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TIKTOK FOR SCIENCE LEARNING: THE INTERPLAY OF TIKTOK AS AN EDUCATIONAL TOOL, USABILITY, SATISFACTION, SKILLS, AND FUTURE IMPACT

Marwan M. A. Abualrob

Abstract. *The growing incorporation of social media into the field of science education encourages the current study to investigate the relationships and interactions of TikTok as an Educational Tool (ET), Pedagogical and Scientific Skills (PSS), TikTok's Ease of Use (EU), its Educational and Future Impact (EFI), and Participant Satisfaction (PS). The study sample consisted of 174 students, including Physics, Chemistry, and Biology majors from the Faculty of Science, and Elementary Education majors from the Faculty of Education who are trained to teach science at the elementary level. Among them, 58 students received training to create educational TikTok videos. Data were analyzed using Structural Equation Modeling (SEM) with SmartPLS 4 in two main stages. Findings indicate that both ET and EU significantly enhance PSS and EFI, with PS serving as a key mediator in improving the learning experience. EU had the greatest impact, highlighting the importance of the pedagogical value of intuitive and engaging design. Grounded in the Technology Acceptance Model (TAM), the study found that users were more likely to adopt TikTok as an educational tool when they perceived it as both beneficial and user-friendly, which in turn contributed to the development of PSS. These findings suggest that TikTok can be an efficient ET, particularly in science education, when designed to enhance engagement and accessibility.*

Keywords: *TikTok for education, science learning, technology acceptance model, science education*

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Introduction

Social media platforms emerge as influential tools across various domains, including education, with TikTok standing out for its user-friendly interface. Since its launch in 2016, TikTok's EU has been one of the primary factors for its success, enabling users to film, edit, and share audio-visual content of up to 10 minutes, all within the same app (Garg & Pahuja, 2020). TikTok has gained popularity as a platform for educational content, amassing billions of views across various fields (Sampige et al., 2024). It offers straightforward tools and a vast library of images, audio clips, and videos, enabling users to create highly original and complex videos. While initially seen as a platform primarily for the younger generation, it has since attracted a diverse user base, producing a multiplicity of content (Bhandari & Bimo, 2022).

As digital technologies continue to advance in education, it is crucial to understand the role of social media platforms in enhancing science education. One of the most popular of these among learners is TikTok, a platform that offers short, engaging, and accessible educational content. TikTok's integration into higher education supports competence acquisition and enhances student engagement through microlearning environments (Conde-Caballero et al., 2024).

TikTok is becoming a popular platform among educators for sharing experiences and professional practices, indicating its potential impact on teaching methodologies and digital learning environments (Hartung et al., 2023). The platform's algorithm curates personalized content based on user interactions, enhancing students' engagement with the app (Ramsden & Talbot, 2024). Isma et al. (2021) have emphasized TikTok's role in creating interactive learning experiences, proposing broader implications for educational strategies. Likewise, Hayes et al. (2020) have suggested that TikTok could enhance engagement between both public and undergraduate students in the fields of chemistry and science education.

Their study has revealed that viewers of educational TikTok videos developed a greater interest in chemistry and reported enjoyment in learning the subject.

Social media has transformed science communication, enabling the rapid dissemination of science-related content to public audiences. Short-form video-focused platforms like TikTok are efficient vehicles for the dis-

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semination of scientific knowledge, bridging the gap between scientific research and the lay populace by making complex topics more accessible and engaging. For instance, research abstracts presenting research findings have accrued the most engagement on TikTok, indicating a great public desire for condensed scientific knowledge.

This enables educators to reach broader audiences, enhancing science literacy through dynamic and engaging short-form videos (Rein, 2023). However, a study by Pereira and Ha (2024) has found that many videos on the platform contained misleading claims related to environmental issues, highlighting the critical role of science education in combating misinformation.

Furthermore, TikTok videos' social dynamics, shaped by user interactions and relationships, facilitate knowledge and skill sharing (Zea & Jung, 2019). Recent studies have indicated that knowledge circulation on TikTok depends on content structure, engagement levels, and audience interaction (Tian et al., 2023). Similarly, Liu et al. (2024) argue that TikTok's interactive nature creates a seamless learning experience. Research has also documented instances of TikTok being utilized for pedagogical purposes (Radin & Light, 2022; Thornton, 2022). According to Rand and Brushett (2023), TikTok videos can help bridge the gap between teachers and students, providing a fun and casual method to stay updated on course materials.

Beyond its technical features, research indicates that young users engage with TikTok in various ways. In a study by McLean et al. (2023), participants reported that the app strengthened their relationships, enhanced their awareness of privilege, and supported self-expression. These factors highlight TikTok's role in promoting digital interactions and support networks, which can influence education and social learning.

Despite its growing popularity and emerging pedagogical applications in higher education, the educational potential of TikTok remains underexplored (Gálvez-Ruiz et al., 2025). One reason factor is the lack of validated research tools to assess its impact on learning outcomes. Another is the fact that it is considered a relatively novel application (Lamimi et al., 2024). While the platform is widely used by younger audiences, studies examining its role in teaching and learning remain limited, prompting debate over whether it functions more as a source of meaningful knowledge or mere entertainment (Zulkifli et al., 2022). Nonetheless, recent findings point to a growing body of educational content on the platform, highlighting its untapped academic potential (Lamimi et al., 2024).

Several studies have examined the role of social media platforms in promoting collaborative learning, student motivation, and self-efficacy, demonstrating their potential impact on pedagogical approaches (Astleitner & Schlick, 2024). Learning support, motivation, and self-efficacy improve student engagement in educational settings, increasing their participation in social media-enhanced learning environments (Astleitner & Schlick, 2024). Yélamos-Guerra et al. (2022) have found that integrating TikTok into a course project improved students' comprehension and engagement. Their findings have demonstrated how this innovative approach promotes active learning in a motivating manner, highlighting the potential of TikTok as a supplementary ET. Moreover, Deng and Yu (2023) have stated that social media platforms – such as TikTok – encourage technology adoption due to their EU and novelty, offering valuable insights into learner behavior within digital learning spaces.

