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Effectiveness of interactive learning media development based on articulate storyline 3 in elementary school education

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ABSTRACT

The development of learning media in the form of interactive media involving animations, quizzes, and videos facilitates better understanding of learning material through two-way communication between the media and students, making the material more concrete and easier to comprehend. This study aims to develop an interactive learning media product based on Articulate Storyline 3 for use in elementary schools and to describe the feasibility of this media in such settings. The method used is Research and Development (R&D) with the ADDIE development model, which includes the stages of analysis, design, development, implementation, and evaluation. This research contributes to the development of interactive learning media using Articulate Storyline in private elementary schools, improving student learning outcomes and enhancing the overall learning process at the elementary level. The results show that interactive media based on Articulate Storyline 3 effectively enhances student understanding, particularly in abstract topics such as magnetism. Its features promote active learning, improve academic performance, and support various learning styles. Developed using the ADDIE model, the media fosters an inclusive and engaging learning environment. However, its success depends on teacher readiness and available infrastructure. Overall, this media offers an innovative approach to enrich primary education. This study contributes to the development of interactive learning media based on Articulate Storyline 3, which is effective in enhancing students' understanding, especially in abstract topics like magnetism. By supporting active learning and various learning styles, this media offers an innovative approach to enrich the learning experience in primary education.

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INTRODUCTION

One of the key challenges in implementing the Merdeka Curriculum is fostering learners who are independent and proactive in seeking knowledge without fully relying on teachers. Kalyani and Rajasekaran (2018), Andersson (2019), and Siregar et al. (2023) argue that the traditional lecture-based approach is no longer relevant to the demands of modern education. Therefore, there is a need for instructional media that promote process skills and encourage active learning. According to Hong et al. (2016), Situmorang et al. (2024), and Jia et al. (2024), interactive media can facilitate two-way communication between teachers and students, making learning more engaging and effective. Jones et al. (2024) also emphasize the importance of utilizing technology, such as e-learning software like Articulate Storyline 3, which integrates visual, audio, and video elements and allows for easily accessible publication formats. Alobaid (2021), Daryanes et al. (2023), and Pan (2023) highlight that such tools enhance student engagement, motivation, and interest in learning. Similarly, Charline et al. (2023), Feng and Xiao (2024), and Ansori et al. (2024) affirm that interactive learning media create a more dynamic learning environment and help students better comprehend the material. Thus, technological innovation in the form of interactive learning media plays a vital role in delivering effective and relevant education in today's context.

Based on several expert perspectives, a major challenge in implementing the Merdeka Curriculum is fostering learners who are independent and active in seeking knowledge, rather than fully relying on teachers. According to Kalyani and Rajasekaran (2018), as well as Andersson (2019), passive learning methods such as traditional lectures are no longer adequate to meet the needs of modern education. Siregar et al. (2023) also emphasize the importance of cultivating learner autonomy through more engaging instructional strategies. In this context, Hong et al. (2016), Situmorang et al. (2024), Jia et al. (2024), and Jones et al. (2024) highlight the role of learning media in supporting process skills and encouraging active student participation. Experts such as Alobaid (2021), Daryanes et al. (2023), Pan (2023), and Wen and Ma (2024) argue that digital tools like Articulate Storyline 3, which integrate visual, audio, and video components, provide accessible and effective formats for interactive learning. Charline et al. (2023), Feng and Xiao (2024), and Ansori et al. (2024) assert that such media significantly increase student engagement, motivation, and interest in learning. Further supporting its efficacy, Putwain et al. (2024) observe that this tool enhances student motivation and achievement, particularly in science education. Yin (2022) notes its usefulness for thematic learning, while Hippisley and Douglas (2002) affirm its reliability as an interactive instructional tool. Moreover, van Laar et al. (2020) emphasize its effectiveness in cultivating 21st-century skills and report positive student responses to its use. Building on these findings, the present study will investigate the application of such media in primary education and evaluate its impact on student learning outcomes.

This research aims to explore the application of interactive learning media based on Articulate Storyline 3 in assisting elementary schools' teaching and learning process, especially in the subjects of Natural and Social Sciences. Through this research, it is expected to know how much the media can increase students' motivation, interest, and learning achievement. In addition, this research also aims to assess the effectiveness of Articulate Storyline 3 in supporting the development of critical, creative, collaborative, and communicative thinking skills (4C), which are very important in facing the challenges of 21st-century learning. More than just theory, this research is expected to provide practical benefits for teachers in creating a more active, interactive, and fun learning atmosphere, where students not only passively receive material but are also actively involved in the learning process. The results are expected to guide curriculum development that is more innovative and in line with the needs of modern education.

The use of interactive learning media based on Articulate Storyline 3 in elementary schools, especially in Natural and Social Sciences subjects, shows a very positive impact on the learning process. This media not only succeeds in increasing students' motivation and interest in learning but can also make learning materials more accessible. With its interactive and engaging design, Articulate Storyline 3 encourages students to be more involved in the learning process, making

learning feel more fun and dynamic. Students who previously may have felt bored or less interested in conventional lecture methods are now more enthusiastic about participating in lessons. In addition, this media also plays a vital role in developing 21st-century skills, namely critical, creative, collaborative, and communicative thinking (4C). Articulate Storyline 3 allows students to be more active in thinking and solving problems, collaborating with classmates, and honing communication skills. Combining visual, audio, and interactive elements facilitates more comprehensive and holistic learning.

RESEARCH METHOD

The research method used in this study is the development research method or Research and Development (R&D), which aims to produce certain products and test their effectiveness in an educational context (Busetto et al., 2020; Foster, 2023). This research uses the ADDIE development model, which is one of the models often used in development research. According to Sarpong et al., (2023), the ADDIE model consists of five stages, namely: (1) Analysis, where learning problems and needs are identified; (2) Design, the stage of designing a solution or product in accordance with the results of the analysis; (3) Development, where the design is transformed into a real product or learning media; (4) Implementation, which involves applying the product in an actual learning situation; and (5) Evaluation, which aims to assess the effectiveness of the product and make improvements if necessary.

In this study, the trial was conducted by involving four validators who are experts in their respective fields, namely material expert validators, teaching material experts, language experts, and learning experts. These validators provided important input regarding the feasibility and quality of the products developed (Thiagarajan et al., 1974). Data collection techniques in this study included observation, interviews, documentation, and tests. The data obtained were divided into two types: qualitative data and quantitative data. Qualitative data was collected through descriptions from observation sheets, interviews, and documentation, which described the views and feedback from validators and learners. Meanwhile, quantitative data was obtained from the pre-test and post-test results, which were used to measure the improvement of learning outcomes after the use of interactive learning media.

For data analysis, a Likert scale was used as a tool to measure perceptions and attitudes towards the developed learning media. According to Zakariah, the Likert scale is very effective for measuring attitudes, opinions, and perceptions of a person or group towards social phenomena. The use of this scale allows researchers to obtain data in numerical form which is then analyzed quantitatively. To determine the effectiveness of the developed product, a t-test is used, which serves to compare the results of the pre-test and post-test, so that it can be assessed whether there is a significant increase in students' understanding and learning outcomes after the use of learning media (Swiatek et al, 2016).

