immediate scoring feedback), and relatedness (shared familiar platform), thereby fostering intrinsic motivation. Additionally, (Csikszentmihalyi, 1990) Flow Theory offers insight into why game-based learning environments sustain attention: when challenge and skill are balanced and immediate feedback is provided, learners enter a state of deep cognitive engagement that promotes retention and conceptual understanding.

The use of TikTok in education is also increasing. Research has shown that TikTok can effectively enhance student engagement and academic motivation, particularly among young learners, because its interactive features and user-friendly interface align with students' daily digital habits (Amaluisa Rendón et al., 2023). However, prior studies on TikTok in education have been limited to one-directional, passive video content. AR-based educational game development has similarly focused predominantly on the Instagram platform and secondary education levels. Consequently, no study has yet specifically integrated the TikTok platform, AR technology, and interactive educational games into a single learning medium designed for IPAS learning at the elementary school level within the Merdeka Curriculum context.

A preliminary study at MI Muhammadiyah Sonorejo confirmed these issues. Grade VI students demonstrated difficulties understanding abstract IPAS concepts

requiring spatial visualization, such as the solar system and Earth's rotation and revolution. The class average was 55.42 (MMC = 70), with 69.2% of students (18 out of 26) failing to meet the minimum competency threshold. Although students showed enthusiasm for interactive and visual activities, consistent use of interactive learning media had not been implemented.

Prior research has demonstrated the potential of combining AR and game-based approaches in education. Android-based educational games have achieved high feasibility ratings (Alba et al., 2023), while game-based learning has been shown to improve conceptual understanding in various subjects (Faijah et al., 2022). In the AR-TikTok domain specifically, (Danuarta et al., 2024) demonstrated that AR-based TikTok filters effectively increased users' knowledge from 30% to 75%, while (Mahligawati et al., 2025) showed that Instagram filter-based educational games improved cognitive learning outcomes on abstract concepts.

The present study addresses the identified gap by integrating TikTok, AR technology, and structured educational game mechanics into a single medium designed for curriculum-aligned IPAS learning at the elementary level. This study aims to develop a TikTok filter-based educational game using AR technology through TikTok Effect House, specifically designed to improve Grade VI students' conceptual understanding of IPAS at MI Muhammadiyah Sonorejo, following the 4D model (Thiagarajan et al., 1974).

METHODS

This study employed a Research and Development (R&D) approach aimed at producing an educational game product based on a TikTok filter for IPAS learning at the elementary school level. According to (Sugiyono, 2019), research and development is a research method used to produce a specific product and test its effectiveness. The development process followed the 4D model proposed by, consisting of four systematic stages: Define, Design, Develop, and Disseminate. This model was selected due to its clear and structured stages that are well-suited for developing technology-based learning media (Mulyatiningsih, 2011). A mixed methods approach was adopted in this study, combining qualitative and quantitative data to provide a comprehensive evaluation of the developed product (Cano & Lomibao, 2023). Qualitative data were obtained from expert feedback and open-ended responses during the validation process, while quantitative data were derived from expert validation scores, user response questionnaires, and pretest-posttest results.