Research indicates that microlearning through social media can enhance educational outcomes across many disciplines, with TikTok being one of the platforms highlighted in the literature (Denojean-Mairet et al., 2024). Integrating microlearning with social media increases learner satisfaction, broadens accessibility, and provides more effective engagement, demonstrating its potential to improve learning outcomes, regardless of the specific platform used (Denojean-Mairet et al., 2024). Further, Khlaif and Salha (2021) have argued that TikTok supports the development of both scientific and educational competencies through microlearning strategies.

Despite the growing interest in TikTok's use in education, significant knowledge gaps remain regarding its effectiveness in developing problem-solving skills (PSS), improving learning outcomes, and sustaining long-term engagement in science education. As a relatively new platform, TikTok's potential as a source of knowledge remains underexamined (Lamimi et al., 2024). This gap is partly attributed to the lack of validated research tools for assessing its educational impact (Gálvez-Ruiz et al., 2025).

Although TikTok is primarily known as a source of entertainment, several studies suggest that it holds potential as an educational tool. As Lamimi et al. (2024) note, the literature on TikTok's educational value remains limited, yet the platform hosts a growing number of educational videos. Likewise, Zulkifli et al. (2022) have further confirmed the scarcity of research exploring whether TikTok supports learning or simply serves as entertainment. Despite the uncertainties, emerging research supports TikTok's role in enhancing student engagement and learning outcomes. For instance, Cube et al. (2025) have found that students demonstrated high levels of engagement when using TikTok for learning, as well as an improvement in their ability to recall information. In the context of science education, TikTok has shown potential in increasing student interest and motivation to learn scientific concepts

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(Ling & Mohamad Nasr, 2024). Still, despite its growing usage, the platform's educational benefits remain largely unexamined in higher education settings (Gálvez-Ruiz et al., 2025).

While this study highlights the educational potential of TikTok in science instruction, it is important to recognize the influence of cultural and regional contexts on its use and reception. TikTok's educational effectiveness may vary significantly across different sociocultural environments due to differences in digital literacy, educational norms, language use, and perceptions of informal learning. As this study was conducted within a specific cultural and educational setting, its findings should not be generalized uncritically. Future research should investigate how similar approaches might be adapted or interpreted in other international contexts, especially where technological access, institutional support, or learner expectations differ.

This study explores the interrelationships between PSS, EU, EFI, and PS in the context of using TikTok as an ET. Through exploring these dimensions, the study aims to deepen our understanding of TikTok's potential to enrich science education and to develop evidence-based strategies for its effective integration into education.

Theoretical Framework

TikTok's integration into science education is supported by the TAM, which offers a reliable framework for analyzing its adoption and impact on learning outcomes. The TAM, developed by Fred Davis in 1989, is a theoretical framework used to explain and predict how users come to accept and use a technology. The model suggests that two main factors influence a person's intention to use a technology: Perceived Usefulness and EU (Davis et al., 1989). Perceived Usefulness refers to the extent to which a person feels that use of a given system will improve their academic success, whereas EU refers to the degree to which a user considers a tool to be effortless to use. In education, tools seen as both easy and beneficial are more likely to be adopted by learners. According to the TAM, learners are more likely to incorporate TikTok as a learning tool if they deem it both user-friendly and valuable for education.

The TAM has been widely applied in assessing digital learning adoption, making it suitable for evaluating TikTok as an ET. A comparative assessment using e-lectures, classroom response systems, classroom chat, and mobile virtual reality showed that classroom response systems had the highest degree of acceptance. While the acceptance of mobile virtual reality declined over time (Sprenger & Schwaninger, 2021).

TAM remains the most commonly used and recognized model for measuring technology acceptance (Estriegana et al., 2019). It has been effectively applied to various technologies, including social media platforms (Abrahim et al., 2019; Dumpit & Fernandez, 2017). Its strong explanatory power and simplicity contribute to its continued influence in measuring technology acceptance (Granić & Marangunić, 2019; Scherer, Siddiq, & Tondeur, 2019).

Research consistently demonstrates that perceived EU, along with perceived usefulness and content richness, significantly influences behavioral intentions to adopt TikTok as a pedagogical tool (Lamimi et al., 2024). Lamimi et al. (2024) have found that perceived usefulness, ease of use, user attitudes, and content richness greatly enhance behavioral intentions to use TikTok as a learning tool, particularly for creating short, bite-sized educational content. Further, Omar and Dequan (2020) argue that user motivations, specifically archiving, self-expression, social interaction, and escapism, significantly influence TikTok usage, more so than personality traits. While the impact of each factor may vary, they collectively offer valuable insights into user behaviors in educational settings. Research also suggests that EU and perceived usefulness directly impact behavioral intention, enhancing learning effectiveness and knowledge acquisition (Elaine & Fuady, 2023).

A study by Al-Khasawneh et al. (2022) indicates that the intention to use TikTok is influenced by user-generated content, enjoyment, and EU. Furthermore, Tan and Singh (2022) argue that video-related features in TikTok, such as duets, show potential for promoting engaging and meaningful learning experiences in virtual environments. User-generated content had the strongest positive impact, followed by the perceived enjoyment, then sense of belonging, EU, and perceived usefulness. These findings have affirmed their hypotheses on the app's effectiveness as an ET. Another study has found that TikTok's integration into higher education granted high levels of PS and engagement, demonstrating its effectiveness in promoting interactive learning environments (Conde-Caballero et al., 2024).

Research shows that TikTok can be an effective tool for enhancing student engagement and learning. In a recent study, Cube et al. (2025) have confirmed an improvement in students' ability to recall information when using TikTok as an educational tool, proving their enhanced engagement. Similarly, Ling and Mohamad Nasr (2024) have explored TikTok's effectiveness in increasing students' interest in science. The results of their findings show that

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while TikTok has the potential to be a fascinating and creative learning platform, the level of its effectiveness in stimulating engagement depends on the strategic use of content.