The formula used to calculate the percentage results of product feasibility also uses a Likert scale, where respondents' answers are categorized into a scale that maps the level of agreement or disagreement with certain statements. Thus, the Likert scale makes it easy to assess and validate research results related to perceptions and acceptance of the interactive learning media developed (Mishra et al., 2018). Here's the formula:

$$P = \frac{\sum x}{\sum xi} \times 100\%$$

Description:

P : Percentage score of each research aspect
$\sum$ x : The number of respondents' answer values in one item
$\sum$ xi : Number of ideal scores in one item

According to Umakantha (2016), the t test is used to determine whether the independent variable has a partial influence on the dependent variable. One of the methods used to test the

effectiveness of development products is through the t test. The analysis technique in the t test is based on the results of the pretest and posttest of grade V students, which were carried out as part of the experiment using interactive learning media. This t-test produces a t-count value that shows a significant difference between student learning outcomes before and after the use of the learning media, which proves that the media is effective in improving learning outcomes. Here is the formula:

$\bar{x}_D$ = respondent average (differentiation)
D = D-$\bar{x}_D$
N = number of respondents

The pretest was conducted before the interactive learning media was applied, to determine the initial condition of student learning outcomes. After the treatment, which is the use of interactive media, a posttest is conducted to measure the improvement of learning outcomes. The results of the t-test then produce a t-count value, which is an indicator of whether there is a significant difference between learning outcomes before and after the use of the learning media. If the t-count shows a significant difference, this means that the interactive learning media has a real influence in improving student learning outcomes. Thus, the t-test not only helps measure the success of the treatment, but also provides quantitative evidence of the effectiveness of the media in supporting the improvement of learning quality.

RESULTS AND DISCUSSION

Results

Condition of learners before using interactive learning media

Based on the results of observations and interviews, it was found that the learning process is still dominated by the use of printed media, images, and textbooks, as well as the application of conventional methods such as lectures interspersed with discussions. Some identified obstacles include students' lack of focus, classroom noise, sleepiness, and low motivation to learn, mainly caused by personal problems. In addition, many educators have yet to be able to design interactive learning media, which results in boredom and a lack of student attention during learning. This condition impacts the low achievement of student learning outcomes, as evidenced by the average daily test score of 66%, where 15 out of 24 students have yet to reach the Minimum Completion Criteria (KKM). Although facilities such as Chromebooks, projectors, and Wi-Fi are available, their use could be more optimal due to the limited technological skills of educators and the lack of training to create interactive learning media. In class V, Chromebooks are only used for Computer-Based National Assessment (ANBK) and have not been utilized in daily learning. Therefore, it is necessary to develop more effective interactive learning media, such as Articulate Storyline 3, to help students understand abstract concepts more concretely and improve the overall quality of learning.

Before applying interactive learning media based on Articulate Storyline 3, researchers first conducted observations, interviews, and documentation with VA class students. From the results of these activities, it was found that there were several obstacles in the learning process, especially in the subjects of Natural and Social Sciences (IPAS). One indicator is the results of students' daily tests, which show an average score of 65.8, which indicates that students' understanding of the material provided by IPAS could be more could be more optimal. Based on these findings, researchers sought to assess how students' competence and learning outcomes could be improved after using interactive learning media. For this reason, researchers conducted a pre-test before learning media was applied to measure students' initial understanding of the material. After applying Articulate Storyline 3-based media, researchers conducted a post-test to see changes in students' understanding and mastery of the material. Through the comparison of the pre-test and post-test results, researchers can evaluate how much the learners' understanding has improved after

using the interactive learning media, as well as the effectiveness of the media in helping them master the material more deeply. The following are the results of the learners' pre-test obtained through the formula:

$$P = \frac{\Sigma x}{\Sigma x ideal} \times 100\%$$

$$P = \frac{1380}{2400} \times 100\%$$

$$P = 58\%$$

Based on the analysis of pre-test results in Natural and Social Sciences (IPAS) for 24 students, only two students successfully met the Minimum Completion Criteria (KKM), while the remaining 22 students still fell short of the KKM. Overall, the percentage of pre-test scores reached 58%, indicating that the majority of students had not achieved the established passing standard. This data was derived from the pre-test results, where the symbol "x" represents the pre-test scores, and "P (100%)" indicates the scores in percentage form. The accompanying table description illustrates the students' passing status, showing that most students fall into the "did not pass" category.

These results indicate that students' understanding of the IPAS material is inadequate, and the majority of students have not been able to master the concepts taught. Based on this condition, researchers see an urgent need to develop more effective learning media to help students improve their understanding. Therefore, the development of interactive learning media based on Articulate Storyline 3 is expected to provide a solution in overcoming this gap. The interactive media is designed to make learning more interesting and easily understood by students, so that it can help them master the material better and improve their learning outcomes significantly.

Media feasibility trial in learning for learners

Based on the assessment results from experts, the developed learning media is considered highly suitable for use. The evaluation was conducted by media experts, material experts, and learning experts, who assessed the validity of the media from various aspects. The following are the results of the validity test conducted:

Table 1
Media Expert Validity Test Results

No	Area of Expertise	Score	Criteria
1	Media Expert	94%	Very Decent
2	Material Expert	98%	Very Decent
3	Learning Expert	96%	Very Decent

Referring to Table 1, the evaluation conducted by the experts yielded impressive results, with the media expert providing a score of 94%, the material expert giving 98%, and the learning expert assigning a score of 96%. Based on the predetermined assessment criteria, these scores fall within the "Very Feasible" category. This classification implies that the developed learning media possesses a high quality in content accuracy, media presentation, and instructional design. The consistency of high scores across different areas of expertise reflects the effectiveness and readiness of the media for educational use. Therefore, this learning media is appropriate and highly recommended for application in classroom settings, as it has been validated to support an engaging and practical learning experience for students.

Table 2
Categories of Learning Media Feasibility

No	Precentage	Interpretation Criteria
1	81% ≤ P ≤ 100%	Very Decent

2	$61 \leq P < 81\%$	Feasible
3	$41\% \leq P < 61\%$	Decent Enough
4	$21\% \leq P < 41\%$	Not Decent
5	$0\% \leq P < 21\%$	Very less worthy

Table 2 categorizes learning media feasibility based on specific percentage ranges. According to this interpretation, a score between 81% and 100% is labeled as "Very Feasible," while scores ranging from 61% to 80% are considered "Feasible." Scores between 41% and 60% are categorized as "Fairly Feasible," and any score below 41% falls under either the "Less Feasible" or "Very Less Feasible" classifications. Using this benchmark, the evaluated learning media—achieving a score above 81%—is placed within the "Very Feasible" category. This classification highlights the media's high quality and compliance with the established evaluation standards. It also indicates that the media effectively supports learning objectives, offering functionality and reliability in classroom applications. The results affirm that this learning media is ready for use and has strong potential to enhance student engagement and learning outcomes across various educational contexts.

The classification of learning media feasibility is based on assessment percentage ranges, concluding that the developed media falls into the "Very Feasible" category due to achieving a score above 81%. Although this explanation is systematic and indicates that the media meets quality standards, several critical notes can be offered. First, the paragraph does not clearly present the specific indicators or criteria used in the feasibility assessment, leaving readers without a complete understanding of the aspects being evaluated. Second, while a high score suggests feasibility, there is no further discussion about the potential limitations of the media, such as accessibility for students with special needs or technical challenges in its use across different devices. Third, the claim that the media is ready for use and can enhance student engagement should ideally be supported by empirical data or in-depth field observations, rather than relying solely on expert validation results.