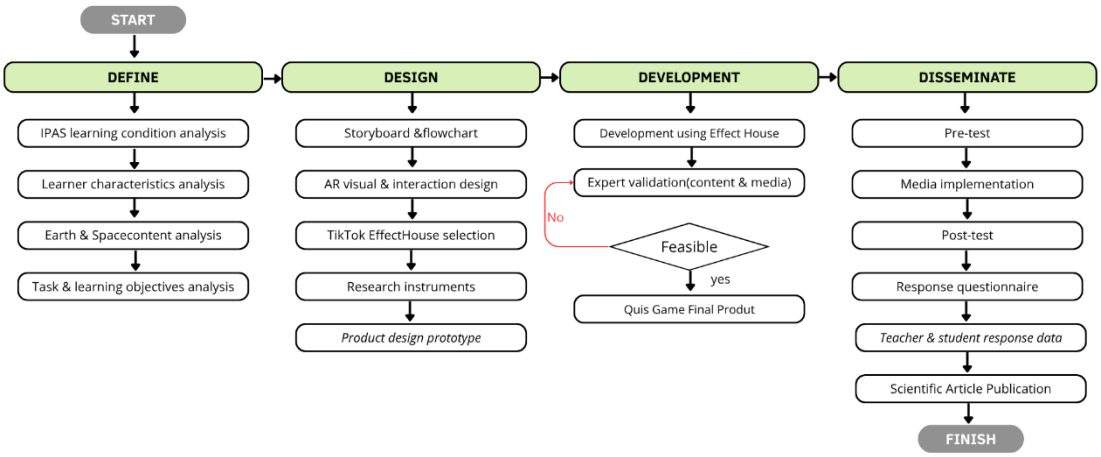

Figure 1 game Filter Quiz Flowchart 4D Model

The The Define stage involved a front-end analysis through semi-structured interviews with the Grade VI teacher, a student characteristic analysis covering learning interests and digital technology habits, and a learning material analysis to identify IPAS content suitable for AR-based game integration. The Design stage produced the game architecture including interface layout, navigation flow, gameplay mechanics, and storyboard. Navigation relies entirely on face tracking — players select answers by moving their head left or right — enabling a hands-free, kinesthetic interaction grounded in research on embodied cognition and multimodal engagement (Mayer, 2001). The Develop stage involved product development using TikTok Effect House, followed by iterative expert validation and revision. The Disseminate stage involved a pretest, implementation, posttest, and administration of response questionnaires to 26 Grade VI students.

The research instruments comprised: (1) expert validation questionnaires — a material expert instrument with 20 items and a media expert instrument with 24 items; (2) user response questionnaires for teachers (15 items) and students (10 items); (3) a conceptual understanding test in the form of multiple-choice items covering learning objectives TP 5.1–5.3 at cognitive levels C1–C4; and (4) an interview guide for the Define stage.

The conceptual understanding test was developed through two stages of validation prior to use. First, content validity was established through expert review by the material expert, who assessed 20 initial items across four dimensions: content and material alignment, item construction, language clarity, and cognitive level appropriateness. The content validity review yielded a perfect score of 100% across all four dimensions, confirming that all items were linguistically appropriate and aligned with the targeted cognitive levels (C1–C4). Second, empirical validity was established through a pilot test administered to 27 students outside the trial sample. Item validity was analyzed using Point-Biserial Correlation (r table = 0.381, $\alpha = 0.05$, df = 25). Of the 20 items, 15 were declared valid (r hitung > 0.381) and 5 were excluded. Instrument reliability was assessed using Cronbach's Alpha, yielding a coefficient of 0.8284, categorized as High (Good), indicating that the instrument was reliable for use as a research measurement tool. The final 15 valid items were used as the pretest and posttest instrument in this study.

It is acknowledged that this study has two key methodological limitations. First, the small sample size (n = 26, single school) limits the generalizability of the findings. Second, the one-group pretest–posttest design without a control group means that the observed improvement cannot be attributed exclusively to the intervention; extraneous variables such as teacher facilitation and student motivation may have contributed. These limitations are addressed in the conclusion.

Quantitative data from validation and response questionnaires were analyzed using a percentage formula following Akbar's (2013) feasibility criteria: Very Feasible (85.01%–100%), Feasible (70.01%–85.00%), Less Feasible (50.01%–70.00%), and Not Feasible (1.00%–50.00%). Since pretest–posttest data were not normally distributed (Shapiro-Wilk), hypothesis testing was performed using the Wilcoxon Signed Ranks Test. Learning improvement magnitude was measured using the normalized N-Gain formula (Hake, 1999): high (≥ 0.70), medium (0.30–0.69), and low (< 0.30).

RESULTS

The Define stage was carried out through a semi-structured interview with the Grade VI IPAS teacher at MI Muhammadiyah Sonorejo on March 8, 2026, supported by

daily assessment data. Findings revealed that instruction relies entirely on lecture-based methods with textbooks as the primary resource, and the available projector remains unused due to installation complexity. Students struggle most with abstract concepts requiring spatial visualization, particularly the solar system and Earth's rotation and revolution, as "there is no real picture of it, it only exists in drawings." Motivation is low in lecture settings, though technology proficiency is high given that almost all students regularly use smartphones and have prior experience using mobile devices in learning. Enthusiasm is notably higher for TikTok-based activities, with the teacher noting that "students are very enthusiastic, especially when it involves TikTok." The school permits supervised smartphone use in class. These conditions were reinforced by daily assessment results showing a class average of 55.42 (MMC = 70), with 69.2% of students (18 out of 26) failing to meet the minimum competency threshold, as illustrated in Figure 2, establishing the need for a visual, interactive AR-based game covering Earth's rotation and revolution, effects on daily life, and solar system characteristics (TP 5.1–5.3, cognitive levels C1–C4).

