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Interactive Multimedia in Physical Education: The Effectiveness of Powtoon in Improving Learning Outcomes in Elementary Schools

Oman[1], Shofiatul Khusnah[2], Arita Marini[3*], Gusti Yarmi[4], Desy Safitri[5], Sujarwo[6], Musril Zahari[7], Leola Dewiyani[8]

[1] Physical Education Department, Universitas Negeri Jakarta, Jakarta, Indonesia
[2,3,4] Elementary School Teacher Education Department, Universitas Negeri Jakarta, Jakarta, Indonesia
[5,6] Social Studies Education Department, Universitas Negeri Jakarta, Jakarta, Indonesia
[7] Accounting Department, Sekolah Tinggi Ilmu Ekonomi Indonesia Jakarta, Jakarta, Indonesia
[8] Industrial Engineering Department, Universitas Muhammadiyah Jakarta, Jakarta, Indonesia

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ABSTRAK

*Rendahnya hasil belajar pendidikan jasmani pada siswa sekolah dasar disebabkan oleh penggunaan media pembelajaran yang kurang interaktif dan menarik. Kondisi ini menghambat keterlibatan siswa dalam proses pembelajaran, sehingga diperlukan inovasi media yang mampu meningkatkan minat dan pemahaman siswa. Penelitian ini bertujuan untuk mengembangkan multimedia interaktif berbasis Powtoon guna meningkatkan hasil belajar pendidikan jasmani siswa kelas IV SD. Metode penelitian yang digunakan adalah penelitian dan pengembangan (R&D) dengan mengadaptasi model pengembangan yang mencakup tahapan analisis kebutuhan, desain, pengembangan, hingga evaluasi produk. Data dikumpulkan melalui tes hasil belajar yang dilakukan sebelum (*pretest*) dan sesudah (*posttest*) penggunaan media interaktif. Analisis data meliputi uji normalitas dengan Kolmogorov-Smirnov dan uji homogenitas menggunakan SPSS versi 24, yang menunjukkan bahwa data berdistribusi normal dan homogen. Uji-t yang dilakukan mengindikasikan perbedaan yang signifikan antara hasil belajar* pretest *dan* posttest*, di mana hasil belajar siswa meningkat secara signifikan setelah menggunakan multimedia interaktif berbasis Powtoon. Temuan ini menunjukkan bahwa penggunaan multimedia interaktif berbasis Powtoon efektif dalam meningkatkan hasil belajar pendidikan jasmani. Dengan demikian, dapat disimpulkan bahwa multimedia interaktif berbasis Powtoon memberikan pengaruh positif terhadap peningkatan hasil belajar sekolah dasar.*

ABSTRAK

The low learning outcomes in physical education among elementary school students are attributed to the use of less interactive and engaging learning media. This condition hinders students' engagement in the learning process, necessitating media innovation to enhance their interest and comprehension. This study aims to develop Powtoon-based interactive multimedia to improve the learning outcomes of fourth-grade elementary school students in physical education. The research employed a research and development (R&D) method by adapting a development model encompassing needs analysis, design, development, and product evaluation stages. Data were collected through pretest and post-test learning outcome assessments conducted before and after the use of interactive media. Data analysis included normality tests using the Kolmogorov-Smirnov test and homogeneity tests using SPSS version 24, indicating that the data were normally distributed and homogeneous. The t-test results demonstrated a significant difference between pretest and post-test learning outcomes, showing that students' learning outcomes improved significantly after using Powtoon-based interactive multimedia. These findings indicate that Powtoon-based interactive multimedia is effective in enhancing physical education learning outcomes. Therefore, it can be concluded that the use of Powtoon-based interactive multimedia has a positive impact on improving the physical education learning outcomes of fourth-grade elementary school students.

*Corresponding author.
E-mail addresses: aritamarini@unj.ac.id (Arita Marini)

1. INTRODUCTION

The rapid advancement of science and technology profoundly influences human life, including education. Digital technology has brought about faster, more efficient services and enabled innovative and interactive learning through animations, videos, simulations, and educational games (Kabir et al., 2022; Mutohhari et al., 2021; Quaicoe & Pata, 2020). These tools increase student engagement and make complex concepts more intuitive, paving the way for technology-enhanced learning (TEL). Through tools like animations, videos, simulations, and educational games, teaching has become more interactive and intuitive, making it easier for students to grasp complex concepts (Park et al., 2020; Shuo, 2021; Tarigan et al., 2021). TEL systematically applies information and communication technologies (ICT) to enhance educational processes. This includes designing and implementing digital content that engages users through multimedia formats. Technology-enhanced learning (TEL) encompasses the Application of information and communication technologies (ICT) to improve education (Kabir et al., 2022; Mutohhari et al., 2021; Park et al., 2020; Quaicoe & Pata, 2020; Shuo, 2021; Tarigan et al., 2021). It involves systematically designing, developing, and utilizing digital content to engage learners through multimedia, creating a more immersive and practical learning experience. Many researchers consider improving learning technology synonymous with infrastructure and equipment, and their use is beneficial in education. The development of interactive multimedia involves a systematic process of designing, creating, and implementing digital content that engages users through multiple forms of media (Diah et al., 2021; Zaliluddin et al., 2021).