Discussion

Learning transformation optimizing interactive media for students

The pedagogical value of Articulate Storyline 3 has been discussed from different perspectives. Mendoza-Silva (2021) and Hurtado-Palomino et al. (2022) highlight its accessibility, noting its resemblance to Microsoft PowerPoint, which eases adoption. While this lowers entry barriers, it may also limit exploration if educators rely only on basic functions. In contrast, Marougkas et al. (2023) and Zhao et al. (2023) emphasize interactivity, arguing that features such as quizzes, drag-and-drop tasks, and branching scenarios foster student-centered learning and deeper engagement. Their view suggests that the platform's true strength lies in transforming passive presentations into active experiences. Capatina et al. (2024) extend the discussion by stressing user-friendliness and customization, enabling differentiated pathways that support diverse learners in both digital and face-to-face contexts. Compared with the accessibility focus of earlier studies, their findings point toward adaptability and inclusivity. Overall, these perspectives indicate that the long-term impact of Articulate Storyline 3 depends on its critical, creative integration by educators.

Scholars highlight different yet complementary perspectives on the pedagogical potential of Articulate Storyline 3. Pimdee et al. (2023) and Mustajab et al. (2023) stress its interactive features quizzes, animations, and audio-visual elements as central to improving student engagement and comprehension. While their emphasis illustrates the software's strength in fostering active learning, it also risks reducing the discussion to surface-level interactivity without considering design rigor. Addressing this limitation, Lyu and Takikawa (2022), Wahlström et al. (2023), and Kong and Wang (2024) situate Articulate Storyline 3 within a Research and Development (R&D) framework. Their view underscores that effective media design must follow systematic stages of needs analysis, design, development, implementation, and evaluation, ensuring products respond to actual educational demands. Abdulrahaman et al. (2020) and Sivakumar et al. (2023) extend this argument by emphasizing that the R&D approach allows for empirical validation, linking technological

features with measurable learning outcomes. Taken together, these studies suggest that while interactivity enhances engagement, its real pedagogical value emerges only when grounded in rigorous, iterative development processes.

The development of learning media through the ADDIE model is widely recognized, yet scholars emphasize different critical aspects of each phase. Abdulrahaman et al. (2020) and Spatioti et al. (2022) outline its five systematic stages, but Ashford-Rowe et al. (2013) stress that the Analysis phase is decisive, as inadequate identification of learning needs and learner characteristics can undermine the effectiveness of later stages. Moving to the Design phase, Itasanmi (2022) highlights the importance of the Media Content Outline (GBIM), which not only organizes material but also ensures coherence between learning objectives and interactive features an aspect often overlooked when design is treated superficially. During Development, the translation of scripts into functional media reflects the practical test of prior planning. For Implementation, Ibarra-Sáiz et al. (2020) caution that testing should be viewed not merely as technical troubleshooting but as an opportunity for iterative refinement. Their perspective aligns with Juhong et al. (2022) and Davison (2024), who argue that robust evaluation requires measurable evidence through pre- and post-tests, linking design decisions to actual learning outcomes. Thus, while ADDIE offers structure, its real value lies in how critically each stage is executed, particularly in contextual applications such as teaching "Magnetism" within Islamic elementary curricula.

The integration of Articulate Storyline 3 in class learning has been framed by scholars as both a technological and pedagogical strategy, though their emphases vary. Hadjileontiadou et al. (2015) highlight the affordances of Chromebooks, noting that direct interaction with media and the flexibility of HTML formats broaden accessibility. While this demonstrates alignment with digital learning needs, Chanchumni and Mangkhang (2021) argue that mere access is insufficient without embedding the technology into meaningful 21st-century pedagogical practices. Beyond individual interaction, Jong (2023) and Shabur and Siddiki (2024) stress the collaborative dimension, showing how small group division enhances peer learning and supports less confident students. This view shifts the focus from technology as a delivery tool to its role in fostering social construction of knowledge. Complementing these perspectives, Mayer (2008) underscores the cognitive benefit of visual media, suggesting that interactivity combined with visualization aids comprehension of abstract concepts such as magnetism. Collectively, these findings suggest that the pedagogical value of Articulate Storyline 3 lies not only in technological integration but also in how it mediates collaboration and visualization to strengthen engagement and understanding.

Despite the pedagogical promise of Articulate Storyline 3 and Chromebooks, several studies warn that technology alone does not guarantee effective learning. Haleem et al. (2022) and Mhlanga (2024) caution that without sufficient digital literacy among teachers and students, the potential of interactive media remains underutilized. Li et al. (2024) further argue that the sustainability of technology integration depends less on hardware provision than on the continuous development of user competence. This highlights the central role of teacher support, not merely as technical assistance but as capacity-building to help learners and educators overcome digital barriers. Complementing this perspective, Albanese et al. (2010) and Acıkgoz and Babadogan (2021) emphasize the pedagogical importance of practical, experiment-based learning. Their findings suggest that hands-on activities such as creating magnets through induction bridge theory and practice, fostering both conceptual understanding and skill acquisition. Taken together, these insights underline that meaningful learning outcomes emerge not from technology provision alone, but from its integration with teacher facilitation and experiential approaches that cultivate deeper student engagement.

From a skills assessment perspective, scholars agree that experiments provide more than just a measure of academic achievement. Chueh and Kao (2024) and Boardman et al. (2024) emphasize that evaluating attitudes, collaboration, and problem-solving offers a more holistic view of student development. Their position suggests that learning effectiveness should not be reduced to test scores but extended to competencies essential in 21st-century education. Supporting this, Dori and Belcher

(2005) and Lombardi et al. (2021) demonstrate that active engagement in experiments such as magnet creation strengthens retention and conceptual mastery by involving students physically and cognitively. Yet, as Yen and Thao (2024) caution, the benefits of such active learning may be compromised by infrastructure limitations, including internet instability and technical issues with devices like Chromebooks. Taken together, these studies indicate that while experiment-based and interactive approaches foster deeper, more holistic learning, their success is conditional upon reliable technological and institutional support that enables seamless implementation.

The development of interactive learning media requires more than a linear process of planning, design, content creation, and evaluation. Jones and Davis (2011) outline these stages as a foundation, yet Trust and Pektas (2018) argue that their effectiveness depends on the extent to which content is meaningfully aligned with learning objectives rather than simply following procedural steps. Mayer (2009) strengthens this view by emphasizing the integration of multimedia visual, audio, and video as key to promoting cognitive engagement, though his work also implies that poor design can overload learners rather than support them. Moving beyond design principles, Mebert et al. (2020) stress the role of interactivity in sustaining student engagement, while Thornberg et al. (2020) and Li et al. (2024) highlight gamification and personalization as strategies to increase motivation. Taken together, these perspectives suggest that the pedagogical value of Articulate Storyline 3 lies not merely in technological integration but in critically designed, student-centered strategies that connect multimedia elements with purposeful engagement.

The main purpose of implementing interactive learning media is to improve student understanding and academic performance, often assessed through pre- and post-test comparisons (Song et al., 2014; Anderson & Elms, 2022). While these assessments demonstrate measurable gains, they risk narrowing the evaluation of learning outcomes to cognitive achievement alone. Gan et al. (2024) expand this view by emphasizing that the effectiveness of Articulate Storyline 3 also depends on overcoming barriers of infrastructure and digital competence, suggesting that technological readiness is as critical as instructional design. Dori and Belcher (2005) further highlight that interactive frameworks should not only support knowledge acquisition but also cultivate technological proficiency, collaboration, and problem-solving skills essential for real-world application. Compared with Song et al. (2014) and Anderson & Elms (2022), who focus on academic metrics, Dori and Belcher (2005) foreground broader competencies. Collectively, these perspectives suggest that the true value of interactive media emerges when cognitive, technical, and social dimensions of learning are integrated through well-supported implementation.