Research Hypotheses

In light of these observations and the limited yet growing body of research, the current research aims to investigate the structural relationships among using TikTok as an ET, its EU, PS, PSS, and its EFI. Guided by the theoretical framework and existing research on the use of TikTok in educational environments, this study formulates a set of research hypotheses to test the proposed relationships between these constructs.

Drawing from the theoretical framework and prior research on TikTok's role in education, this study formulates a set of research hypotheses to investigate the proposed relationships between its key constructs. These hypotheses aim to explore how EU and PS influence TikTok's adoption as an ET, as well as the app's significance in enhancing PSS and the EFI.

The hypotheses have been categorized into two groups: direct hypotheses, which test the relationships between the core constructs, and mediating hypotheses, which examine PS's role as a mediator in these relationships.

Direct Hypotheses (Structural Model)

- H1: Using TikTok as an ET enhances PSS.
- H2: TikTok's EU enhances PSS.
- H3: Using TikTok as an ET enhances EFI.
- H4: TikTok's EU enhances EFI of TikTok.
- H5: PS enhances PSS of TikTok.
- H6: PS enhances the EFI of TikTok.

Mediating Hypotheses (Indirect Effects)

- H7: PS mediates the relationship between TikTok as an ET and PSS enhancement.
- H8: PS mediates the relationship between TikTok's EU and PSS enhancement.
- H9: PS mediates the relationship between TikTok as an ET and EFI.
- H10: PS mediates the relationship between TikTok's EU and EFI.

Research Methodology

General Background

This study employed a descriptive approach to analyze the relationships between TikTok as an ET, PSS, TikTok's EU, EFI, and PS in science education. This approach was chosen for its effectiveness in exploring the complex, multidimensional relationships between key constructs, such as ET, EU, PSS, EFI, and PS within this educational context. It offered valuable insights into TikTok's potential as an educational tool and supported its effective application in science education. The use of the Structural Equation Model (SEM) enabled the researcher to simultaneously assess both direct and indirect effects among constructs, providing a nuanced and comprehensive understanding of how TikTok's usability and educational applications influence scientific learning outcomes.

Furthermore, grounding the study in the TAM provided a robust theoretical framework for understanding users' adoption behaviors and perceptions (Davis et al., 1989; Venkatesh & Davis, 2000; Muhaimin et al., 2019; Alshammari & Alkhwaldi, 2025).

Data Collection

To guide the research process, the data collection phase included several stages aligned with the study's objectives and methodology. The project was implemented during the Fall 2025 semester and involved both training activities and field engagement. Students received structured support to explore TikTok as a platform for science education through video production, peer collaboration, and reflective discussions. To have greater participation across different departments and ensure widespread outreach, data collection was conducted electronically.

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Participants

The study involved a sample of 174 students, including Elementary Education majors who are trained to teach science at the elementary level, and Science faculty students majoring in Physics, Chemistry, or Biology. These students were both consumers and creators of TikTok educational content (i.e., those who regularly watch or produce short science videos).

The selected methodology allowed for a comprehensive evaluation of learner engagement, skill development, and satisfaction. This integrated approach was essential to capture the dynamic interactions necessary for advancing the use of TikTok as a pedagogical medium in science learning environments (Conde-Caballero et al., 2024). Participants were selected via purposive sampling, a type of non-probability sampling, based on their educational background and involvement in TikTok-based learning. The final sample comprised 174 students from various academic backgrounds, including Physics, Chemistry, Biology (from the Faculty of Science), and Elementary Education (from the Faculty of Education). Among them, 58 students—27 from Elementary Education, 9 from Physics, and 22 from Chemistry—were enrolled in the Science Teaching Methods course and received training to create short educational videos on TikTok. These students were categorized into three groups based on their majors: Elementary Education, Physics, and Chemistry.

Procedures

The project involved training students to integrate TikTok into science education by engaging their peers from related disciplines. Throughout the semester, students covered science topics from elementary and secondary education curricula. Each trained student mentored two peers from other departments, such as Elementary Education, Biology, Chemistry, or Physics, who were not enrolled in the Science Teaching Methods course. This approach expanded the sample size and reinforced the study's ability to assess TikTok's potential in knowledge dissemination. In addition, this peer-to-peer approach allowed for collaborative learning and encouraged the participation of a larger student population from different disciplines, thus improving generalizability.

This approach leveraged TikTok's interactive and collaborative features to facilitate rapid knowledge sharing. The inclusion of students from diverse scientific disciplines further enhanced the generalizability of the study's findings across different fields. At the end of the project, students attended a discussion on their educational content and participated in its evaluation. To incentivize participation, the project was worth 10% of the students' final unit grade, inspired by a method used in a study by Conde-Caballero et al. (2024), with full marks awarded to those who met all assessment criteria outlined in the Content Evaluation Rubric.

Instrument

Before collecting data, the researchers conducted a pilot test involving 20 students from the Faculty of Science, part of the study population, not the final sample, along with five professors. The questionnaire was refined based on their feedback in terms of wording, format, numbering, and item sequencing to improve clarity and coherence.

The finalized questionnaire consisted of two sections. The first one collected demographic data, such as participants' willingness to participate, gender, and academic major (Elementary Education, Physics, Chemistry, or Biology). The second included 35 items measuring key concepts in the research model: ET, EU, PS, PSS, and EFI, each of which was assessed through seven criteria.

The second section items were measured using a 5-point Likert scale, developed based on insights from the educational literature (Chen, 2020; Conde-Caballero et al., 2023; Elevate.io Team, n.d.; Jacobs et al., 2022; Jerasa et al., 2024; Omar & Dequan, 2020; Radin & Light, 2022; Shahin, 2023; Xavierine & Shanthi, 2024). Item formulation was guided by established theoretical frameworks and empirical findings, ensuring relevance and suitability for the study context.