However, integrating Information and Communication Technology (ICT) in education is a positive and vital step towards a more effective and engaging learning experience. The success of TEL depends on more than just the availability of technology; it requires effective integration into teaching practices and curricula (Ly et al., 2024; Selvaraj et al., 2021; H. Zhang & Li, 2024). Various ICT tools and applications can enrich the learning process by presenting more interactive content, facilitating collaboration between students and teachers, and increasing accessibility to educational resources. Education should build universal skills such as creativity, innovation and entrepreneurship, imagination and emotional expression, and the integration of knowledge and creativity (Gerbaudo-González et al., 2024; Henriksen et al., 2020). However, every student has different creative potential, and a flexible and inclusive approach is essential for creativity to flourish among all students. This requires curriculum, teaching, and learning environment changes to create spaces that stimulate and support creative expression. The challenge related to learning media is to create media that can accommodate the diversity of learning styles and creative potential of each student (Arif et al., 2019; Rahmi & Samsudi, 2020). Each individual has a unique way of learning so that the media used must be able to adapt to these various needs (Priantini & Widiastuti, 2021; Sudirman et al., 2020). Many media are still static, such as textbooks or slide presentations, even though they are more dynamic and interactive media. Therefore, to support the development of students' creative potential, learning media are needed that are more diverse, innovative, and can be accessed equally by all students.

This research is very relevant to the current state of education, especially with the transition to online learning accelerated by the pandemic. While online learning can offer flexibility, challenges arise when the material presented, especially in physical education learning, could be more exciting and challenging for students (Ebrahim & Wyk, 2024; Singh et al., 2023). The low ability of teachers to utilize technology and the lack of innovation in developing digital learning media can hinder the effectiveness of learning (Hadjadji et al., 2024; Malysheva et al., 2022; Rohles et al., 2022). To make today's learning efficient, technology innovation is needed. Learning media development is an integral part of the learning process and must be directed at meaningful learning that encourages students to acquire the skills necessary for life in this century (Dahlke et al., 2024; He et al., 2024; Hinostroza et al., 2024; Pogorskiy & Beckmann, 2023).

Physical education education in elementary schools plays a crucial role in fostering physical fitness, teamwork, and healthy lifestyles among young students. However, traditional teaching methods in physical education often fail to capture students' interest, leading to decreased motivation and suboptimal learning outcomes. Integrating digital technology and the internet is very important in education to expand the boundaries of the teaching and learning process (Ding et al., 2024; Elshaer et al., 2024; Nakandala et al., 2024; Njiepue Nouffeussie et al., 2024; Salem Abdullah Bajaber, 2024; Sutiah & Supriyono, 2024). However, to experience significant integration between digital technology and the internet, improving students' cognitive aspects is also necessary. Integrating digital technology and the internet in education must be balanced with serious efforts to improve students' cognitive elements. This can be achieved through a well-designed curriculum, learning approaches that encourage critical thinking, and support for teachers to use technology effectively in learning. Thus, significant integration between digital technology and the internet in learning can be successful (An et al., 2024; Cheng et al., 2024; Fambeu & Yomi, 2024; Vilhunen et al., 2025; F. Zhang, 2024; Y. Zhang et al., 2024).

In contrast to previous research, which did not involve collaboration between various media, learning only focused on one media. Therefore, learning tends to get boring, and students may no longer be

interested in learning. It is necessary to develop innovative learning media that can improve the quality of learning and create a more significant learning experience for students (Chang et al., 2021; Liu & Zhou, 2024; Mlambo et al., 2020; Sarosa, 2021; Y. Zhang et al., 2024). The limitations of effective learning media in explaining material can potentially reduce students' motivation and understanding of the material being studied. Therefore, because learning media allows students to participate actively in class, students' interest in learning increases, and there is the potential for improving their learning outcomes. In this research, researchers used interactive media with the Powtoon application to provide opportunities for students to participate actively in the learning process. Learning is currently carried out through technology-based media, so this research is essential. While previous research has highlighted the benefits of multimedia in education, it typically focuses on single-medium tools (e.g., static videos or text-based resources). These approaches often lead to monotonous lessons that fail to sustain student interest. Few studies have explored integrating multiple forms of media—such as animation, interactive quizzes, and storytelling—into a cohesive learning experience tailored to physical education.

Despite the potential of ICT in education, several challenges remain (1) lack of engagement in physical education shown that traditional methods rely heavily on physical demonstrations and verbal instructions, which often fail to captivate students' interest, resulting in decreased motivation and suboptimal outcomes; (2) insufficient use of technology displayed that the teachers face difficulties in utilizing digital tools effectively, leading to missed opportunities in creating innovative learning experiences. The pandemic-driven shift to digital education revealed gaps in teachers' ability to innovate and adapt physical education content for online platforms; (3) limited integration of multimedia indicated that previous studies have predominantly focused on single-medium learning tools, resulting in monotonous and less impactful teaching methods (Dai, 2024; Dang et al., 2024; Lohr et al., 2024; Y. Zhang et al., 2024). Existing physical education materials often lack interactivity and fail to make complex concepts accessible, particularly in topics requiring higher cognitive engagement. These issues highlight the need for a more comprehensive approach to developing engaging and effective learning tools.