Effectiveness of using interactive learning media for learners

The elementary school experiment demonstrates the potential of Articulate Storyline 3-based interactive media to improve student comprehension, yet scholars interpret its impact from different angles. Radtke et al. (2021) show significant gains in post-test scores, particularly for students who initially scored below the Minimum Competency Criteria (KKM), indicating that interactive media can help close achievement gaps. Duong et al. (2022) reinforce this finding, reporting that 91% of students in the Science and Social Science (IPAS) subject achieved the KKM, underscoring its effectiveness in raising overall performance. However, Song and Cai (2024) shift the focus from scores to cognitive depth, arguing that interactive tools foster more meaningful conceptual understanding rather than short-term improvements alone. Similarly, Yakovleva and Yakovlev (2014) stress that the quality of the learning process is as important as outcomes, suggesting that interactivity enhances not only achievement but also the overall educational experience. Taken together, these perspectives indicate that the real value of interactive media lies in combining measurable achievement with deeper, process-oriented learning gains.

The t-test results, showing a t-count of 8.93 exceeding the critical value of 1.71, provide strong statistical evidence that Articulate Storyline 3-based interactive media significantly improved student learning outcomes. Sabah and Altalbe (2022) and Tran-Duong (2023) highlight that such quantitative validation strengthens claims of effectiveness, yet they also caution that statistical gains

should be interpreted alongside pedagogical quality. Zhang and Wang (2021) and Karan and Angadi (2024) similarly report positive impacts of interactive media on fifth-grade learning, particularly in science-related subjects, suggesting consistency across contexts. However, while their findings support measurable academic improvement, they also point to the need for examining how interactivity specifically shapes conceptual understanding rather than merely boosting test scores. Zainil et al. (2017) extend this argument by stressing that engagement and comprehension are interdependent, meaning statistical outcomes should be linked to experiential learning quality. Collectively, these perspectives suggest that while quantitative evidence confirms effectiveness, the true value of Articulate Storyline 3 lies in balancing measurable outcomes with deeper, student-centered learning processes.

The statistical test results confirm that Articulate Storyline 3-based interactive media significantly improved student learning outcomes, particularly in understanding abstract concepts such as magnetism. The use of visuals and interactive elements made complex ideas more concrete, aligning with Majid et al. (2012), who highlight the role of interactivity in enhancing comprehension. Beyond content delivery, the media also reduced learning disparities by enabling both low and high achieving students to reach competency standards. This suggests, as Maruyama (2022) argues, that interactive media fosters inclusivity by accommodating diverse learning styles. Yusuf et al. (2024) further emphasize that such tools are particularly effective for abstract scientific subjects, where visualization and active engagement are essential for conceptual clarity. Compared with Majid et al. (2012), who stress comprehension gains, Maruyama (2022) and Yusuf et al. (2024) extend the discussion toward inclusivity and equity. Collectively, these perspectives underscore that the effectiveness of interactive media lies not only in improving test performance but also in promoting deeper, more equitable learning experiences.

The questionnaire results, showing 92% positive student responses, indicate strong acceptance of Articulate Storyline 3-based interactive media. Ong and Quek (2023) interpret such positive perceptions as evidence of feasibility and pedagogical value, though high satisfaction alone does not guarantee long-term learning gains. Zamiri and Esmaeili (2024) add that comfort and motivation are critical affective factors, suggesting that engagement should be viewed as both emotional and cognitive. Hanaysha et al. (2023) emphasize that interactivity transforms the classroom into a dynamic, student-centered environment, shifting the focus from teacher-driven instruction to learner autonomy. This finding aligns with Cents-Boonstra et al. (2020), Kit et al. (2022), and Volpe et al. (2023), who argue that interactive tools enhance participation and interest, ultimately contributing to improved comprehension. However, their research also implies that effectiveness depends on how interactivity is embedded within instructional design. Collectively, these perspectives suggest that positive perceptions are significant but must be critically linked to sustained engagement and measurable academic outcomes.

The findings indicate that interactive media contributes not only to short-term grade improvements but also to more meaningful learning experiences. Schindler et al. (2017) underline its potential to deepen comprehension, while Iku-Silan et al. (2023) stress that active and independent engagement is central to achieving this depth. Yet, these benefits are not automatic. Salam et al. (2018) and Parmaxi and Zaphiris (2019) caution that the success of interactive approaches depends on teachers' ability to manage technology and continually update digital content, highlighting the risk of stagnation if educators lack adequate support. Haile et al. (2024) reinforce this point by emphasizing that sustained professional development is critical for ensuring teachers can fully harness tools like Articulate Storyline 3. Compared with Schindler et al. (2017) and Iku-Silan et al. (2023), who focus on student engagement, these later studies shift attention to teacher competence as a determining factor. Collectively, the evidence suggests that interactive media's long-term effectiveness rests on the synergy between student-centered design and continuous teacher capacity-building.

Overall, this experiment reinforces the effectiveness of Articulate Storyline 3-based learning media, yet a critical analysis shows its value lies in bridging learning disparities. Zhang et al. (2024)

highlight its capacity to enhance comprehension broadly, while Dubinsky and Hamid (2024) stress its role in reducing achievement gaps between low and high performing students. This finding resonates with Mayer's (2009) cognitive theory of multimedia learning, which argues that comprehension improves when verbal, visual, and interactive elements are integrated. However, as Simic et al. (2021) point out, the effectiveness of such tools is maximized when combined with active learning strategies, such as experiments on magnet induction, which transform abstract concepts into tangible experiences. Furthermore, Holly et al. (2021) and Hennessy et al. (2022) argue that inclusivity is not merely a byproduct but a core strength of interactive media, enabling differentiation by pace and style. Compared with Zhang et al. (2024), who emphasize general effectiveness, these scholars underscore its critical role in ensuring equitable and context-sensitive learning outcomes.

The framework for creating and applying interactive learning media demonstrates that its effectiveness depends not only on design but also on continuous refinement. Skulmowski and Xu (2022) and Christopoulos and Mystakidis (2023) argue that integrating multimedia elements such as graphics and animations enhances engagement, yet they caution that poorly designed interactivity may lead to cognitive overload. This insight emphasizes the importance of Mahdavi-Ardestani et al. (2023), who highlight preliminary testing as a safeguard against both technical and pedagogical flaws, ensuring classroom readiness. Beyond functionality, Reed et al. (2021) stress that iterative evaluation based on student feedback is essential, as it transforms media from a static product into a dynamic tool responsive to learners' needs. Comparatively, while Reed et al. focus on adaptability through feedback, Gligorea et al. (2023) and Zhai et al. (2024) underline the necessity of external validation to meet academic standards, ensuring scalability and broader acceptance. Together, these perspectives suggest that sustainable impact arises from balancing innovation, quality assurance, and educational alignment.

