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Effectiveness of using digital learning media (projectors) in mathematics learning

Afriska Della Imamiyah, Kharisma Putri Erlinawati, Mohammad Nurwahid*

Tadris Matematika, Institut Alif Muhammad Imam Syafi'i, Lamongan, Indonesia

*) Corresponding Author (e-mail: muhammadnurwahid@inamis.ac.id)

Abstract

Despite the widespread promotion of digital technology integration in Indonesian schools, empirical evidence on how simple digital tools, such as projectors, are pedagogically used in mathematics classrooms remains limited, particularly from an in-depth qualitative perspective. Previous studies have primarily focused on learning outcomes, while paying less attention to classroom processes, teacher readiness, and contextual challenges. This study addresses this gap by exploring the effectiveness of using projectors in junior high school mathematics learning. Employing a qualitative case study approach, data were collected through classroom observations, semi-structured interviews, and document analysis at SMP Islam Bustanul Hikmah, involving 30 seventh-grade students and three mathematics teachers. The findings indicate that projector use supports students' conceptual understanding, enhances learning motivation, and promotes more interactive classroom engagement. However, technical constraints, variations in teachers' digital competence, and potential over-reliance on technology emerged as significant challenges. The study concludes that projectors can effectively support mathematics learning when integrated meaningfully into pedagogy and supported by adequate infrastructure, teacher competence, and school policy.

Keywords: Learning Media, Projector, Mathematics Leaning.

Abstrak

Meskipun integrasi teknologi digital telah banyak dipromosikan di sekolah-sekolah di Indonesia, bukti empiris mengenai bagaimana perangkat digital sederhana seperti proyektor dimanfaatkan secara pedagogis dalam pembelajaran matematika masih terbatas, terutama dari perspektif kualitatif yang mendalam. Penelitian sebelumnya sebagian besar berfokus pada hasil belajar, sementara perhatian terhadap proses pembelajaran di kelas, kesiapan guru, dan tantangan kontekstual masih relatif minim. Penelitian ini bertujuan untuk mengisi kesenjangan tersebut dengan mengeksplorasi efektivitas penggunaan proyektor dalam pembelajaran matematika di tingkat sekolah menengah pertama. Dengan menggunakan pendekatan studi kasus kualitatif, data dikumpulkan melalui observasi kelas, wawancara semi-terstruktur, dan analisis dokumen di SMP Islam Bustanul Hikmah, yang melibatkan 30 siswa kelas VII dan tiga guru matematika. Hasil penelitian menunjukkan bahwa penggunaan proyektor mendukung pemahaman konseptual siswa, meningkatkan motivasi belajar, serta mendorong keterlibatan kelas yang lebih interaktif. Namun demikian, keterbatasan teknis, variasi kompetensi digital guru, dan potensi ketergantungan berlebihan pada teknologi muncul sebagai tantangan yang signifikan. Penelitian ini menyimpulkan bahwa proyektor dapat mendukung pembelajaran matematika secara efektif apabila diintegrasikan secara bermakna ke dalam praktik pedagogik dan didukung oleh infrastruktur yang memadai, kompetensi guru, serta kebijakan sekolah.

Kata Kunci: Media Pembelajaran, Proyektor, Pembelajaran Matematika.

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1. Introduction

Mathematics learning at the junior high school level continues to face fundamental challenges, particularly related to students' difficulties in understanding abstract concepts such as variables, functions, geometric relationships, and graphical representations. These difficulties are often associated with instructional practices that rely heavily on symbolic explanations and verbal instruction, offering limited visual or experiential support. Consequently, many students perceive mathematics as a difficult and monotonous subject, which negatively affects their motivation and conceptual understanding (Kholil & Safianti, 2019; Sinaga & Ansari, 2018).

In response to these challenges, the Indonesian Ministry of Education and Culture has promoted the integration of information and communication technology (ICT) into school learning since 2013. The integration of technology is expected to improve learning effectiveness, enhance student engagement, and facilitate the understanding of abstract concepts through visualization and interactivity. Previous studies have shown that digital technology can increase the attractiveness and effectiveness of learning by enabling students to observe complex, abstract, or difficult-to-access phenomena in more concrete ways (Anita & Nugraha, 2022).