The COVID-19 pandemic accelerated the shift to online learning, exposing significant gaps in the preparedness of educators to utilize technology creatively. With the increasing reliance on digital tools, it is urgent to develop innovative teaching methods that make learning enjoyable and impactful. Physical education, often sidelined in digital transformation, requires attention to preserve its benefits for students' physical and cognitive development. The urgency of the study concludes *first,* shifting learning needs: as education evolves to meet digital-era demands, traditional teaching methods risk becoming obsolete. There is an urgent need to bridge this gap through innovative, student-centred approaches*. Second,* impact on students' development**:** physical education contributes to physical fitness, teamwork, and healthy lifestyles. Addressing the shortcomings of traditional methods is essential to ensure these benefits are fully realized*. Third,* teacher readiness: teachers need practical, user-friendly tools that enable them to deliver engaging lessons, especially in a subject like physical education, which faces unique challenges in digital settings. The primary goals of this research are to determine the effectiveness of Powtoon-based interactive multimedia in improving physical education outcomes and to develop a dynamic and engaging multimedia tool that fosters active student participation and enhances the learning experience. This study differentiates itself by combining various multimedia elements through the Powtoon application to create a cohesive and interactive learning environment. Unlike prior research focusing on single-media tools, this approach ensures a richer, more diverse educational experience. The integration of multimedia, animation, and interactivity has the potential to improve student motivation and outcomes significantly.

2. METHOD

This research is research and development (Research and Development). Research and Development (R&D) research methods are research methods used to produce specific products and test the effectiveness of these methods. This research design of this media development method uses research and development, using the ADDIE model comprising five phases: (1) analyze: identify the needs and requirements for creating practical multimedia learning tools; (2) design: develop a detailed blueprint for Powtoon-based interactive multimedia; (3) development: create and refine the multimedia product based on the design specifications; (4) implementation: use the developed media in the experimental group's learning process; (5) evaluation: Assess the effectiveness of the multimedia through pretest and posttest comparisons. The study also adopts an experimental method to test the effectiveness of the developed multimedia. As an experimental and control group, this research was conducted on 33 fourth-grade elementary school students in Setiabudi District, South Jakarta, Indonesia. The study follows a one-group pretest-posttest design, where the experimental group receives the treatment, and their knowledge is assessed before and after the intervention. The comparison of pretest and posttest scores will be analyzed

using statistical tests to find out whether there is a significant difference in students' knowledge of the learning material after explaining the game of baseball. The population comprises fourth-grade elementary school students in Setiabudi District, South Jakarta, Indonesia. Using the Slovin formula, the sample size was determined, and 33 students were selected for the experimental and control groups.

Pretest and Posttest focused on cognitive skills, measuring understanding and learning outcomes related to baseball material. The tests assess students' knowledge before and after the intervention. This research uses pretest and posttest instruments related to students' cognitive skills, including students' understanding of the material and learning outcomes. After the experimental treatment, the group was given a pretest and posttest. A pretest was administered to gauge the baseline understanding of baseball-related material. Treatment was done where the experimental group participated in lessons using Powtoon-based interactive multimedia. Posttest was conducted to evaluate the students' knowledge after the intervention. With treatment, pretest scores can be compared with posttest scores. A comparison of the Pretest and Posttest of one group shows the effect of treatment. The normality Test uses the Kolmogorov-Smirnov test to determine whether the data is normally distributed. The Homogeneity Test uses Levene's test to ensure the variance across groups is uniform, which is essential for parametric testing. Hypothesis testing used a paired sample t-test to compare pretest and post-test scores and identify significant differences in students' learning outcomes after using the multimedia. Significance is tested at $\alpha = 0.05$. $p<0.05$: Reject the null hypothesis, indicating a significant difference. $p\geq0.05$: Fail to reject the null hypothesis, indicating no significant difference.

3. RESULT AND DISCUSSION

Results

The steps for the Powtoon-based interactive media display developed are as follows. Firstly, the user can open the website https://www.powtoon.com/account/login/ and then log in. After logging in, the user can select the desired application form. Furthermore, the user can select the available template. If the user wants to use the "education" template, he can click "edit in studio". If the user has chosen a suitable template, the fourth step in making learning videos with Powtoon is editing the slides. Then, the user can click "Pick a background colour" to choose a suitable background colour. Moreover, the user can click "Text" to enter the title and content of the material. Next, the user can click "Characters" to enter the desired character or image. If the user wants to add a video, click "Videos". Then, the user can click "Audio" to add music or voiceover. After that, the user can click at the top to see a preview of the resulting video before publishing it. Next, the user can click "Export" to get four options: publish, download, upload and share.

Interactive media was developed by collaborating with Powtoon as a learning video for fourth-grade physical education material. Apart from that, this media is equipped with a Quizizz link as an evaluation that students can access directly. The following is a display of the media cover page, which contains a table of contents of the material that students will study and animations according to the theme. After that, the second slide, which contains the meaning of the baseball game, appears on the material page. The media is presented in Figure 1.

Figure 1. Interactive Media

Apart from that, there is also a page that displays the techniques for playing baseball; each technique includes a video link so that students understand and can practice directly. The page display can be seen in Figure 2. After students watch a learning video about baseball, the researcher wants to evaluate a quiz to see how much they understand the material that has been explained. Students can join using the code displayed on the screen, as in Figure 2.