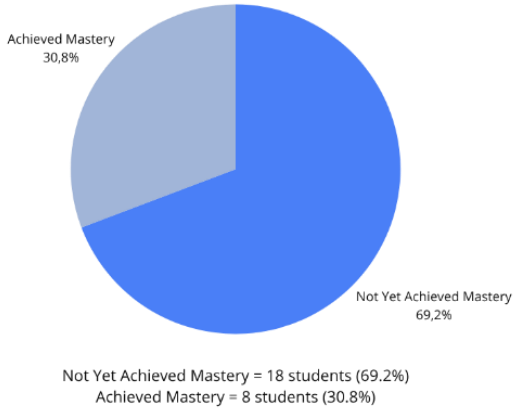

Figure2 Distribution of Learning Mastery

The Design stage produced the game architecture of the TikTok filter-based educational game, covering interface layout, navigation flow, IPAS material content, and the game mechanic blueprint. The interface was designed as a full-screen AR filter accessible directly through TikTok, featuring an intro screen with brief instructions, a 10-question quiz display area, two answer choice panels positioned on the left and right sides of the screen, a question progress indicator, and a Start button to initialize the game and reset the score. Navigation relies entirely on face tracking — the player selects an answer by moving their head left or right — eliminating the need for touch input and enabling a hands-free, immersive interaction. The game integrates a true-false quiz mechanic with automatic scoring (+10 for correct, +0 for incorrect) and displays the cumulative final score upon completion of all 10 questions. Questions are randomized on each play session and cover the three learning objectives (TP 5.1–5.3), spanning cognitive levels C1 to C4 on Earth's rotation and revolution, their effects on daily life, and solar system characteristics. The game was developed using TikTok Effect House with node-based visual scripting for logic control and face tracking configuration. This format trains conceptual recognition speed and cognitive accuracy through repeated practice, consistent with findings that game-based interactive formats significantly enhance student engagement and learning outcomes in science subjects (Fitriya et al., 2024).

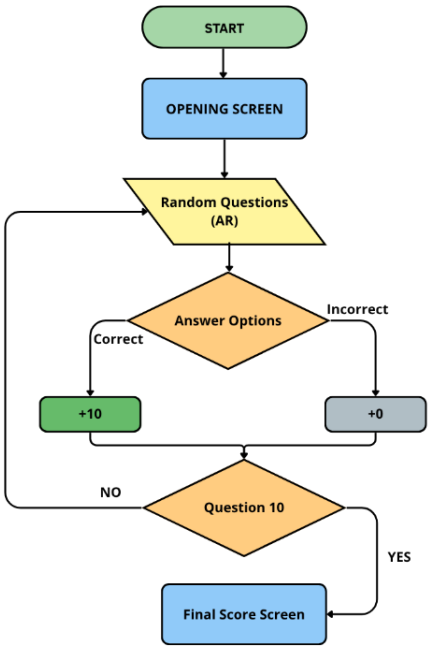

Figure3 game Filter Quiz Flowchart

The Develop stage was carried out after the Design phase was fully completed. This stage successfully produced the final TikTok filter-based educational game built utilizing TikTok Effect House and its node-based visual scripting system. Subsequently, the product underwent expert validations and iterative revisions with its final interface presented in Figure 4.