The rapid development of the digital era has brought significant changes to mathematics education, creating new opportunities to present abstract concepts in more meaningful and engaging forms. Digital learning media allow mathematics instruction to move beyond static explanations toward dynamic visualization, interactive demonstrations, and real-time problem solving. Research indicates that technology-supported mathematics learning can help students better understand complex concepts and improve overall learning effectiveness (Aminullah, 2024).

Among the various digital tools available in schools, projectors are one of the most accessible and widely used media, particularly in educational contexts with limited access to advanced digital infrastructure. Projectors enable teachers to present visual representations, animations, graphs, and step-by-step problem-solving processes that support students' conceptual understanding. They also allow the integration of videos, simulations, and student presentations, which can accommodate diverse learning styles and encourage active classroom participation (Anita & Nugraha, 2022; Kadek et al., 2024).

From a pedagogical perspective, visualization plays a crucial role in supporting students' cognitive processes in mathematics learning. As an abstract discipline, mathematics requires learners to mentally represent objects and relationships that are not directly observable. Learning approaches that emphasize visualization such as diagrams, digital simulations, and dynamic representations can bridge the gap between abstract symbols and students' mental models, thereby improving conceptual clarity, engagement, and retention (Amidi & Zahid, 2016). This view is consistent with constructivist learning theory, which emphasizes that knowledge is constructed through mediated and concrete learning experiences (Sinaga & Ansari, 2018; Tamrin et al., 2011).

Digital learning media, particularly projectors, offer practical solutions to address these pedagogical needs by providing visual and interactive learning support. Through projector-assisted instruction, teachers can present materials enriched with animations and real-time demonstrations that make abstract mathematical ideas more accessible. Previous research has reported that the use of visual media in mathematics learning contributes to improved conceptual understanding and increased student engagement (Kadek et al., 2024; R. I. M. Pratiwi & Wiarta, 2021). Nevertheless, the effectiveness of such media depends largely on meaningful pedagogical integration and teachers' readiness to use technology effectively (Aminullah, 2024).

Despite their potential benefits, the implementation of digital learning media in Indonesian mathematics classrooms still faces several challenges. Infrastructure limitations, including unstable electricity, malfunctioning equipment, and limited supporting devices, often hinder the consistent use of projectors. In addition, variations in teachers' digital competence and resistance to changing traditional instructional practices pose significant barriers to effective technology integration (Y. Pratiwi & Nugraheni, 2022; Wahyudi et al., 2024). Existing studies tend to focus on learning outcomes or technological innovation, while fewer studies explore, from a qualitative perspective, how simple and widely available tools such as projectors are actually used in everyday classroom practice.

This gap highlights the need for in-depth qualitative research that examines the effectiveness of projector use within authentic mathematics learning contexts. Therefore, this study aims to analyze the effectiveness of using digital learning media, specifically projectors, in junior high school mathematics learning. The study is guided how effective is the use of digital learning media (projectors) in supporting junior high school students' mathematics learning. Additionally, this study seeks to identify factors that support and hinder projector implementation and to provide recommendations for optimizing the use of digital learning media in mathematics instruction.

2. Research Method

This study uses a qualitative approach with a case study method. The qualitative approach was chosen because this study aims to deeply understand the phenomenon of using digital learning media in the context of mathematics learning. The case study was chosen to provide a comprehensive picture of the implementation of projectors in mathematics learning in one particular school. The research was conducted at Bustanul Hikmah Islamic Middle School in the even semester of the 2024/2025 academic year, precisely in May to June 2025. This school was chosen because it has consistently implemented the use of digital learning media and has adequate technological facilities. The subjects of the study consisted of 30 students of class VII-A and 3 mathematics teachers at SMP Islam Bustanul Hikmah. The selection of class VII-A was carried out by purposive sampling with the consideration that the class had used a projector in mathematics learning for at least one semester. The three mathematics teachers were selected based on their teaching experience using digital media for at least 2 years.