While the post-test outcomes indicated notable improvements in student performance, it is important to recognize that factors like students' motivation and excitement toward using new technology may have also contributed. This suggests that the positive results might not be solely attributed to the media itself. As such, additional studies are recommended to examine the long-term effects of utilizing this interactive learning tool and to assess how consistent support for teachers can enhance its implementation. Ensuring educators are equipped with the necessary skills and resources to use the technology effectively is crucial for sustaining its impact. Despite these considerations, the interactive media developed using Articulate Storyline 3 has demonstrated clear effectiveness in improving student understanding and academic outcomes. Moreover, it fosters an engaging, inclusive, and dynamic learning atmosphere that aligns well with modern educational technology trends. Its ability to connect content with interactive features makes it a valuable asset in transforming classroom learning experiences.

CONCLUSION

The use of Articulate Storyline 3-based interactive learning media has proven effective in enhancing students' understanding, especially for abstract topics like magnetism. Its interactive features such as quizzes, animations, and simulations support active and collaborative learning, encouraging deeper engagement and comprehension. Statistical tests revealed significant improvements in student learning outcomes, including higher achievement of minimum competency standards (KKM). Additionally, positive student responses indicate that the media creates an enjoyable and inclusive learning environment. Developed through the ADDIE model and supported by experiment-based approaches, this media accommodates various student learning styles. However, successful implementation still depends on infrastructure readiness and teachers' ability to manage the technology effectively. Overall, Articulate Storyline 3 serves as an innovative solution that enriches the primary education learning process.

Theoretically, the findings support Mayer's Cognitive Theory of Multimedia Learning, showing that combining visual, auditory, and interactive elements improves comprehension,

particularly for abstract scientific concepts. They also align with active learning theory, emphasizing the role of student engagement in meaningful learning. Practically, the success of Articulate Storyline 3-based media highlights its potential as an effective and scalable tool in primary education. Its interactive features can help educators create more inclusive, student-centered lessons. However, successful implementation depends on adequate teacher training and technological infrastructure. Therefore, schools must invest in professional development and digital resources to maximize learning outcomes. These implications underscore the importance of integrating interactive media into curriculum design to enhance student understanding and academic achievement.

Based on these findings, future research is recommended to explore the long-term impact of Articulate Storyline 3-based interactive media on student learning outcomes across different subjects and grade levels. Comparative studies involving various types of interactive learning platforms could help identify the most effective tools for specific content areas. In addition, qualitative research focusing on teacher and student experiences could provide deeper insights into challenges and best practices for implementation. Further investigation into the role of teacher training and digital literacy in maximizing the effectiveness of interactive media is also essential. Expanding research to diverse educational settings, including rural or under-resourced schools, would offer a broader understanding of the media's applicability and scalability in different contexts.

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REFERENCE

Abdulrahaman, M. D., Faruk, N., Oloyede, A. A., Surajudeen-Bakinde, N. T., Olawoyin, L. A., Mejabi, O. V., Imam-Fulani, Y. O., Fahm, A. O., & Azeez, A. L. (2020). Multimedia tools in the teaching and learning processes: A systematic review. *Heliyon, 6(11)*, e05312. https://doi.org/10.1016/j.heliyon.2020.e05312

Acıkgoz, T., & Babadogan, M. C. (2021). Competency-based education: Theory and practice. *Psycho-Educational Research Reviews, 10(3)*, 67–95. https://doi.org/10.52963/PERR_Biruni_V10.N3.06

Albanese, M. A., Mejicano, G., Anderson, W. M., & al. (2010). Building a competency-based curriculum: The agony and the ecstasy. *Advances in Health Sciences Education, 15(4)*, 439–454. https://doi.org/10.1007/s10459-008-9118-2

Alobaid, A. (2021). ICT multimedia learning affordances: Role and impact on ESL learners' writing accuracy development. *Heliyon, 7(7)*, e07517. https://doi.org/10.1016/j.heliyon.2021.e07517

Anderson, G., & Elms, B. (2022). Practise and repeat, or practice and critique? A story of learning, feeling and resistance in teacher education. *Changing English, 29(4)*, 351–367. https://doi.org/10.1080/1358684X.2022.2093697

Andersson, R. (2019). Employee communication responsibility: Its antecedents and implications for strategic communication management. *International Journal of Strategic Communication, 13(1)*, 60–75. https://doi.org/10.1080/1553118X.2018.1547731

Ansori, M. Z., Faiza, D., Thamrin, & Efrizon. (2024). Development of digital circuits learning media using articulate storyline with the 4D model. *Journal of Hypermedia & Technology-Enhanced Learning (J-HyTEL), 2(3)*, 338–351. https://doi.org/10.58536/j-hytel.v2i3.145

Ashford-Rowe, K., Herrington, J., & Brown, C. (2013). Establishing the critical elements that determine authentic assessment. *Assessment & Evaluation in Higher Education, 39(2)*, 205–222. https://doi.org/10.1080/02602938.2013.819566

Boardman, A. G., Polman, J. L., Scornavacco, K., Potvin, A. S., Garcia, A., Dalton, B., Stamatis, K., Guggenheim, A., & Alzen, J. L. (2024). Examining enactments of project-based learning in secondary english language arts. *AERA Open, 10*. https://doi.org/10.1177/23328584241269829

Busetto, L., Wick, W. & Gumbinger, C. (2020). How to use and assess qualitative research methods. *Neurol. Res. Pract. 2(14)*. https://doi.org/10.1186/s42466-020-00059-z

Capatina, A., Juarez-Varon, D., Micu, A., & Micu, A. E. (2024). Leveling up in corporate training: Unveiling the power of gamification to enhance knowledge retention, knowledge sharing, and job performance. *Journal of Innovation & Knowledge, 9(3)*, 100530. https://doi.org/10.1016/j.jik.2024.100530

Cents-Boonstra, M., Lichtwarck-Aschoff, A., Denessen, E., Aelterman, N., & Haerens, L. (2020). Fostering student engagement with motivating teaching: An observation study of teacher and student behaviours. *Research Papers in Education, 36(6)*, 754–779. https://doi.org/10.1080/02671522.2020.1767184

Chanchumni, R., & Mangkhang, C. (2021). Creative learning design in social studies to promote productive citizenship of secondary school students. *Higher Education Studies, 11(4)*, 84-90. https://doi.org/10.5539/hes.v11n4p84

Charline, C., Jo, S., & Frederic, E. (2023). Use of learning media to increase student learning motivation in junior high schools. *World Psychology, 2(3)*, 176–189. https://doi.org/10.55849/wp.v2i3.402

Christopoulos, A., & Mystakidis, S. (2023). Gamification in education. *Encyclopedia, 3(4)*, 1223-1243. https://doi.org/10.3390/encyclopedia3040089

Chueh, H.-E., & Kao, C.-Y. (2024). Exploring the impact of integrating problem-based learning and agile in the classroom on enhancing professional competence. *Heliyon, 10(3)*, e24887. https://doi.org/10.1016/j.heliyon.2024.e24887

Daryanes, F., Darmadi, D., Fikri, K., Sayuti, I., Rusandi, M. A., & Situmorang, D. D. B. (2023). The development of articulate storyline interactive learning media based on case methods to train student's problem-solving ability. *Heliyon, 9(4)*, e15082. https://doi.org/10.1016/j.heliyon.2023.e15082

Davison, I. (2024). The effects of completing collaborative or independent writing on the development of language use in individual writing. *Journal of Second Language Writing, 65*, 101128. https://doi.org/10.1016/j.jslw.2024.101128