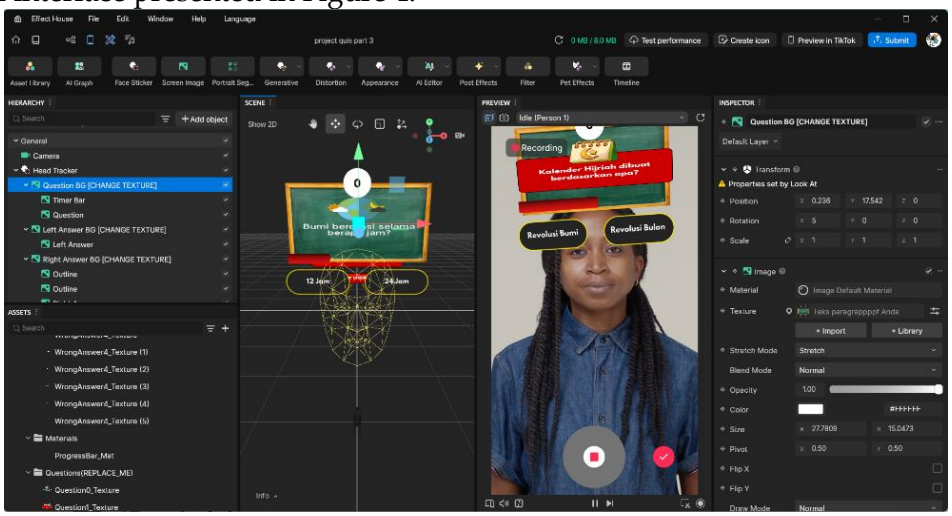

Figure 4 game Filter Quiz Interface

The material expert validation yielded an overall score of 83%, placing the product in the "Feasible" category, while the media expert validation yielded a higher score of 94.79%, categorized as "Very Feasible." The complete validation results are presented in Tables 1 and 2.

Table 1. Content Expert Validation Results

No	Assessment Aspect	Score	Score Max	Percentage
1	Alignment of Material with Curriculum	20	24	83%
2	Quality of Material Content	20	24	83%
3	Language and Readability	14	16	88%
4	Material Presentation	12	16	75%
	Total/Average	66	80	83%

The content expert validation result of 83% places the developed product in the "feasible" category. This indicates that the material embedded within the TikTok filter-based educational game aligns with the IPAS Merdeka Curriculum, is linguistically appropriate for Grade VI students, and is presented in a structured and comprehensible manner. The slightly lower score on the Material Presentation aspect (75%) suggests that future development could improve the arrangement and sequencing of content within the filter interface.

Table 2. Media Expert Validation Results

No	Assessment Aspect	Score	Score Max	Percentage
1	Visual Design	22	24	91.67%
2	Ease of Use	22	24	91.67%
3	Interactivity	24	24	100%
4	Technical Quality	23	24	95.83%
Total/Average		91	96	94.79%

The media expert validation yielded an exceptionally high score of 94.79%, categorized as "very feasible." Particularly noteworthy is the perfect score of 100% on the Interactivity aspect, reflecting that the true-false quiz mechanism with automatic scoring and instant feedback was successfully implemented through TikTok Effect House. The high scores on Visual Design (91.67%) and Technical Quality (95.83%) further confirm that the product meets professional standards for interactive AR-based media.

The Disseminate stage was conducted on a limited basis involving 26 Grade VI students at MI Muhammadiyah Sonorejo. Activities at this stage included a pretest, implementation of the TikTok filter-based educational game, a posttest, and the administration of teacher and student response questionnaires. The results are presented through descriptive statistics, normality testing, hypothesis testing, normalized N-Gain analysis, and questionnaire response data. The documentation of this comprehensive trial process is clearly presented in Figure 5.

Figure 5. Students and Teacher Trial Activity

Descriptive Statistics

The measurement results showed a pretest mean score of 60.12 (SD = 8.48) with scores ranging from 40 to 80. Following the implementation of the learning media, the posttest mean score increased to 82.54 (SD = 7.80) with scores ranging from 67 to 94, as presented in Table 3.

Table 3. Descriptive Statistics of Pretest and Posttest

Variable	Mean	SD	Min	Max
Pretest	60.12	8.48	40	80
Posttest	82.54	7.80	67	94

Shapiro-Wilk Normality Test

A Shapiro-Wilk normality test was conducted on the pretest, posttest, and N-Gain data. The results are presented in Table 4.

Table 4. Results of Shapiro-Wilk Normality Test

Variable	W	Sig.	df	Description
Pretest	0.904	0.019	26	Not Normal
Posttest	0.888	0.008	26	Not Normal
N-Gain	0.920	0.045	26	Not Normal

As shown in Table 4, all three variables obtained Sig. values below 0.05, indicating that the data were not normally distributed. Therefore, hypothesis testing was conducted using the Wilcoxon Signed Ranks Test as a non-parametric alternative.

Wilcoxon Signed Ranks Test

The results of the Wilcoxon Signed Ranks Test are presented in Table 5 and Table 6 bellow.

Table 5. Wilcoxon Signed Ranks Test – Ranks

Description	N	Mean Rank	Sum of Ranks
Negative Ranks (Posttest < Pretest)	0	.00	.00
Positive Ranks (Posttest > Pretest)	25	13.00	325.00
Ties (Posttest = Pretest)	1	-	-
Total	26	-	-

Table 6. Test Statistics of Wilcoxon Signed Ranks Test

	Posttest – Pretest
Z	-4.408
Asymp. Sig. (2-tailed)	0.000

Table 8 shows that 25 out of 26 students experienced an increase in score from pretest to posttest (positive ranks), no student experienced a decrease (negative ranks), and 1 student showed no change in score (ties). The test statistics in Table 9 yielded Z = −4.408 with Asymp. Sig. (2-tailed) = 0.000.