The research instruments used include: learning observation guidelines for observing teacher and student activities during learning using a projector, semi-structured interview guidelines for teachers and students, documentation sheet to collect supporting documents such as lesson plans, student learning outcomes, and photos of learning activities. Data collection is carried out through three main techniques: Participatory observation during 12 mathematics learning meetings using a projector, In-depth interviews with 3 mathematics teachers and 15 randomly selected students.

Data were analyzed using the Miles & Huberman model which consists of three stages: data reduction, which is the process of selecting and simplifying raw data, presentation of data in the form of narrative text and tables, drawing conclusions and verification. to ensure data validity, triangulation and member checking were applied. Source triangulation was conducted by comparing data obtained from teachers, students, and classroom observations. Method triangulation involved cross-checking findings from observations, interviews, and documentation. Member checking was carried out by sharing preliminary interpretations with the participating teachers to confirm the accuracy and credibility of the findings.

3. Results and Discussion

3.1. Results

The results of interviews and observations are presented as follows:

Table 1. Teachers' Perspectives on the Use of Projectors in Mathematics Learning

Aspect	Teacher A	Teacher B	Teacher C
Main Perspective	The projector helps students understand abstract mathematical concepts more easily through clear visualization.	The projector increases learning efficiency and reduces time spent drawing or explaining manually.	The projector creates more interactive, engaging, and enjoyable learning experiences.
Observed Benefits	Students show greater enthusiasm and better conceptual understanding, especially in geometry topics.	Lessons become more efficient and structured; time saved is used for discussion and exercises.	Students are more motivated, confident, and actively participate in learning activities.
Observed Challenges	Technical problems such as damaged cables or projector connection failures sometimes interrupt learning.	Difficulty connecting devices and limited mastery of presentation or math software.	Students become dependent on visuals; they lose focus when the projector fails.
Suggestions/ Expectations	Regular maintenance and backup devices are needed to avoid class disruption.	Teachers need continuous training in digital media and technology integration.	Teachers should balance the use of digital and traditional methods to maintain engagement.

In contrast to the teachers' viewpoints, the second set of findings highlights students' learning experiences during projector-assisted mathematics lessons. Students' responses provide insight into how projector use affects interest, understanding, motivation, participation, and perceived challenges. These perspectives are summarized in Table 2.

Table 2. Students' Perspectives on the Use of Projectors in Mathematics Learning

Aspect	Students' Views and Experiences	Impacts on Learning	Illustrative Quotations
Interest and Enjoyment	Based on interview data, 13 out of 15 interviewed students stated that mathematics lessons became more interesting and enjoyable when projectors were used.	Increased attention and willingness to participate actively during class.	"Math becomes more exciting, sir. We can see interesting pictures and sometimes animations, so it's not boring anymore."
Conceptual Understanding	Students found it easier to understand abstract topics such as geometry, algebra, and graphs through visuals and real-time examples.	Improved comprehension and retention of mathematical concepts.	"It's easier to imagine the shape of a prism or how the graph changes when the variable moves."
Motivation to Learn	The use of colorful slides, videos, and moving visuals encouraged students to be more motivated and curious about mathematical problems.	Greater persistence in solving exercises and exploring problems.	"When the teacher shows the animation, I want to try solving the question myself."
Class Participation	Students became more confident to present answers and interact with the teacher during learning activities.	Strengthened communication and collaborative learning among peers.	"We often come to the front to explain our answers using the slides."
Challenges Experienced	Some students admitted difficulty focusing when the projector had technical issues or when the visuals were too fast.	Temporary distraction or reduced engagement when the projector was not available.	"If the projector suddenly stops working, it's harder to follow the lesson."
Expectations for Improvement	Students hoped teachers would continue using projectors and add more interactive and game-like media.	Desire for more engaging and participatory mathematics learning.	"I hope we can also play math games or quizzes using the projector."

3.2. Discussion

Empirical Findings on the Use of Projectors in Mathematics Learning

Improving Understanding of Mathematical Concepts

Analysis of classroom observation data indicated that projector use consistently supported students' understanding of abstract mathematical concepts, particularly in topics requiring spatial visualization such as geometry and graphical representations. During observed lessons, students appeared more attentive and actively engaged when teachers displayed visual representations of three-dimensional objects, graphs, and dynamic transformations. For example, in geometry lessons, projectors were used to present rotatable three-dimensional figures, allowing students to visually explore changes in shape, volume, and surface area. These observations suggest that visual exposure plays a crucial role in helping students connect abstract symbols with concrete representations.