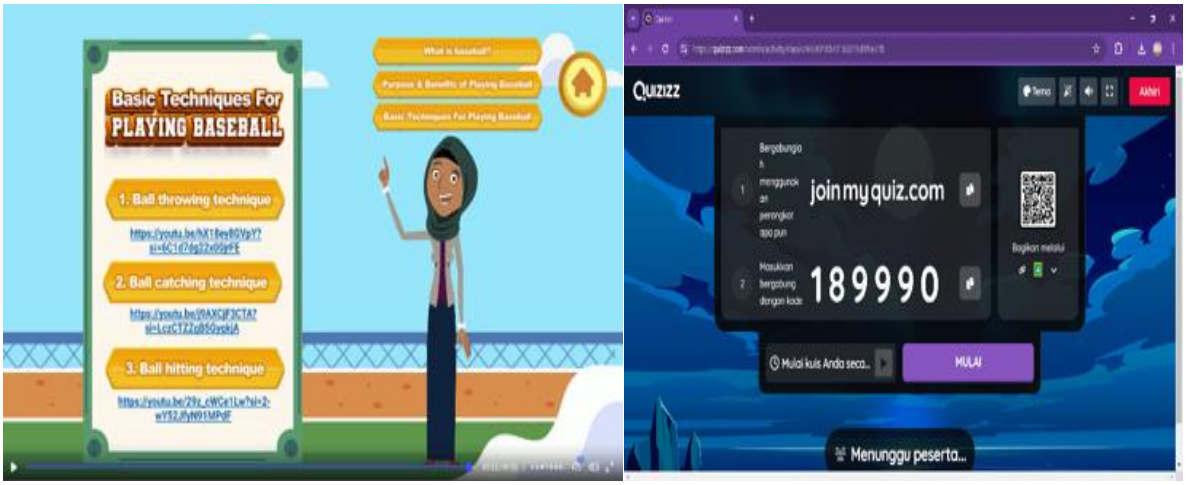

Figure 2. Material Page and Quiz Page

The Kolmogorov-Smirnov test was carried out to test the distribution of the data. In this case, as presented in Table 1, the data distribution was tested using SPSS 24. It can be concluded that the data is normally distributed. In Table 2, the homogeneity test results in this study used SPSS 24. Based on Table 2 due to a significance value larger than 0.05 stating that H0 is accepted, it can be concluded that the data is homogeneous.

Table 1. Normality Test Results

Groups		Kolmogorov-Smirnov			Shapiro-Wilk		
		Statistic	df	Sig.	Statistic	df	Sig.
Learning Outcomes	Pre-Test	0.126	33	0.200	0.941	33	0.073
	Post Test	0.141	33	0.093	0.942	33	0.080

Table 2. Homogeneity Test Results

Parameters		Levene Statistic	df1	df2	Sig.
Learning Outcomes	Based on Mean	1.908	1	64	0.172
	Based on Median	1.906	1	64	0.172
	Based on the Median and with adjusted df	1.906	1	62.463	0.172
	Based on trimmed mean	1.895	1	64	0.173

Next, the researcher used the t-test to test the significance level; then, the researcher used SPSS 24 to present the data in Table 3. There was a significant difference between the pretest learning results for those who had not received treatment using the multimedia application-based Powtoon and the Posttest after receiving treatment using the multimedia-based Powtoon. Therefore, the null hypothesis is rejected.

Table 3. T-Test Results

Groups		F	Sig.	t	df	Sig. (2 tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
Learning Outcomes	Equal variances assumed	5.478	0.022	4.548	64	0.000	4.394	0.966	6.324	2.464
	Equal variances are not assumed.			4.548	56.080	0.000	4.394	0.966	6.329	2.459

Table 3 shows that applying Powtoon-based interactive media can improve the physical education learning outcomes of fourth-grade elementary school students in Setiabudi District, South Jakarta, Indonesia. Thus, the research can be declared successful because Powtoon-based interactive media can significantly influence student learning outcomes. Therefore, Powtoon-based interactive media for online learning is critical, especially regarding baseball material.

Discussion

Technology integration in education has transformed the traditional learning environment into a more dynamic and engaging experience. Powtoon, an innovative platform for creating animated and interactive presentations, offers immense potential to enhance the educational process, particularly in physical education. This study aims to develop Powtoon-based interactive multimedia tailored to improve learning outcomes in physical education for fourth-grade elementary school students. Supported by recent research, this approach leverages engaging visuals, interactive elements, and user-friendly design to address the unique challenges of teaching physical education in the digital era (Liu & Zhou, 2024; Obeso et al., 2023; Vargas-Montoya et al., 2023). Using animation and interactive elements can increase student engagement, facilitate understanding of the material, and increase information retention (Le & Pham, 2024; SANFO, 2023; Tierney et al., 2024). Thus, Powtoon makes learning more enjoyable and practical and positively impacts student learning outcomes. In the digital era, students are more interested in activities involving technology, both in games and learning.