Dori, Y. J., & Belcher, J. (2005). How does technology-enabled active learning affect undergraduate students' understanding of electromagnetism concepts? *Journal of the Learning Sciences, 14(2)*, 243–279. https://doi.org/10.1207/s15327809jls1402_3

Dubinsky, J. M., & Hamid, A. A. (2024). The neuroscience of active learning and direct instruction. *Neuroscience & Biobehavioral Reviews, 16(3)*, 105737. https://doi.org/10.1016/j.neubiorev.2024.105737

Duong, H. T., Bui, P. U., & Lu, K. N. (2022). The effectiveness of blended learning on students' academic achievement, self-study skills and learning attitudes: A quasi-experiment study in

teaching the conventions for coordinates in the plane. *Heliyon, 8(12)*, e12657. https://doi.org/10.1016/j.heliyon.2022.e12657

Feng, Z., & Xiao, H. (2024). The impact of students' lack of learning motivation and teachers' teaching methods on innovation resistance in the context of big data. *Learning and Motivation, 87*, 102020. https://doi.org/10.1016/j.lmot.2024.102020

Foster, C. (2023). Methodological pragmatism in educational research: From qualitative-quantitative to exploratory-confirmatory distinctions. *International Journal of Research & Method in Education, 47(1)*, 4–19. https://doi.org/10.1080/1743727X.2023.2210063

Gan, Y., Zhang, J., Wu, X., & Gao, J. (2024). Chain mediating effects of student engagement and academic achievement on university identification. *SAGE Open, 14(1)*. https://doi.org/10.1177/21582440241226903

Gligorea, I., Cioca, M., Oancea, R., Gorski, A.-T., Gorski, H., & Tudorache, P. (2023). Adaptive learning using artificial intelligence in e-learning: A literature review. *Education Sciences, 13(12)*, 1216. https://doi.org/10.3390/educsci13121216

Hadjileontiadou, S. Dias, J. Diniz, & L. Hadjileontiadis (2015). FIS/IFIS modeling in professional and collaborative learning: A systemic approach. *IGI Global*. https://doi.org/10.4018/978-1-4666-8705-9.ch012

Haile, K. W., Olamo, T. G., & Yemiru, M. A. (2024). Utilizing communication strategies to enhance reflective learning in Ethiopian EFL classrooms. *Heliyon, 10(13)*, e32585. https://doi.org/10.1016/j.heliyon.2024.e32585

Haleem, A., Javaid, M., Qadri, M. A., & Suman, R. (2022). Understanding the role of digital technologies in education: A review. *Sustainable Operations and Computers, 3*, 275–285. https://doi.org/10.1016/j.susoc.2022.05.004

Hanaysha, J. R., Shriedeh, F. B., & In'airat, M. (2023). Impact of classroom environment, teacher competency, information and communication technology resources, and university facilities on student engagement and academic performance. *International Journal of Information Management Data Insights, 3(2)*, 100188. https://doi.org/10.1016/j.jjimei.2023.100188

Hennessy, S., D'Angelo, S., McIntyre, N., Koomar, S., Kreimeia, A., Cao, L., Brugha, M., & Zubairi, A. (2022). Technology use for teacher professional development in low- and middle-income countries: A systematic review. *Computers and Education Open, 3*, 100080. https://doi.org/10.1016/j.caeo.2022.100080

Hippisley, J., & Douglas, G. (2002). The reliability and validity of an interactive arithmetic test. *British Journal of Educational Technology. 29*. 303-320. http://dx.doi.org/10.1111/1467-8535.00077

Holly, M., Pirker, J., Resch, S., Brettschuh, S., & Gütl, C. (2021). Designing VR experiences – expectations for teaching and learning in VR. *Educational Technology & Society, 24(2)*, 107–119. https://www.jstor.org/stable/27004935

Hong, J.-C., Hwang, M.-Y., Szeto, E., Tsai, C.-R., Kuo, Y.-C., & Hsu, W.-Y. (2016). Internet cognitive failure relevant to self-efficacy, learning interest, and satisfaction with social media learning. *Computers in Human Behavior, 55(Part A)*, 214–222. https://doi.org/10.1016/j.chb.2015.09.010

Hurtado-Palomino, A., De la Gala-Velásquez, B., & Ccorisapra-Quintana, J. (2022). The interactive effect of innovation capability and potential absorptive capacity on innovation performance. *Journal of Innovation & Knowledge, 7(4)*, 100259. https://doi.org/10.1016/j.jik.2022.100259

Ibarra-Sáiz, M. S., Rodríguez-Gómez, G., & Boud, D. (2020). The quality of assessment tasks as a determinant of learning. *Assessment & Evaluation in Higher Education, 46(6)*, 943–955. https://doi.org/10.1080/02602938.2020.1828268

Iku-Silan, A., Hwang, G.-J., & Chen, C.-H. (2023). Decision-guided chatbots and cognitive styles in interdisciplinary learning. *Computers & Education, 201*, 104812. https://doi.org/10.1016/j.compedu.2023.104812

Itasanmi, S. A. (2022). Determinants of the behavioural intention of open distance learning students to use digital tools and resources for learning in Nigeria. *Journal of Adult and Continuing Education, 29(1)*, 124-146. https://doi.org/10.1177/14779714221135655

Jia, M., Zhao, Y. (C.), Song, S., Zhang, X., Wu, D., & Li, J. (2024). How vicarious learning increases users' knowledge adoption in live streaming: The roles of parasocial interaction, social media affordances, and knowledge consensus. *Information Processing & Management, 61(2)*, 103599. https://doi.org/10.1016/j.ipm.2023.103599

Jones, B. D., Topuz, K., & Sahbaz, S. (2024). Predicting undergraduate student evaluations of teaching using probabilistic machine learning: The importance of motivational climate. *Studies in Educational Evaluation, 81*, 101353. https://doi.org/10.1016/j.stueduc.2024.101353

Jones, P. & Davis, R. (2011). *Instructional Design Methods Integrating Instructional Technology*. In I. Management Association (Ed.), instructional design: concepts, methodologies, tools and applications (pp. 101-113). IGI Global Scientific Publishing. https://doi.org/10.4018/978-1-60960-503-2.ch110

Jong, M. S.-Y. (2023). Pedagogical adoption of SVVR in formal education: Design-based research on the development of teacher-facilitated tactics for supporting immersive and interactive virtual inquiry fieldwork-based learning. *Computers & Education, 207*, 104921. https://doi.org/10.1016/j.compedu.2023.104921

Juhong, J., Mordmuang, A., Jewboonchu, J., & Udomwech, L. (2022). Effectiveness of an online educational video intervention to improve the knowledge and behavior of contact lens care during the COVID-19 Pandemic: A pre-test/post-test design. *Heliyon, 8(10)*, e11009. https://doi.org/10.1016/j.heliyon.2022.e11009

Kalyani, D., & Rajasekaran, K. (2018). Innovative teaching and learning. *Journal of Applied and Advanced Research, 3(1)*. https://doi.org/10.21839/jaar.2018.v3iS1.162

Karan, B., & Angadi, G. R. (2024). Potential risks of artificial intelligence integration into school education: A systematic review. *Bulletin of Science, Technology & Society, 43(3-4)*, 67-85. https://doi.org/10.1177/02704676231224705