The questionnaire was distributed electronically for better accessibility, despite some potential limitations, such as limited internet access for some participants. To mitigate these limitations, data collection was expanded to maximize participation, thereby enhancing the credibility of the results.

To ensure the quality of the instrument, the psychometric properties were carefully evaluated. The internal consistency and construct validity were examined using PLS-SEM. Reliability was assessed through Cronbach's Alpha and Composite Reliability (CR), while convergent validity was verified using the Average Variance Extracted (AVE). Discriminant validity was established through the Fornell-Larcker criterion. These procedures are explained

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in detail in the Results section. The instrument consisted of multiple items. The items are statements designed to measure participants' perceptions of each construct in the model. The full list of questionnaire items is provided in Appendix A.

Data Analysis

The study employed SEM using Smart-PLS4, conducted in two main stages. The first stage Standard Model Analysis involves assessing the measurement tool's reliability and consistency using internal consistency measures. The second stage Structural Model Analysis examines the relationships between the study's hypothesized key constructs. SEM was selected for its proficiency in estimating complex relationships between manifest and latent constructs, providing greater precision in result interpretation.

As an emerging tool in education, TikTok requires a study design that ensures consistent measurement across participants, enabling reliable comparisons of its impact on skill enhancement and PS. This study contributes to a deeper understanding of TikTok's effective integration into science education, offering insights necessary for developing innovative educational strategies.

To ensure the measurement model's soundness, the study evaluated key reliability and validity metrics, including CR and Factor Loadings, as detailed below:

Composite Reliability (CR)

CR values exceeding .70 indicated consistent measurement of the key constructs across different criteria. These constructs are: PSS enhancement, the effectiveness of TikTok as an ET, EU, EFI, and PS. Such values confirmed the constructs' stability and validity, ensuring a strong foundation for further statistical analysis. This .70 threshold is widely supported in psychometric literature, as it reflects internal consistency and supports the reliability of the structural equation model. According to Hair et al. (2016), a CR value of .70 or higher was considered acceptable for exploratory research, suggesting that the latent construct is measured consistently across its observed variables. Fornell and Larcker (1981) also emphasized that CR values above .70 indicate a construct's reliability, validating its use in subsequent statistical procedures.

Factor Loadings

Factor analysis examined the variance among interrelated constructs and evaluated how well each corresponds to a specific factor. A construct's factor loading measured the correlation between a construct and a specific factor, demonstrating how much variance in the factor is explained by the construct. In the SEM, a factor had to account for a sufficient portion of the observed variance to be considered significant. A generally accepted threshold for significance was a factor loading of .50 or higher, reflecting a meaningful relationship between the factor and its construct. This level of loading indicates that the factor effectively captures the underlying constructs, reinforcing the validity of the measurement model. According to Hair et al. (2016), a factor loading of .50 or higher was considered acceptable, particularly in social science research. This threshold implies that the construct explains at least 25% of the variance in the observed variable. Similarly, Fornell and Larcker (1981) argued that loadings above .50 reflect substantial shared variance between the indicator and its latent factor, reinforcing convergent validity. These benchmarks support the interpretation of .50 as a meaningful threshold in SEM.

Research Results

The following results detail the psychometric properties and structural relationships derived from the PLS-SEM analysis, including factor loadings, CR, and relationships between key constructs. The study explored the interactions between TikTok as an ET, EU, PS, PSS, and EFI. Results showed that all factor loadings exceeded the .50 threshold recommended by Hair et al. (2016), confirming the constructs' reliability and validity. This ensures the items accurately represent the underlying dimensions of TikTok's role in science learning. Table 1 below presents the results for each construct, including mean, standard deviation, outer loadings, VIF values, and indicators of reliability and validity.

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Table 1
Construct: Mean, Standard Deviation, Outer Loading, VIF, Reliability, and Validity

Constructs	Codes	*M*	*SD*	Outer loadings	VIF	α	CR	AVE
ET	ET.1	4.212	0.588	.829	2.907	.902	.923	.633
	ET.2	4.206	0.614	.839	3.350			
	ET.3	4.141	0.732	.809	2.306			
	ET.4	4.218	0.666	.751	1.875			
	ET.5	4.188	0.643	.765	1.933			
	ET.6	4.212	0.690	.839	2.814			
	ET.7	4.124	0.731	.728	1.753			
EU	EU.1	4.224	0.650	.699	1.460	.789	.848	.501
	EU.2	3.871	0.964	.793	1.939			
	EU.3	4.053	0.786	.509	1.298			
	EU.4	4.165	0.650	.752	1.702			
	EU.5	4.347	0.646	.675	1.575			
	EU.6	4.306	0.680	.672	1.596			
	EU.7	3.918	0.839	.540	1.188			
PS	PS.1	3.806	0.956	.734	1.796	.859	.892	.544
	PS.2	4.206	0.696	.674	1.427			
	PS.3	3.971	0.788	.798	2.153			
	PS.4	4.042	0.651	.784	1.992			
	PS.5	3.929	0.789	.781	1.961			
	PS.6	4.006	0.867	.631	1.409			
	PS.7	4.072	0.749	.744	1.820			
PSS	PSS.1	4.265	0.649	.706	1.747	.874	.903	.572
	PSS.2	4.129	0.861	.735	1.961			
	PSS.3	4.329	0.563	.820	2.413			
	PSS.4	4.131	0.662	.739	1.742			
	PSS.5	4.143	0.843	.685	1.688			
	PSS.6	4.226	0.663	.799	2.507			
	PSS.7	4.167	0.740	.801	2.182			
EFI	EFI.1	4.077	0.699	.849	2.609	.855	.890	.538
	EFI.2	4.066	0.803	.767	2.016			
	EFI.3	4.220	0.704	.775	1.935			
	EFI.4	4.089	0.741	.659	1.797			
	EFI.5	4.018	0.803	.698	1.967			
	EFI.6	4.320	0.676	.647	1.751			
	EFI.7	4.337	0.663	.720	1.846			

These findings confirmed that the key factors influencing the use of TikTok in science education were measured accurately, aligning with the overall research objective, and thus allowing for a reliable analysis of the constructs' relationships. This, in turn, promoted the formulation of educational strategies, such as integrating TikTok into science curricula and developing training programs to enhance PSS. The confirmed reliability of these factors ensured that the recommendations were based on solid empirical evidence, thereby supporting TikTok's effective use as an ET.