Powtoon is not just a presentation tool, but also it is a transformative medium that redefines how information is delivered and absorbed. Through vibrant animations, compelling storytelling, and interactive features, Powtoon enables educators to easily present abstract or theoretical concepts to young learners (Blinkoff et al., 2023; Roganović, 2024). In physical education, where practical Application and conceptual understanding must go hand-in-hand, Powtoon can visually illustrate movements, strategies, and principles that might otherwise be difficult to convey in traditional classroom settings. Powtoon is an online web application allowing users to create animated cartoons or video presentations easily. Powtoon is software designed to create attractive exposures, with animation features such as handwriting and cartoon characters, dynamic transition effects, and simple timing (Anita & Kardena, 2021; Basri et al., 2021; Udin & Rezania, 2024). Its ability to quickly produce animated cartoons or video presentations opens up new opportunities for users to convey information more interestingly and dynamically. Animation features such as handwriting and cartoon characters can provide a creative touch that makes presentations more attractive, including recording audio narration, creating animations, designing interactive quizzes, and assembling video clips. Powtoon and similar tools offer a range of features that streamline this process, such as built-in animation tools, voiceover capabilities, and the ability to import external media. The key is ensuring each element serves a clear educational purpose and enhances the learning experience (Istiqomah & Adi, 2024; Sari et al., 2024; Yhonara et al., 2022).

Introducing multimedia elements like animations, interactive quizzes, and visual storytelling can make learning more appealing and accessible. Moreover, multimedia tools like Powtoon align with the natural inclinations of today's students, who are accustomed to engaging with digital content through games, videos, and apps (Ananda & Zulfadewina, 2023; Toharudin & Kurniawan, 2023). Research highlights that such tools significantly enhance student engagement, foster active participation, and improve retention rates, particularly when learning involves visual and experiential components. Learning media can convey messages from sender to recipient to stimulate students' thoughts, feelings, concerns and interests so that the learning process runs effectively and achieves learning goals (Ananda & Zulfadewina, 2023; Ari Prasetyo et al., 2024; Basri et al., 2021; Fitriyani & Solihati, 2022; Perpisa et al., 2023; Wahyuni et al., 2023). Using apps like Powtoon, which offers engaging animation features, can increase student engagement and enrich their learning experience. By incorporating elements of fun and interactivity, the goal is to increase student participation, understanding, and retention of physical education concepts and skills (Basri et al., 2021; Fitriyani & Solihati, 2022). The limitation of this research is that this research only develops interactive multimedia based on Powtoon for physical education of grade IV elementary school students. It is recommended that other research develop other interactive multimedia based on Powtoon for other subjects. The implication of this research is that the interactive multimedia based on Powtoon that is developed can be used in physical education of grade IV elementary school students. This media can help students in learning.

4. CONCLUSION

The results of this study indicate that there is a significant difference in learning outcomes between the post-test and those who received treatment with the Application of Powtoon-Based interactive media,

and the initial trial, which did not receive special or conventional treatment. So interactive media based on Powtoon has a positive effect on the learning outcomes of physical education and health class IV in Setiabudi District, South Jakarta. It is recommended that interactive media based on Powtoon can be applied in elementary schools to improve student learning outcomes. The limitation of this study is that this study was only applied to elementary school students in the South Jakarta area. So that further research can cover the areas of East, West, Central and North Jakarta to determine the effect of technology on student learning outcomes comprehensively.

5. REFERENCES

An, R., Addas, A., Rehman, N., & Rehman, S. (2024). Predicting online learning experiences in sports education during the COVID-19 pandemic: Implications for pedagogical strategies. *Heliyon*, *10*(17). https://doi.org/10.1016/j.heliyon.2024.e37159.

Ananda, S. R., & Zulfadewina, Z. (2023). Analysis of the Effect of Powtoon Application Interactive Learning Media on Mathematics Learning Ability of Elementary School Students. *Jurnal Paedagogy*, *10*(1), 268. https://doi.org/10.33394/jp.v10i1.5688.

Anita, A. S., & Kardena, A. (2021). The Effect Of Using Powtoon Toward Students' Motivation In Writing. Of English Language Pedagogy. *ELP (Journal of English Language Pedagogy)*, *6*(1), 1–13. https://doi.org/10.36665/elp.v6i1.369.

Ari Prasetyo, W., Hartatik, S., & Rulyansah, A. (2024). The Effect Of Using Powtoon Media On Elementary School Students' Mathematics Learning Outcomes On Time Measurement Material. *Basica: Journal of Primary Education*, *4*(1). https://doi.org/10.37680/basica.v4i1.5321.

Arif, M. F., Praherdhiono, H., & Adi, E. P. (2019). Pengembangan Video Pembelajaran Ipa Materi Gaya Untuk Siswa Sekolah Dasar. *Jktp*, *2*(4), 329–335.

Basri, M., Fadli, F. F., & Sumargono. (2021). The Effect of Using the Powtoon Application on Student Learning Motivation. *Review of International Geographical Education Online*, *11*(5), 4018–4024. https://doi.org/10.48047/rigeo.11.05.283.

Blinkoff, E., Nesbitt, K., T., G., R., M., Pasek, K., & H. (2023). Investigating the contributions of active, playful learning to student interest and educational outcomes. *Acta Psychologica*, *238*(103983). https://doi.org/10.1016/j.actpsy.2023.103983.

Chang, T., Hsu, M., Kwon, J., Kusdhadny, M. L. S., & Hong, G. (2021). Effect Of Online Learning For Dental Education In Asia During The Pandemic Of COVID-19. *Journal of Dental Sciences*. https://doi.org/10.1016/j.jds.2021.06.006.

Cheng, Y. T., Lavieri, P. S., Sá, A., & Astroza, S. (2024). Investigating the effects of ICT evolution and the COVID-19 pandemic on the spatio-temporal fragmentation of work activities. *Transportation Research Part A: Policy and Practice*, *187*. https://doi.org/10.1016/j.tra.2024.104192.