Kit, P. L., Liem, G. A. D., & Chong, W. H. (2022). Teacher-student relationship and student engagement: The moderating role of educational hope. *Educational Psychology, 42(9)*, 1180–1197. https://doi.org/10.1080/01443410.2022.2108766

Kong, S.-C., & Wang, Y.-Q. (2024). The impact of school support for professional development on teachers' adoption of student-centered pedagogy, students' cognitive learning and abilities: A three-level analysis. *Computers & Education, 215*, 105016. https://doi.org/10.1016/j.compedu.2024.105016

Li, Y., Chen, D., & Deng, X. (2024). The impact of digital educational games on student's motivation for learning: The mediating effect of learning engagement and the moderating effect of the digital environment. *PloS one, 19(1)*, e0294350. https://doi.org/10.1371/journal.pone.0294350

Lombardi, D., Shipley, T. F., Bailey, J. M., Bretones, P. S., Prather, E. E., Ballen, C. J., Knight, J. K., Smith, M. K., Stowe, R. L., Cooper, M. M., Prince, M., Atit, K., Uttal, D. H., LaDue, N. D., McNeal, P. M., Ryker, K., St. John, K., van der Hoeven Kraft, K. J., & Docktor, J. L. (2021). The curious construct of active learning. *Psychological Science in the Public Interest, 22(1)*, 8-43. https://doi.org/10.1177/1529100620973974

Lyu, Z., & Takikawa, H. (2022). Media framing and expression of anti-china sentiment in COVID-19 related news discourse: An analysis using deep learning methods. *Heliyon, 8(8)*, e10419. https://doi.org/10.1016/j.heliyon.2022.e10419

Mahdavi-Ardestani, S. F., Adibi, S., Golshan, A., & Sadeghian, P. (2023). Factors influencing the effectiveness of e-learning in healthcare: A fuzzy ANP study. *Healthcare (Basel, Switzerland), 11(14)*, 2035. https://doi.org/10.3390/healthcare11142035

Majid, M. S. Z. B. A, Azmat Ali, M. M. B., Abdul Rahim, A. A. B., & Khamis, N. Y. B. (2012). The development of technical english multimedia interactive module to enhance student centered learning (SCL). *Procedia - Social and Behavioral Sciences, 67*, 345–348. https://doi.org/10.1016/j.sbspro.2012.11.337

Marougkas, A., Troussas, C., Krouska, A., & Sgouropoulou, C. (2023). Virtual reality in education: A review of learning theories, approaches, and methodologies for the last decade. *Electronics, 12(13)*, 2832. https://doi.org/10.3390/electronics12132832

Maruyama, T. (2022). Strengthening support of teachers for students to improve learning outcomes in mathematics: Empirical evidence on a structured pedagogy program in El Salvador. *International Journal of Educational Research, 115*, 101977. https://doi.org/10.1016/j.ijer.2022.101977

Mayer, R. E. (2008). Applying the science of learning: Evidence-based principles for the design of multimedia instruction. *American Psychologist, 63(8)*, 760–769. https://doi.org/10.1037/0003-066X.63.8.760

Mebert, L., Barnes, R., Dalley, J., Gawarecki, L., Ghazi-Nezami, F., Shafer, G., … Yezbick, E. (2020). Fostering student engagement through a real-world, collaborative project across disciplines and institutions. *Higher Education Pedagogies, 5(1)*, 30–51. https://doi.org/10.1080/23752696.2020.1750306

Mendoza-Silva, A. (2021). Innovation capability: A sociometric approach. *Social Networks, 64*, 72–82. https://doi.org/10.1016/j.socnet.2020.08.004

Mhlanga, D. (2024). Digital transformation of education, the limitations and prospects of introducing the fourth industrial revolution asynchronous online learning in emerging markets. *Discover Education, 3(32)*. https://doi.org/10.1007/s44217-024-00115-9

Mishra, P., Pandey, C. M., Singh, U., & Gupta, A. (2018). Scales of measurement and presentation of statistical data. *Annals of cardiac anaesthesia, 21(4)*, 419–422. https://doi.org/10.4103/aca.ACA_131_18

Mustajab, H., Fauziah, N. N., & Putri, R. M. (2023). Implementation of articulate media on learning outcomes of class V students at MIN 1 Banyuwangi. *In Proceedings of the 2nd Annual Conference of Islamic Education 2023 (ACIE 2023)* (pp. 28–34). Atlantis Press. https://doi.org/10.2991/978-2-38476-182-1_5

Ong, S. G. T., & Quek, G. C. L. (2023). Enhancing teacher–student interactions and student online engagement in an online learning environment. *Learning Environ Res 26*, 681–707. https://doi.org/10.1007/s10984-022-09447-5

Pan, X. (2023). Online learning environments, learners' empowerment, and learning behavioral engagement: The mediating role of learning motivation. *SAGE Open, 13(4)*. https://doi.org/10.1177/21582440231205098

Parmaxi, A., & Zaphiris, P. (2019). Lessons learned from a design-based research implementation: A researcher's methodological account. *International Journal of Research & Method in Education, 43(3)*, 257–270. https://doi.org/10.1080/1743727X.2019.1671327

Pimdee, P., Ridhikerd, A., Moto, S., Siripongdee, S., & Bengthong, S. (2023). How social media and peer learning influence student-teacher self-directed learning in an online world under the 'new normal'. *Heliyon, 9(3)*, e13769. https://doi.org/10.1016/j.heliyon.2023.e13769

Putwain, D. W., Mallaburn, A., & Held, T. (2024). Science motivation, academic achievement, career aspirations in early adolescents. *Learning and Individual Differences, 116*, 102577. https://doi.org/10.1016/j.lindif.2024.102577

Radtke, T., Apel, T., Schenkel, K., Keller, J., & von Lindern, E. (2021). Digital detox: An effective solution in the smartphone era? A Systematic Literature Review. *Mobile Media & Communication, 10(2)*, 190-215. https://doi.org/10.1177/20501579211028647

Reed, M. S., Ferré, M., Martin-Ortega, J., Blanche, R., Lawford-Rolfe, R., Dallimer, M., & Holden, J. (2021). Evaluating impact from research: A methodological framework. *Research Policy, 50(4)*, 104147. https://doi.org/10.1016/j.respol.2020.104147

Sabah, N. M., & Altalbe, A. A. (2022). Learning outcomes of educational usage of social media: The moderating roles of task–technology fit and perceived risk. *Sustainability, 14(14)*, 8895. https://doi.org/10.3390/su14148895

Salam, R., Akib, H., & Daraba, D. (2018). Utilization of learning media in motivating student learning. *In Proceedings of the 1st International Conference on Social Sciences (ICSS 2018)*. (pp. 1100-1103). Atlantis Press. https://doi.org/10.2991/icss-18.2018.232

Sarpong, D., Boakye, D., Ofosu, G., & Botchie, D. (2023). The three pointers of research and development (R&D) for growth-boosting sustainable innovation system. *Technovation, 122*, 102581. https://doi.org/10.1016/j.technovation.2022.102581

Schindler, L. A., Burkholder, G. J., Morad, O. A. (2017). Computer-based technology and student engagement: A critical review of the literature. *Int J Educ Technol High Educ, 14 (25)*. https://doi.org/10.1186/s41239-017-0063-0

Shabur, M. A., & Siddiki, M. R. (2024). Investigating social media's impact on the new era of interactive learning: A case study of Bangladesh. *Heliyon, 10(4)*, e26234. https://doi.org/10.1016/j.heliyon.2024.e26234