Construct Reliability and Validity

The study assessed reliability and validity using Cronbach's Alpha (α), CR, and AVE. Cronbach's Alpha values ranged from .789 to .902, while CR values ranged from .848 to .923, both exceeding the recommended 0.70

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threshold. These results validated internal consistency, confirming that the scale items effectively measured their respective constructs.

AVE values ranged from .501 to .633, exceeding the .50 threshold set by Fornell and Larcker (1981). This indicated that the constructs accounted for over 50% of the variance in their indicators, confirming strong convergent validity. Constructs such as TikTok as an ET (α = .902, CR = .923, AVE = .633), PSS (α = .874, CR = .903, AVE = .572), and EFI (α = .855, CR = .890, AVE = .538) showed particularly high reliability and validity.

Overall, the findings affirmed the strength of the measurement model, validating its suitability for further structural analysis. Despite minor deviations, such as lower outer loadings for a few items, the overall construct reliability and validity remained unaffected. Future research could explore refining item formulations to enhance measurement precision.

Discriminant Validity

Discriminant validity ensured that the model constructs were distinct and captured unique theoretical concepts. The study assessed discriminant validity using the Fornell-Larcker criterion (Fornell & Larcker, 1981), which remains a widely accepted approach in structural equation modeling. This method evaluates the correlations between constructs to confirm their distinctiveness. Table 3 below presents the results of this analysis.

The findings indicated that all constructs met the Fornell-Larcker criterion, as their square roots of AVE exceeded their correlations with other constructs. For instance, EFI had a diagonal value of .845, surpassing its correlations with ET .791 and EU .771. These results validated the distinctiveness of each construct, ensuring minimal overlap within the model.

Table 2
Discriminant Validity (Fronell)

Fornell	EFI	ET	EU	PS	PSS
EFI	.845				
ET	.791	.788			
EU	.771	.768	.770		
PS	.756	.629	.701	.737	
PSS	.784	.752	.750	.720	.756

The findings confirmed strong discriminant validity, a critical requirement in SEM, ensuring that each construct represented a unique dimension within the theoretical framework. The confirmation of discriminant validity enhanced the theoretical clarity of the model and increased the credibility of the statistical outcomes (Fornell & Larcker, 1981; Henseler, Ringle, & Sarstedt, 2015). This verified the accuracy of the measurement model, providing a reliable foundation for further structural analysis and emphasizing the importance of distinguishing the constructs in this study.

HTMT

The Heterotrait-Monotrait Ratio (HTMT) was used to evaluate the discriminant validity of the constructs in this study. To establish construct distinction, the HTMT ratio should remain below .85 or .9 for a more forgiving criterion. This threshold is well-established in recent methodological literature. Henseler, Ringle, and Sarstedt (2015) introduced HTMT as a reliable and sensitive method for assessing discriminant validity in variance-based SEM, recommending a threshold of .85 to confirm distinctiveness between constructs. In exploratory studies, a more lenient threshold of 0.90 is considered acceptable (Henseler et al., 2015). Therefore, the acceptable HTMT values reported in Table 4 affirm the uniqueness of each construct, reinforcing the validity of the model and minimizing the risk of construct overlap.

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Table 3
HTMT Ratios

Constructs	HTMT Ratio
EFI	.871
ET	.784
EU	.835
PS	.819
PSS	.845

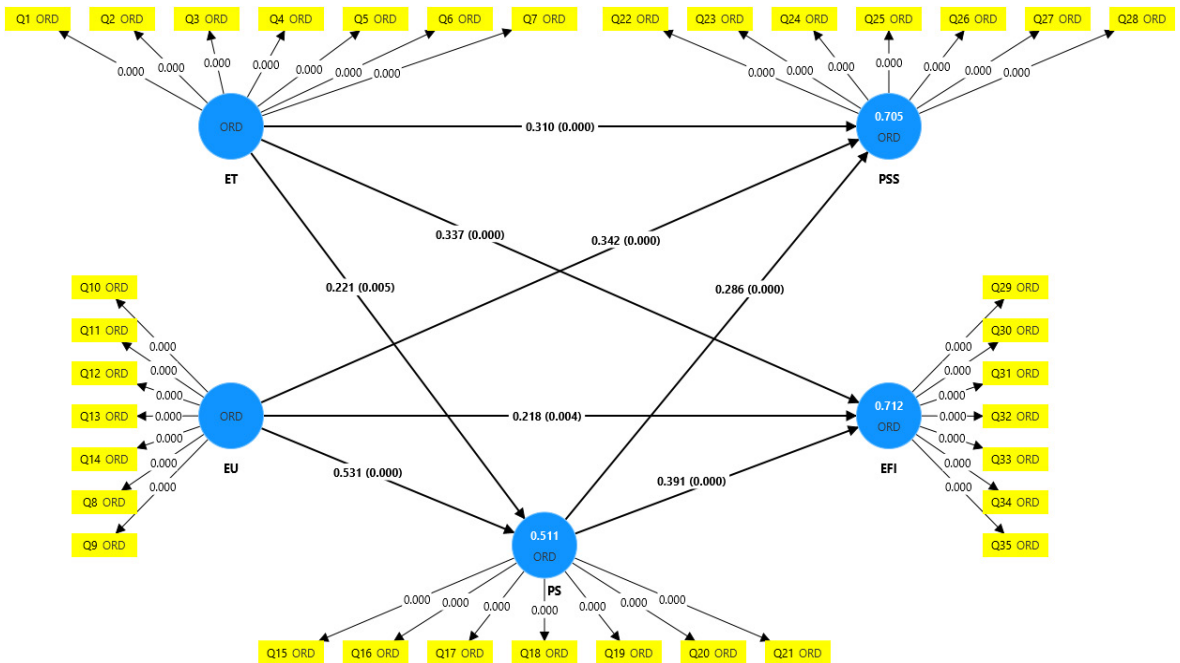
These findings confirmed that the study's constructs were distinct, instilling confidence that the measurement model was properly specified and that each construct accurately captured a unique dimension of the research. This distinction was fundamental for ensuring the construct validity of the measurement model. When constructs were empirically distinct, it minimized the risk of multicollinearity and conceptual overlap, preserving the clarity and interpretability of the structural paths. According to Henseler, Ringle, and Sarstedt (2015), achieving discriminant validity confirms that each construct measures a statistically and conceptually unique domain.