Dahlke, J., Beck, M., Kinne, J., Lenz, D., Dehghan, R., Wörter, M., & Ebersberger, B. (2024). Epidemic effects in the diffusion of emerging digital technologies: evidence from artificial intelligence adoption. *Research Policy*, *53*(2). https://doi.org/10.1016/j.respol.2023.104917.

Dai, X. (2024). A study on mindful agency's influence on college students' engagement with online teaching: The mediating roles of e-learning self-efficacy and self-regulation. *Acta Psychologica*, *243*. https://doi.org/10.1016/j.actpsy.2024.104146.

Dang, T. D., Phan, T. T., Vu, T. N. Q., La, T. D., & Pham, V. K. (2024). Digital competence of lecturers and its impact on student learning value in higher education. *Heliyon*, *10*(17). https://doi.org/10.1016/j.heliyon.2024.e37318.

Diah, L., Adnyani, S., Suprianti, G. A. P., Putu, N., Marsakawati, E., Deby, P., & Narotama, A. (2021). Powtoon as the Implementation of Edutainment for Young Learners. *Advances in Social Science, Education and Humanities Research*. https://doi.org/10.2991/assehr.k.210407.239.

Ding, Y., Song, X., Zhu, Y., Xi, R., & Shi, Z. (2024). Digital technology and Chinese-style industrial modernization: Dynamic threshold effect based on R&D Human resources. *Heliyon*, *10*(21). https://doi.org/10.1016/j.heliyon.2024.e38484.

Ebrahim, S., & Wyk, J. M. (2024). Engagement and learning approaches among medical students in an online surgical teaching programme: A cross-sectional study. *Surgery Open Science*, *22*, 53–60. https://doi.org/10.1016/j.sopen.2024.10.010.

Elshaer, I. A., Azazz, A. M. S., Ghaleb, M. M., Abdulaziz, T. A., Mansour, M. A., & Fayyad, S. (2024). The impact of work-related ICT use on perceived injustice: Exploring the effects of work role overload and psychological detachment. *Journal of Open Innovation: Technology, Market, and Complexity*, *10*(1). https://doi.org/10.1016/j.joitmc.2024.100208.

Fambeu, A. H., & Yomi, P. T. (2024). Do ICTs promote the renewable energy consumption? The moderating

effects of economic growth and structural transformation in Africa. *International Economics*, *180*. https://doi.org/10.1016/j.inteco.2024.100563.

Fitriyani, W., & Solihati, N. (2022). The Effect of Powtoon-Based Audiovisual Media on Indonesian Language Learning Outcomes. *MIMBAR PGSD Undiksha*, *10*(1), 148–154. https://doi.org/10.23887/jjpgsd.v10i1.46996.

Gerbaudo-González, N., Rodríguez-González, R., Facal-Mayo, D., & Gandoy-Crego, M. (2024). Personalized interactive multimedia systems to support meaningful activities in dementia care: A systematic review To be published in. *Archives of Gerontology and Geriatrics. Archives of Gerontology and Geriatrics*, *127*. https://doi.org/10.1016/j.archger.2024.105575.

Hadjadji, N., Toulan, N., & Dorra, M. (2024). Impact of digital architecture: The impact of digital technology on ecological formations and its effect on determinants of identity and culture in architectural design. *Journal of Engineering Research (Kuwait*. https://doi.org/10.1016/j.jer.2023.09.004.

He, G., Jiang, H., & Zhu, Y. (2024). The effect of digital technology development on the improvement of environmental governance capacity: A case study of China. *Ecological Indicators*, *165*. https://doi.org/10.1016/j.ecolind.2024.112162.

Henriksen, D., Richardson, C., & Shack, K. (2020). Mindfulness and creativity: Implications for thinking and learning. *Thinking skills and creativity*, *37*, 100689. https://doi.org/10.1016%2Fj.tsc.2020.100689.

Hinostroza, J. E., Armstrong-Gallegos, S., & Villafaena, M. (2024). Roles of digital technologies in the implementation of inquiry-based learning (IBL): A systematic literature review. In *Social Sciences and Humanities Open* (Vol 9). Elsevier Ltd. https://doi.org/10.1016/j.ssaho.2024.100874.

Istiqomah, I., & Adi, B. S. (2024). The Effect of Using Powtoon Animation Learning Media on Solar System Material on the Learning Outcomes of Class VI Elementary School Students. *Jurnal Penelitian Pendidikan IPA*, *10*(3), 1450–1457. https://doi.org/10.29303/jppipa.v10i3.5909.

Kabir, K. H., Hassan, F., Mukta, M. Z. N., Roy, D., Darr, D., Leggette, H., & Ullah, S. M. A. (2022). Application of the technology acceptance model to assess the use and preferences of ICTs among field-level extension officers in Bangladesh. *Digital Geography and Society*, *3*, 100027. https://doi.org/10.1016/j.diggeo.2022.100027.

Le, T. T., & Pham, T. T. (2024). Emotional maturity in EFL teaching: Exploring Vietnamese teachers' perceptions and its impact on student learning outcomes. *Ampersand*, *13*. https://doi.org/10.1016/j.amper.2024.100183.