Simic, G., Tkalcic, M., Vukic, V., Mulc, D., Spanic, E., Sagud, M., Olucha-Bordonau, F. E., Vukšić, M., & R Hof, P. (2021). Understanding emotions: origins and roles of the amygdala. *Biomolecules, 11(6)*, 823. https://doi.org/10.3390/biom11060823

Siregar, J., Riniati, W., Aziz, F., Mahendika, D., & Abdullah, D. (2023). The role of pictures and videos in the learning independence of elementary school students. *Journal on Education, 5(4)*, 13558-13568. https://jonedu.org/index.php/joe/article/view/2364

Situmorang, E. Y., Lumban Tobing, L., Sihombing, R., Tambunan, A. M., & Panggabean, E. C. (2024). Penerapan media pembelajaran video animasi dalam meningkatkan hasil belajar mata pelajaran bahasa indonesia pada siswa kelas III SD Negeri Siborongborong Tahun 2024. *Jurnal Pendidikan Sosial dan Humaniora, 3(3)*, 3356–3365. https://publisherqu.com/index.php/pediaqu/article/view/1298

Sivakumar, A., Jayasingh, S., & Shaik, S. (2023). Social media influence on students' knowledge sharing and learning: An empirical study. *Education Sciences, 13(7)*, 745. https://doi.org/10.3390/educsci13070745

Skulmowski, A., & Xu, K. M. (2022). Understanding cognitive load in digital and online learning: A new perspective on extraneous cognitive load. *Educ Psychol Rev 34*, 171–196. https://doi.org/10.1007/s10648-021-09624-7

Song, H. S., Pusic, M., Nick, M. W., Sarpel, U., Plass, J. L., & Kalet, A. L. (2014). The cognitive impact of interactive design features for learning complex materials in medical education. *Computers & education, 71*, 198–205. https://doi.org/10.1016/j.compedu.2013.09.017

Song, H., & Cai, L. (2024). Interactive learning environment as a source of critical thinking skills for college students. *BMC medical education, 24(1)*, 270. https://doi.org/10.1186/s12909-024-05247-y

Spatioti, A. G., Kazanidis, I., & Pange, J. (2022). A comparative study of the ADDIE instructional design model in distance education. *Information, 13(9)*, 402. https://doi.org/10.3390/info13090402

Swiatek, P. R., Chung, K. C., & Mahmoudi, E. (2016). Surgery and research: A practical approach to managing the research process. *Plastic and reconstructive surgery, 137(1)*, 361–366. https://doi.org/10.1097/PRS.0000000000001888

Thiagarajan, S., Semmel, D. S., & Semmel, M. I. (1974). *Instructional development for training teachers of exceptional children*: A Sourcebook.

Thornberg, R., Forsberg, C., Hammar Chiriac, E., & Bjereld, Y. (2020). Teacher–student relationship quality and student engagement: A sequential explanatory mixed-methods study. *Research Papers in Education, 37(6)*, 840–859. https://doi.org/10.1080/02671522.2020.1864772

Tran-Duong, Q. H. (2023). The effect of media literacy on effective learning outcomes in online learning. *Educ Inf Technol 28*, 3605–3624. https://doi.org/10.1007/s10639-022-11313-z

Trust, T., & Pektas, E. (2018). Using the ADDIE model and universal design for learning principles to develop an open online course for teacher professional development. *Journal of Digital Learning in Teacher Education, 34(4)*, 219–233. https://doi.org/10.1080/21532974.2018.1494521

Umakantha, N. (2016). A new approach to probability theory with reference to statistics and statistical physics. *Journal of Modern Physics, 7*, 989-1003. http://dx.doi.org/10.4236/jmp.2016.79090

van Laar, E., van Deursen, A. J. A. M., van Dijk, J. A. G. M., & de Haan, J. (2020). Determinants of 21st-century skills and 21st-century digital skills for workers: A systematic literature review. *Sage Open, 10(1)*. https://doi.org/10.1177/2158244019900176

Volpe, R. J., Hill, E., Briesch, A. M., & Leiwant, I. (2023). Classroom observation of student behavior: A review of seven observation codes. *School Psychology Review, 54(1)*, 105–127. https://doi.org/10.1080/2372966X.2023.2245360

Wahlström, N., Bossér, U., & Vogt, B. (2023). Teaching as a pedagogical responsibility: An introduction. *Journal of Curriculum Studies, 55(1),* 1–7. https://doi.org/10.1080/00220272.2023.2172361

Wen, J., & Ma, B. (2024). Enhancing museum experience through deep learning and multimedia technology. *Heliyon, 10(12)*, e32706. https://doi.org/10.1016/j.heliyon.2024.e32706

Yakovleva, N. O., & Yakovlev, E. V. (2014). Interactive teaching methods in contemporary higher education. *Pacific Science Review, 16(2)*, 75–80. https://doi.org/10.1016/j.pscr.2014.08.016

Yen, P. H., & Thao, L. (2024). Exploring the implementation and perception of competency-based assessment practices among Vietnamese EFL instructors. *Language Testing in Asia, 14,(26*). https://doi.org/10.1186/s40468-024-00300-5

Yin, S. K. (2022). A study of the effects of thematic language teaching on the promotion of multimedia design students' listening and speaking skills. *Frontiers in psychology, 13*, 915145. https://doi.org/10.3389/fpsyg.2022.915145

Yusuf, M. R., Abbas, N., & Ismail, Y. (2024). Development of interactive learning multimedia based on google site on the sequence and series material for grade XI IPA I students of SMA Negeri 1 Tilango. *Numerical: Jurnal Matematika Dan Pendidikan Matematika, 8(1)*. https://doi.org/10.25217/numerical.v8i1.4986

Zainil, M., Prahmana, R. C. I., Helsa, Y., & Hendri, S. (2017). ICT media design for higher grade of elementary school mathematics learning using CS6 program. *Journal of Physics: Conference Series, 943(1)*, 012046. https://doi.org/10.1088/1742-6596/943/1/012046

Zamiri, M., & Esmaeili, A. (2024). Methods and technologies for supporting knowledge sharing within learning communities: A systematic literature review. *Administrative Sciences, 14(1)*, 17. https://doi.org/10.3390/admsci14010017

Zhai, C., Wibowo, S. & Li, L. D. (2024). The effects of over-reliance on AI dialogue systems on students' cognitive abilities: A systematic review. *Smart Learn. Environ. 11, 28*. https://doi.org/10.1186/s40561-024-00316-7

Zhang, W., & Wang, Z. (2021). Theory and practice of VR/AR in K-12 science education—a systematic review. *Sustainability, 13(22)*, 12646. https://doi.org/10.3390/su132212646

Zhang, X., Chen, Y., Hu, L., Bao, Y., Tu, Y.-F., & Hwang, G.-J. (2024). A metaphor-based robot programming approach to facilitating young children's computational thinking and positive learning behaviors. *Computers & Education, 215*, 105039. https://doi.org/10.1016/j.compedu.2024.105039

Zhao, X., Ren, Y., & Cheah, K. S. L. (2023). Leading virtual reality (VR) and augmented reality (AR) in education: Bibliometric and content analysis from the Web of Science (2018–2022). *SAGE Open, 13(3)*. https://doi.org/10.1177/21582440231190821