Normalized N-Gain Analysis

The magnitude of learning improvement was measured using the normalized N-Gain formula (Hake, 1999). The results are presented in Table 10.

Table 7. Results of Normalized N-Gain Analysis

Category	N-Gain Range	Number of Students	Percentage
High	≥ 0.70	6	23.1%
Medium	0.30 – 0.69	17	65.4%
Low	< 0.30	3	11.5%
Mean N-Gain	0.56	26	100%

Table 7 shows that the The majority of students fell into the medium gain category (17 students; 65.4%), followed by high (6 students; 23.1%) and low (3 students; 11.5%). The overall mean N-Gain was 0.56, indicating moderate learning improvement.

Teacher Response Questionnaire

Teacher response data were collected following the implementation of the learning media. The results are presented in Table 8.

Table 8. Teacher Response Results

No	Assessment Aspect	Score	Score Max	Percentage
1	Ease of Use	175	208	84%
2	Alignment with Learning Objectives	183	208	88%
3	Learning Effectiveness	167	208	80%
4	Student Motivation and Engagement	182	208	88%
5	Practicality and Efficiency	173	208	83%
	Total/Average	880	1040	84,6%

Teacher response reached 84.6%, classified in the positive category. Teachers rated Student Motivation and Engagement (88%) and Alignment with Learning Objectives (88%) as the strongest aspects, suggesting that the product is perceived as pedagogically relevant and motivating for students. The slightly lower score on Learning Effectiveness (80%) may reflect teachers' caution in evaluating learning outcomes prior to full classroom implementation.

Table 9. Student Response Results

No	Assessment Aspect	Score	Score Max	Percentage
1	Visual Design and Appearance	71	84	84,5%
2	Ease of Use	73	84	87%
3	Enjoyment and Interest	72	84	86%
4	Learning Benefits	81	84	96%
5	Learning Motivation	72	84	86%
	Total/Average	369	420	88%

Student response was 88%, also in the positive category, with the highest score on Learning Benefits (96%), indicating that students strongly perceived the educational value of the game.

DISCUSSION

The development of the TikTok filter-based educational game produced a product validated as feasible by both content and media experts, demonstrating that the integration of TikTok's AR platform with game-based learning principles can yield a technically and pedagogically sound learning medium. The content expert validation score of 83% (Feasible) indicates that the IPAS material aligns with Merdeka Curriculum competencies and is linguistically appropriate for Grade VI students. The slightly lower score on Material Presentation (75%) suggests that future iterations should optimize content arrangement within the spatial constraints of the AR mobile interface. This result is consistent with Saefudin et al. (2024), who reported that TikTok-based IPAS learning media achieved a very feasible validation category.

The media expert validation score of 94.79% (Very Feasible), with a perfect score on the Interactivity aspect (100%), reflects the successful implementation of the true-false quiz mechanism, automatic scoring, and face tracking interaction. These results align with findings by (Alba et al., 2023), who reported high feasibility scores on technical and visual dimensions for Android-based educational games. The high interactivity score is particularly significant given that interactivity is widely recognized as a key determinant of student engagement in game-based learning environments (Li et al., 2024). The face tracking mechanic — where students select answers by moving their head left or right — introduces a kinesthetic interaction layer that distinguishes this product from conventional passive video formats.

The theoretical basis for the product's design effectiveness can be explained through three complementary frameworks. First, (Mayer, 2001) Cognitive Theory of Multimedia Learning posits that simultaneous engagement of visual and kinesthetic channels enhances information processing and reduces split attention. The AR filter integrates question text, 3D animated objects, and face-tracked interaction into a single screen, minimizing the extraneous cognitive load associated with switching between separate information sources, consistent with (Sweller, 1988) Cognitive Load Theory. Second, (Deci & Ryan, 1985) Self-Determination Theory explains the motivational mechanism: the face tracking mechanic supports autonomy (self-directed interaction), the automatic scoring system provides competence feedback, and the familiar TikTok platform fosters relatedness. Third, (Csikszentmihalyi, 1990) Flow Theory accounts for the sustained engagement observed: the randomized quiz format and immediate feedback create a challenge-skill balance conducive to optimal cognitive engagement. These theoretical mechanisms collectively explain why the product produced significant learning improvement despite single-session exposure.