Findings from semi-structured teacher interviews further corroborated these observations. Teachers emphasized that projector-assisted instruction helped students grasp concepts more intuitively and reduced misconceptions. Teacher A explained, "When I teach geometric shapes using a projector, students become more enthusiastic and understand the concepts more easily because they can see clear visualizations." Similarly, Teacher B highlighted instructional efficiency, stating, "Using the projector helps me explain abstract ideas faster, so students can focus more on understanding rather than copying drawings." Teacher C added that visual presentations increased students' confidence, noting that "students are more willing to ask questions and explain their answers when they can refer to what they see on the screen."

Across the interviews, a recurring theme emerged: visualization functions as a mediating tool that bridges abstract mathematical ideas and students' cognitive understanding. This thematic pattern indicates that projectors do not merely serve as presentation devices but actively support meaning-making processes in mathematics learning. These findings align with Priyanda et al. (2025), who reported that digital visualization significantly improves students' comprehension of geometric concepts. From a theoretical perspective, the results are consistent with Vygotsky's social constructivist theory, which emphasizes the role of mediational tools in scaffolding learning within the Zone of Proximal Development (Nabawi, 2023; Tamrin et al., 2011).

Furthermore, the findings support previous studies highlighting the role of digital media in enhancing conceptual understanding. Amidi and Zahid (2016) argue that digital-assisted learning environments promote creative mathematical thinking by providing visual contexts that support reasoning and hypothesis testing. Likewise, Aminullah (2024) and Anita and Nugraha (2022) emphasize that integrating technology into mathematics instruction strengthens conceptual comprehension and improves learning effectiveness. Pratiwi (2021) also found that visual learning media help students understand conceptual relationships by making abstract content more accessible.

Taken together, the triangulation of observation and interview data indicates that projectors function as cognitive and pedagogical mediators in mathematics classrooms. By enabling students to visualize and manipulate mathematical objects dynamically, projectors facilitate conceptual change and support the construction of mental models essential for long-term understanding (Kholil & Safianti, 2019). Thus, rather than merely enhancing presentation quality, projector use contributes substantively to students' conceptual understanding through visualization-driven learning processes.

Increasing Student Motivation and Engagement

Analysis of semi-structured student interview data revealed a clear increase in students' motivation when projectors were integrated into mathematics lessons. Of the 15 interviewed students, 13 students reported feeling more enthusiastic about learning mathematics, describing the lessons as "more exciting" and "less boring" when visual media were used. These responses indicate that projector-assisted instruction positively influenced students' affective engagement with mathematical content.

Findings from classroom observations further supported the interview data. During observed lessons that incorporated projector use, most students actively participated in discussions, problem-solving activities, and classroom interactions. In contrast, observations of conventional chalkboard-based instruction showed more limited student involvement, with fewer students initiating questions or contributing to discussions. Rather than serving as precise statistical measures, these observational patterns reflect recurring behavioral tendencies noted across multiple classroom sessions, indicating a shift toward more active engagement when visual media were present.

The analysis suggests that this increase in motivation and engagement is closely related to the multisensory and interactive characteristics of projector-assisted learning. Visual animations, dynamic representations, and multimedia elements appeared to capture students' attention and sustain their interest throughout the lesson. This finding is consistent with Kadek et al. (2024) who reported that animated digital media enhance students' curiosity and concentration, and with Rahmat Sinaga (2018), who emphasized that audiovisual media can reduce monotony and foster positive emotional responses toward learning.

From a theoretical perspective, students' positive responses align with the Technology Acceptance Model (TAM), which posits that perceived usefulness and enjoyment influence learners' willingness to engage with technology-enhanced learning environments (Oktaria et al., 2024). In this study, students' enthusiasm and active participation suggest that projectors were perceived not only as useful instructional tools but also as enjoyable learning aids that supported their engagement with mathematics.