In this study, constructs such as TikTok as an ET, EU, PSS, EFI, and PS represented distinct dimensions of technology integration in science education. Their empirical differentiation validated the structural model and ensured that each construct contributed uniquely to understanding the educational potential of TikTok.

Structural Model

The structural model (Fig. 1 presents) the results from PLS-SEM using SmartPLS4. After establishing convergent validity in the measurement model, the model's predictive capability and core construct relationships were evaluated individually. This analysis was guided by established criteria, particularly effect size (f^2) and predictive relevance (Q^2). These indicators provided valuable insights into the strength of construct relationships and the model's predictive accuracy, enhancing the soundness and interpretability of the findings.

Figure 1
Structural Model (Path coefficient & p value)



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Effect Size (f^2)

Table 4 demonstrates effect size (f^2) for the study constructs, accentuating the relationships between TikTok as an ET, EU, PS, PSS, and EFI. The results revealed varying levels of influence among these constructs, indicating significant relationships among the study constructs.

Table 4
Effect Size f²

Constructs	*f*-square
ET -> EFI	.156
ET -> PS	.041
ET -> PSS	.128
EU -> EFI	.055
EU -> PS	.236
EU -> PSS	.131
PS -> EFI	.260
PS -> PSS	.135

PS had the strongest effect on EFI (f^2 = .260). This indicated that when learners deemed TikTok educational content engaging and satisfactory, it positively impacted their educational growth and future aspirations. Likewise, EU greatly influenced PS (f^2 = .236), indicating that TikTok's user-friendly nature boosted learners' satisfaction with it as an ET. This reinforced the importance of usability in digital learning adoption. Further, TikTok as an ET had a moderate effect on EFI (f^2 = .156) and PSS (f^2 = .128). This implied that integrating TikTok into education supported learners' future educational aspirations as well as the enhancement of their pedagogical and scientific competencies. Moreover, the relationships between EU and PSS (f^2 = .131) and between PS and PSS (f^2 = .135) emphasized the significance of usability and learner satisfaction in enhancing educational and scientific competencies. Finally, despite ET → PS (f^2 = .041) having a relatively smaller effect, TikTok as an ET still holds a measurable impact on learner satisfaction (Cohen, 1988). This implied that content quality, relevance, and the instructional approach might also have contributed to user engagement.

These findings highlighted the significance of TikTok's usability, participant satisfaction, and pedagogical impact in establishing its effectiveness as an ET. The observed substantial effects reinforced TikTok's potential in modern digital education, particularly in developing learners' skills and future academic growth.

Predictive Relevance (Q^2)

The Predictive Relevance Q^2 value, also known as the Stone-Geisser Q^2 value, evaluated the model's predictive capability alongside R^2, which measured predictive accuracy. A Q^2 value greater than zero for an endogenous reflective construct confirmed that the model had predictive relevance and could provide meaningful future predictions.

The blindfolding procedure was performed with an omission distance (D) of 7. All obtained Q^2 values were greater than zero: EFI .612, PS .488, and PSS .645. These results validated the model's positive predictive relevance for the key constructs in this study, reinforcing the strength of the path model.

The highest recorded predictive relevance was for PSS (Q^2 = .645), supporting the model's prediction of the development of PSS. This indicated that TikTok's integration as an ET significantly influences learners' skill acquisition and knowledge enhancement. Likewise, the predictive relevance of EFI (Q^2 = .612) reinforced the model's ability to predict the long-term educational impact, highlighting TikTok's contribution to students' academic and professional trajectories. The predictive relevance of PS (Q^2 = .488) further supported the model's accuracy, emphasizing the importance of engagement and user experience in assessing TikTok's effectiveness as an educational platform.

These predictive values collectively highlighted the model's strength in predicting the impact of digital educational tools on learner satisfaction, skill development, and future academic prospects. The results indicated that enhancing these factors could improve digital learning experiences and educational outcomes.

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Hypotheses Testing

This study tested ten research hypotheses (H1–H10) to examine the direct and mediating relationships among TikTok as an ET, EU, PS, PSS, and EFI. Figure 1 demonstrates the structural relationships between key constructs, highlighting how TikTok as an ET and EU influences PS, PSS, and EFI. The model revealed that ET and EU significantly affected PSS and EFI, either directly or indirectly through PS.

Table 5
Hypotheses Testing Results

H.	Direction	Path coefficient	*M*	*SD*	*t* value	*p* values	Result
H1	ET -> PSS	.310	.311	0.068	4.531	< .001	Supported
H2	EU -> PSS	.342	.345	0.082	4.160	< .001	Supported
H3	ET -> EFI	.337	.338	0.071	4.743	< .001	Supported
H4	EU -> EFI	.218	.218	0.081	2.677	.004	Supported
H5	PS -> PSS	.286	.284	0.082	3.489	< .001	Supported
H6	PS -> EFI	.391	.393	0.086	4.544	< .001	Supported
H7	ET -> PS -> PSS	.063	.065	0.032	1.957	.025	Supported
H8	EU -> PS -> PSS	.152	.151	0.051	2.974	.001	Supported
H9	ET -> PS -> EFI	.086	.091	0.041	2.110	.017	Supported
H10	EU -> PS -> EFI	.208	.208	0.057	3.635	< .001	Supported

Table 5 exhibits the direct effects of ET on PSS (H1: $\beta = .310$, $p < .001$) and EFI (H3: $\beta = .337$, $p < .001$). These findings confirmed that integrating TikTok into education significantly enhanced PSS, as well as students' future educational impact. Similarly, the direct effects of EU on PSS (H2: $\beta = .342$, $p < .001$) and EFI (H4: $\beta = .218$, $p = .004$) suggest that TikTok's EU had a positive impact on learning outcomes. These findings aligned with those of Elaine and Fuady (2023).