The effectiveness of the learning media was demonstrated through a statistically significant improvement in students' IPAS conceptual understanding, with mean scores increasing from 60.12 (pretest) to 82.54 (posttest). The Wilcoxon Signed Ranks Test yielded $Z = -4.408$, Sig. = 0.000, and 25 out of 26 students experienced score increases. These findings are consistent with(Ayun & Nugroho, 2025), who demonstrated that TikTok-based microlearning effectively improved Grade IV students' IPAS conceptual understanding, and with(Faijah et al., 2022), who found that educational games significantly improved mathematical conceptual understanding.

The mean N-Gain of 0.56 indicates moderate learning improvement, which should be interpreted carefully. It is important to note that an N-Gain in the medium category does not indicate an absence of effectiveness; rather, it reflects the constraints of a single-session intervention with a small and homogeneous sample. Research consistently shows that short-cycle educational technology interventions produce small to moderate gains (Arztmann et al., 2024). The medium N-Gain is characteristic of studies where exposure is limited to a single session, as was the case in the limited disseminate stage. A broader and more sustained implementation is expected to yield higher N-Gain scores. This interpretation is consistent with (Amalia & Prasetyo, 2025), whose systematic review confirmed that AR-based learning media produced moderate gains in elementary science contexts.

The teacher response score of 84.6% and student response score of 88% confirm the practicality and acceptability of the product. It is important to distinguish, however, that these response data measure perception and satisfaction rather than learning outcomes directly; they should not be treated as independent evidence of effectiveness. Teachers rated Student Motivation and Engagement (88%) and Alignment with Learning Objectives (88%) as the strongest aspects, while the slightly lower Learning Effectiveness score (80%) likely reflects teachers' cautious evaluation prior to extended classroom implementation. Among students, Learning Benefits obtained the highest score (96%), suggesting strong perceived educational value. These findings are consistent with (Mahligawati et al., 2025) and indicate that the TikTok platform's familiarity reduces the adoption barrier for both teachers and students.

The present study contributes to the existing literature by demonstrating that TikTok Effect House — previously underutilized in formal educational settings — is a viable development platform for interactive AR-based educational games. While prior studies such as (Danuarta et al., 2024) demonstrated the informational effectiveness of AR-based TikTok filters in public health contexts, and (Dwi Rani & Pramono, 2024) established the usability of AR-based Instagram filters for educational purposes, the current study advances this line of research by integrating TikTok, AR technology, and structured game mechanics into a single curriculum-aligned medium for elementary IPAS learning. (Peikos & Sofianidis, 2024) highlight that the future of AR in science education lies in creating immersive and student-centered experiences, a direction this study directly operationalizes.

CONCLUSION

This This study successfully developed a TikTok filter-based educational game using Augmented Reality technology through TikTok Effect House, designed to improve Grade VI students' conceptual understanding of IPAS concepts at MI Muhammadiyah Sonorejo. The 4D development process produced a product validated as feasible by content experts (83%) and very feasible by media experts (94.79%), confirming its curriculum alignment, visual quality, and technical reliability. The limited trial demonstrated a statistically significant improvement in students' IPAS conceptual understanding, with mean scores increasing from 60.12 to 82.54, supported by a Wilcoxon Signed Ranks Test result of $Z = -4.408$ (Sig. = 0.000) and a mean N-Gain of 0.56 in the medium category.

These findings indicate that integrating TikTok's widely familiar platform with AR technology and game-based learning principles is a promising approach to addressing low student engagement and abstract concept comprehension challenges in elementary science education. It should be noted, however, that these results represent preliminary

evidence from a limited trial, and should not be interpreted as conclusive proof of effectiveness. The study is limited by its small sample size (n = 26), single-school context, and the absence of a control group, all of which constrain the generalizability of the findings.

For future development, it is recommended that the game be: (1) expanded to cover broader IPAS topics and incorporate adaptive difficulty levels; (2) trialed on a larger and more diverse student population; (3) evaluated using a quasi-experimental design with a control group to strengthen causal claims; and (4) implemented over multiple sessions to examine whether sustained exposure produces higher N-Gain scores.

CONFLICT OF INTEREST

The authors declare no financial, institutional, commercial, or personal conflicts of interest in the execution, authorship, or publication of this article. All research activities were conducted independently and in accordance with academic integrity.

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