Liu, Q., & Zhou, W. (2024). The impact of teachers' emotional support on EFL learners' online learning engagement: The role of enjoyment and boredom. *Acta Psychologica*, *250*. https://doi.org/10.1016/j.actpsy.2024.104504.

Lohr, A., Sailer, M., Stadler, M., & Fischer, F. (2024). Digital learning in schools: Which skills do teachers need, and who should bring their own devices? Teaching and Teacher Education. *Teaching and Teacher Education*, *152*. https://doi.org/10.1016/j.tate.2024.104788.

Ly, B., Doeur, B., & Nat, S. (2024). Key factors influencing digital learning adoption among cambodian university students: An integrated theoretical approach. *Computers in Human Behavior Reports*, *15*. https://doi.org/10.1016/j.chbr.2024.100460.

Malysheva, O., Tokareva, E., Orchakova, L., & Smirnova, Y. (2022). The effect of online learning in modern history education. *Heliyon*, *8*(7). https://doi.org/10.1016/j.heliyon.2022.e09965.

Mlambo, S., Rambe, P., & Schlebusch, L. (2020). Effects of Gauteng province's educators' ICT self-efficacy on their pedagogical use of ICTS in classrooms. *Heliyon*, *6*(4). https://doi.org/10.1016/j.heliyon.2020.e03730.

Mutohhari, F., Sofyan, H., & Nurtanto, M. (2021). Technological Competencies: A Study on the Acceptance of Digital Technology on Vocational Teachers in Indonesia. *Proceedings of the 1st International Conference on Law, Social Science, Economics, and Education, ICLSSEE 2021*, 1–11. https://doi.org/10.4108/eai.6-3-2021.2305971.

Nakandala, D., Yang, R., Elias, A., & Fanousse, R. (2024). Effects of managers' environmental consciousness and digital expertise on their technology adoption intentions. *Journal of Cleaner Production*, *474*. https://doi.org/10.1016/j.jclepro.2024.143558.

Njiepue Nouffeussie, A. C., Meka'A, C. B., Noufelie, R., & Ndouyang Balguessam, B. (2024). Use of ICT: What effect on youth access to employment in Cameroon? *Heliyon*, *10*(21), 39967. https://doi.org/10.1016/j.heliyon.2024.e39967.

Obeso, M., Pérez-Pérez, M., García-Piqueres, G., & Serrano-Bedia, A. M. (2023). Enhancing students' learning outcomes through smartphones: A case study of using instagram in higher management education. *International Journal of Management Education*, *21*(3). https://doi.org/10.1016/j.ijme.2023.100885.

Park, H., Kim, H. S., & Park, H. W. (2020). A Scientometric Study of Digital Literacy, ICT Literacy, Information

Literacy, and Media Literacy. *Journal of Data and Information Science*. https://doi.org/10.2478/jdis-2021-0001.

Perpisa, L., Riza, A., & Anggara, S. (2023). Key factors influencing digital learning adoption among cambodian university students: An integrated theoretical approach. *Tell-Us Journal*, *9*(2), 375–382. https://doi.org/10.22202/tus.2023.v9i2.6812.

Pogorskiy, E., & Beckmann, J. F. (2023). From procrastination to engagement? An experimental exploration of the effects of an adaptive virtual assistant on self-regulation in online learning. *Computers and Education: Artificial Intelligence*, *4*. https://doi.org/10.1016/j.caeai.2022.100111.

Priantini, D. A. M. M. O., & Widiastuti, N. L. G. K. (2021). How Effective is Learning Style Material with E-modules During The COVID-19 Pandemic? *Jurnal Ilmiah Sekolah Dasar*, *5*(2), 307–314. https://doi.org/10.23887/jisd.v5i2.37687.

Quaicoe, J. S., & Pata, K. (2020). Teachers' digital literacy and digital activity as digital divide components among basic schools in Ghana. *Education and Information Technologies*. https://doi.org/10.1007/s10639-020-10158-8.

Rahmi, M. N., & Samsudi, M. A. (2020). Pemanfaatan Media Pembelajaran Berbasis Teknologi sesuai dengan karakteristik Gaya Belajar. *Edumaspul: Jurnal Pendidikan*, *4*(2), 355–363. https://doi.org/10.33487/edumaspul.v4i2.439.

Roganović, J. (2024). Familiarity with ChatGPT Features Modifies Expectations and Learning Outcomes of Dental Students. *International Dental Journal*, *64*(6). https://doi.org/10.1016/j.identj.2024.04.012.

Rohles, B., Backes, S., Fischbach, A., Amadieu, F., & Koenig, V. (2022). Creating positive learning experiences with technology: A field study on the effects of user experience for digital concept mapping. *Heliyon*, *8*(4), e09246. https://doi.org/10.1016/j.heliyon.2022.e09246.

Salem Abdullah Bajaber, S. (2024). Factors influencing students willingness to continue online learning as a lifelong learning: A path analysis based on MOA theoretical framework. *International Journal of Educational Research Open*, *7*. https://doi.org/10.1016/j.ijedro.2024.100377.

SANFO, J.-B. M. B. (2023). Examining student ICT use and learning outcomes: Evidence from Japanese PISA data. *Computers and Education Open*, *4*, 100141. https://doi.org/10.1016/j.caeo.2023.100141.