Furthermore, PS significantly influenced PSS (H5: $\beta = .286$, $p < .001$) and EFI (H6: $\beta = .391$, $p < .001$), highlighting the role of engagement and user experience in enhancing TikTok's effectiveness as an ET, which aligned with Al-Khasawneh et al.'s study (2022).

The study also confirmed indirect relationships, where ET and EU impacted PSS and EFI through participant satisfaction (H7–H10). This highlighted how a positive user experience improved learning outcomes and future educational impact, consistent with the findings of Elaine & Fuady (2023).

The strongest indirect effect was observed in EU → PS → EFI (H10: $\beta = .208$, $p < .001$), suggesting that TikTok's user-friendly nature enhanced user satisfaction, which in turn increased future educational benefits. This accorded with the findings of both Conde-Caballero et al. (2024) and Al-Khasawneh et al. (2022).

These findings underscored the importance of usability, engagement, and pedagogical effectiveness in digital learning. Consistent with prior research on educational technology adoption, the results confirmed that platforms like TikTok could enhance learning outcomes when they were engaging, accessible, and pedagogically sound.

Although the findings aligned with previous research, it remained essential to discuss them in detail to establish the model's relevance within the specific educational and cultural context of this study. Discussing consistent results allowed researchers to validate and reinforce theoretical frameworks such as the TAM, confirm the applicability of findings to emerging platforms (such as TikTok in science education), and contribute meaningfully to the broader body of cumulative knowledge.

Discussion

The study findings substantiated TikTok's potential as an effective educational tool in science education. Grounded in the TAM, the results indicated that perceived EU and usefulness, represented as an ET, were key predictors of educational outcomes. This aligns with Davis et al. (1989), reaffirming TAM's relevance in digital learning environments, especially those utilizing short-form video content like TikTok.

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TikTok's user-friendly design plays a crucial role in enhancing learner engagement and skill acquisition, particularly in science disciplines that require visually dynamic and concise explanations. Its intuitive interface enables students to create educational content, which fostered deeper understanding and creative knowledge construction. These results highlight that TikTok's potential as an EU extends beyond technical usability, as it actively promotes PSS and shapes learners' perceptions of academic growth.

The significant impact of TikTok as an ET on both PSS (H1) and EFI (H3) suggested that, beyond technical simplicity, the platform's structure and algorithm could support academic development. These findings are based on previous studies (e.g., Hayes et al., 2020; Radin & Light, 2022), which emphasize TikTok's effectiveness in translating abstract scientific concepts into accessible narratives. The platform encourages students to create content, allowing them to reframe scientific knowledge in pedagogically relevant and socially engaging ways.

PS emerged as a key mediator between TikTok's usability and its educational impact. Mediation analysis confirmed that satisfaction enhances both PSS and the perceived long-term value of learning. Notably, the indirect path from EU → PS → EFI (H10: $\beta = .208$, $p < .001$) exhibited the strongest mediation effect. This supports Conde-Caballero et al.'s (2024) assertion that learner enjoyment, motivation, and autonomy are essential for meaningful learning experiences in digital contexts.

Despite the direct influence of ET on PS ($f^2 = .041$) being relatively modest, the indirect effects via satisfaction were statistically significant. This suggests that content quality or subject relevance alone may not drive satisfaction; rather, the overall user experience, including usability, peer interaction, and perceived achievement, plays a more influential role. Educators and digital content designers should thus prioritize learner-centered design and interactive features that promote intrinsic motivation and ownership of learning.

The findings also reinforced the predictive strength of the research model. The high Q^2 values for PSS (.645), EFI (.612), and PS (.488) validated the model's capacity to forecast educational outcomes and learner engagement. These results highlight TikTok's viability not only as a supplementary tool but also as a structured platform for pedagogical innovation and microlearning, which aligns with Denojean-Mairet et al. (2024).

From a practical standpoint, these findings offered actionable insights for educators and educational technologists. They indicated that merely introducing TikTok as a content delivery tool was not sufficient; meaningful educational impact depends on fostering user satisfaction through interactive, student-centered content that takes advantage of TikTok's visual, social, and creative features (Conde-Caballero et al., 2024). The comprehensive analysis offered by this study goes beyond merely confirming previous findings, ultimately providing a nuanced understanding of how digital tools like TikTok can transform pedagogical practices (Greenhow & Lewin, 2021).

While short-form video platforms, such as TikTok, can offer engaging content, their entertainment-oriented nature and compulsive use patterns have been linked to increased academic stress and decreased academic engagement in students (Dong et al., 2024). Even though TikTok has the ability to support educational goals, studies have shown that its entertainment-oriented qualities and overuse can hinder student academic engagement and drive stress levels higher, negatively affecting learning outcomes (Dong et al., 2024).

A parallel concern involves TikTok's potential to disseminate misinformation, particularly in science education, where oversimplified or decontextualized content may distort scientific facts (Pereira & Ha, 2024). The platform's algorithmic promotion of viral content can amplify such risks. To mitigate this, educators should embed digital literacy and critical evaluation skills into instructional design. Students can be taught to assess the credibility of online sources and encouraged to triangulate information across reliable scientific references. Additionally, assessment tasks can require learners to create TikTok videos grounded in evidence-based content and aligned with curriculum standards, fostering responsible digital content creation. These strategies support a more informed and critically engaged use of TikTok as an educational tool.