Sari, A. P., Haeruddin, & Saputra, G. Y. (2024). The Effect of Using Powtoon Interactive Learning Media to Improve Learning Outcomes in Class X Informatics Subjects at SMK Kesehatan Samarinda. *TEPIAN*, *5*(1), 15–23. https://doi.org/10.51967/tepian.v5i1.2214.

Sarosa, S. (2021). The effect of perceived risks and perceived cost on using online learning by high school students. *Procedia Computer Science*, *197*(2021), 477–483. https://doi.org/10.1016/j.procs.2021.12.164.

Selvaraj, A., Radhin, V., KA, N., Benson, N., & Mathew, A. J. (2021). Effect of pandemic based online education on teaching and learning system. *International Journal of Educational Development*, *85*(May), 102444. https://doi.org/10.1016/j.ijedudev.2021.102444.

Shuo, S. (2021). The Manifestation of Animation and the Reform of Animation Teaching in Digital Media Era. *Advances in Vocational and Technical Education*, *3*(2), 92–97. https://doi.org/10.23977/avte.2021.030218.

Singh, S., Kumar, V., Paliwal, M., Singh, S. V. P., & Mahlawat, S. (2023). Explaining the linkage between antecedents' factors of adopting online classes and perceived learning outcome using extended UTAUT model. *Data and Information Management*, *7*(4). https://doi.org/10.1016/j.dim.2023.100052.

Sudirman, I. N., Ani, N. K. P., & Utari, P. D. (2020). Pemanfaatan Digital Storytelling sebagai Media Pembelajaran Tematik di SD. *Springer Series on Cultural Computing*, 547–558. https://doi.org/10.31764/elementary.v6i1.11519.

Sutiah, & Supriyono. (2024). Enhancing online learning quality: a structural equation modeling analysis of educational technology implementation during the COVID-19 pandemic. *Telematics and Informatics Reports*, *16*, 100175. https://doi.org/10.1016/j.teler.2024.100175.

Tarigan, W. P. L., Sipahutar, H., & Harahap, F. (2021). The Effect of Interactive Digital Learning Module on Student's Learning Activity and Autonomy. *Bioedukasi: Jurnal Pendidikan Biologi*, *14*(2), 196. https://doi.org/10.20961/bioedukasi-uns.v14i2.49366.

Tierney, O., Vasilevski, V., Kinsman, L., & Sweet, L. (2024). Development of the essential learning outcomes for the midwifery student continuity of care learning model: A Delphi study. *Women and Birth*, *37*(3). https://doi.org/10.1016/j.wombi.2024.01.008.

Toharudin, U., & Kurniawan, I. S. (2023). Improving Student Learning Outcomes Using Powtoon Media Apps. *International Journal of Interactive Mobile Technologies*, *17*(24), 40–53. https://doi.org/10.3991/IJIM.V17I24.45983.

Udin, M. F., & Rezania, V. (2024). The Effect of Animated Learning Media Using Powtoon on Student Learning

Outcomes. *Edunesia : Jurnal Ilmiah Pendidikan*, *5*(1), 500–513. https://doi.org/10.51276/edu.v5i1.694.

Vargas-Montoya, L., Gimenez, G., & Fernández-Gutiérrez, M. (2023). ICT use for learning and students' outcomes: Does the country's development level matter? *Socio-Economic Planning Sciences*, *87*. https://doi.org/10.1016/j.seps.2023.101550.

Vilhunen, E., Vesterinen, V. M., Äijälä, M., Salovaara, J., Siponen, J., Lavonen, J., Salmela-Aro, K., & Riuttanen, L. (2025). Promoting university students' situational engagement in online learning for climate education. *Internet and Higher Education*, *65*. https://doi.org/10.1016/j.iheduc.2024.100987

Wahyuni, S., Syamsunir, S., Hermansyah, S., & Tang, J. (2023). The Effect of Using the powtoon Application on learning outcomes of Class XI IPA Students SMAN 1 Sidrap. *International Journal of Educational Narratives*, *1*(5), 313–319. https://doi.org/10.55849/ijen.v1i5.528.

Yhonara, M. A., Astuti, E., & Styaningrum, F. (2022). Effect of Powtoon Media and Problem Based Learning Model on Accounting Student Learning Outcomes. *Jurnal Inovasi Teknologi Pendidikan*, *9*(3), 258–268. https://doi.org/10.21831/jitp.v9i3.53635.

Zaliluddin, D., Bastian, A., & Ramdani, A. (2021). Media Development Learning Game Al-Qur'an Interactive Multimedia Based. *Proceedings of the 1st International Conference on Islam, Science and Technology, ICONISTECH 2019*. https://doi.org/10.4108/eai.11-7-2019.2297421.

Zhang, F. (2024). Effects of game-based learning on academic outcomes: A study of technology acceptance and self-regulation in college students. *Heliyon*, *10*(16). https://doi.org/10.1016/j.heliyon.2024.e36249.

Zhang, H., & Li, F. (2024). The multidimensional influence structure of college students' online gamified learning engagement: a hybrid design based on QCA-SEM. *Heliyon*, *e36485*. https://doi.org/10.1016/j.heliyon.2024.e36485.

Zhang, Y., Zhang, X., & Meng, Z. (2024). Effect of interactive immediacy on online learning satisfaction of international students in Chinese universities: The chain mediating role of learning interest and academic engagement. *Acta Psychologica*, *244*(104202). https://doi.org/10.1016/j.actpsy.2024.104202.