Conclusions and Implications

This study explored the interplay between TikTok as an ET, PSS, EU, EFI, and PS. Grounded in the TAM, the findings highlighted how TikTok's EU and perceived advantages support its adoption in education, improving pedagogical skills, learner satisfaction, and future educational outcomes.

This study contributes to the domain of education research through empirical evidence on the pedagogical implications of TikTok in the science education context. It fills a gap in the literature by investigating how the user experience of TikTok affects cognitive engagement, self-efficacy, and motivation. The findings of this study have implications for teacher development, curriculum design, and the intentional integration of digital media into formal learning environments.

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Unlike prior research that focused on general attitudes toward social media in education, this study uniquely integrates the TAM framework with actual teaching practices involving TikTok. It offers new insights into how short-form video platforms can be used not only for content delivery but also for developing students' pedagogical and reflective skills in science education.

The findings established that EU significantly impacts PSS as well as EFI. This affirms the core premise of the TAM: technology adoption is influenced by usability and perceived usefulness. Participants who found TikTok intuitive and accessible were more likely to incorporate it into their learning, fostering scientific knowledge growth and greater future educational aspirations.

PS emerged as a key mediator between TikTok's EU, its role as an ET, and its impact on learning effectiveness and long-term educational outcomes. The study found that when students perceived TikTok as enjoyable and engaging, they were more likely to participate actively, retain knowledge, and develop essential PSS. These results align with previous research highlighting the significance of digital engagement in promoting meaningful learning experiences.

TikTok's role in science education was further validated through its significant direct and indirect effects on PSS and EFI. These effects affirmed that social media platforms can be effective educational tools when designed and implemented thoughtfully. Integrating TikTok into education enhances engagement, promotes active learning, and facilitates knowledge acquisition, making it a viable solution for modern pedagogical approaches.

The study's findings offer valuable insights into the interactions among TikTok as an ET, PSS, EU, EFI, and PS in shaping the effectiveness of digital learning. These insights provide several practical applications for educators, policymakers, and institutions seeking to optimize the use of TikTok and similar digital tools in education.

Teacher Training and Digital Literacy Programs:

The strong relationship between TikTok's EU, PSS, and EFI stresses the need for teacher training programs to prioritize digital competency development. Hands-on workshops would equip educators with the skills necessary for integrating TikTok into subject-specific instruction, enabling them to create engaging, pedagogically sound educational content.

Continuous Professional Development for Educators:

For in-service teachers, Continuous Professional Development should build their confidence in integrating TikTok into education. Effective Continuous Professional Development initiatives should incorporate peer collaboration, real-world case studies, and structured experimentation with TikTok-based lessons to help educators assess its impact on student engagement and learning outcomes.

Curriculum Integration and Support:

Curriculum designers should incorporate short-form video content as an essential component of modern teaching strategies. The findings indicate that educators are more likely to adopt TikTok for educational purposes when they deem it valuable for enhancing EFI. To enable this, curricula should explicitly include TikTok-based learning activities, video assignments, and assessments that promote interactive, student-centered learning.

Encouraging Student and Teacher Engagement:

The positive relationship between PS and PSS highlights the importance of an engaging learning environment. Educational institutions should encourage teachers to explore TikTok-based teaching approaches, promoting a culture of creativity, collaboration, and innovation in the classroom.

Bridging the Digital Divide:

To reach TikTok's full educational potential, accessibility challenges must be addressed. Policymakers should develop strategies to ensure equitable access to digital resources, providing technical support and digital literacy training for teachers and students to maximize the benefits of technology-driven education.

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Appendix A. Full questionnaire measuring key constructs in the research model: ET, EU, PS, PSS, and EFI.

1. My experience with TikTok videos has enhanced my ability to simplify scientific concepts effectively.
2. The TikTok video experience has improved my understanding of scientific concepts.
3. Creating TikTok videos has helped me strengthen my scientific communication skills with students.
4. After using TikTok, I became more capable of presenting scientific topics in engaging manner.
5. The TikTok video experience helped me develop skills in designing real-life examples that align with students' needs.
6. TikTok videos enhanced my creative thinking in simplifying scientific concepts.
7. Using TikTok helped me better understand students' learning needs.
8. TikTok is an effective tool for simplifying scientific concepts.
9. I believe TikTok can be used as a formal educational tool in the future.
10. TikTok is easy to use for creating educational content.
11. Using TikTok increased students' interest in scientific concepts.
12. The TikTok videos I created captured students' attention more effectively than traditional methods.
13. TikTok supports the use of visual effects to clarify scientific concepts.
14. Creating educational content using TikTok was easier than using other methods.
15. Producing videos with TikTok was easy.
16. The short duration of TikTok videos was sufficient for delivering simplified scientific content.
17. TikTok's built-in video editing tools were easy to use.
18. The design of TikTok's interface made it easier to produce educational videos.
19. Incorporating visual effects into videos using TikTok was straightforward.
20. The tools available on TikTok were sufficient for creating engaging educational content.
21. Overall, using TikTok to create educational content was convenient.
22. TikTok videos increased my awareness of the importance of digital media in education.
23. TikTok videos can serve as an effective tool for training future science teachers.
24. TikTok videos enhanced my perception of the role of technology in educational development.
25. Using TikTok helped me acquire skills that are beneficial to my professional career.
26. I am willing to use TikTok or similar platforms in the future to communicate scientific concepts.
27. TikTok videos contribute to the advancement of modern teaching practices.
28. Using TikTok can have a lasting impact on science education improvement.
29. My overall experience creating TikTok videos was fulfilling.
30. I was satisfied with the support I received during the video production process.
31. Audience feedback helped me improve the quality of the videos I produced.
32. Creating TikTok videos helped me strengthen my teamwork skills.
33. I was satisfied with the collaborative experience during the video creation process.
34. The overall TikTok video experience was enjoyable.
35. I believe the TikTok video experience will have a positive impact on my professional growth.

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