Moreover, observational data indicated that projector use facilitated social and participatory learning processes. When teachers invited students to interpret visual representations or predict outcomes displayed on the screen, students were more

willing to share ideas, collaborate with peers, and explain their reasoning. This finding supports (Hasanah et al., 2025; Tamagola et al., 2025), who argue that visually enriched instruction encourages interaction and sustained effort in mathematical problem-solving.

Overall, the triangulation of interview and observation data demonstrates that projector use contributes to increased student motivation and engagement by transforming mathematics lessons into more interactive, enjoyable, and socially meaningful learning experiences. Importantly, these effects were most evident when teachers actively facilitated discussion and inquiry, indicating that technology functions as a pedagogical enabler rather than an independent determinant of engagement.

Learning Time Efficiency

Analysis of classroom observation data showed that the use of projectors contributed to more efficient management of instructional time in mathematics lessons. During observed sessions, teachers spent less time on procedural tasks such as drawing geometric figures, constructing graphs, or rewriting problem statements on the board. Instead, instructional time was redirected toward conceptual explanation, guided practice, and classroom discussion. For example, in one observed lesson on linear functions, the teacher used a projector to display a dynamic graph in GeoGebra, allowing immediate visualization of changes in slope and intercept as parameters were adjusted. This enabled students to focus on interpreting the mathematical meaning of the changes rather than copying diagrams.

Findings from teacher interviews reinforced these observational insights. Teachers consistently reported that projector-assisted instruction reduced repetitive manual work and improved lesson flow. Teacher B explained, *"Learning time becomes more efficient because I do not need to draw function graphs manually on the board. Students can directly see changes in the graph when the variable value is changed."* Teacher C similarly noted that pre-prepared digital materials helped maintain lesson continuity, stating that *"I can move quickly from explanation to discussion because everything is already prepared on the slides."* These interview responses highlight teachers' perceptions of efficiency gains resulting from the use of projectors.

The triangulation of observation and interview data indicates that instructional efficiency emerged as a recurring theme in projector-assisted mathematics lessons. Observational records showed that saved time was frequently allocated to deeper exploration of concepts, extended problem-solving activities, and responsive teacher–student interactions. This finding aligns with Kholil and Safianti (2019), who reported that technology-assisted guided discovery learning optimizes both conceptual mastery and classroom time use. Aminullah (2024) similarly notes that digital media streamline lesson delivery by enabling teachers to prioritize conceptual explanation and formative assessment over mechanical procedures.

Moreover, Anita and Nugraha (2022) emphasize that systematic lesson planning supported by digital media allows teachers to manage instructional resources more efficiently and reduce cognitive overload. Amidi and Zahid (2016) further argue that

improved time efficiency supports sustained student engagement by creating space for exploratory and reflective learning activities. In the observed classrooms, this was evident when teachers used the additional time to invite students to interpret visual representations, predict outcomes, or explain their reasoning to peers.

Overall, the findings suggest that projector-assisted teaching enhances instructional time efficiency by minimizing procedural load and maximizing opportunities for conceptual dialogue and interaction. However, both observation and interview data indicate that these benefits depend on teachers' digital readiness and preparation. Teachers who were familiar with instructional software and prepared digital materials in advance were better able to leverage projector use effectively, underscoring the importance of adequate training and planning in realizing the full potential of projector-based instruction.

Challenges in Implementing Digital Learning Media

Technical Constraints

Despite the proven benefits of projectors in enhancing mathematical learning, several technical barriers hinder their consistent use in classroom instruction. Field observations revealed three to four technical disruptions during twelve observed lessons. The most common issues included projectors failing to power on, damaged or loose HDMI/VGA cables, and unstable connections between laptops and projectors. Although these problems may seem minor, they had noticeable pedagogical consequences: lessons were delayed, teacher explanations were interrupted, and student focus was often lost.

This finding aligns with Anita & Nugraha (2022) who argue that technological infrastructure problems remain one of the major obstacles to the implementation of digital learning in Indonesian schools. Similarly, Aminullah (2024) emphasizes that without reliable facilities and regular maintenance, the adoption of digital media risks becoming inefficient or counterproductive. These technical interruptions consume valuable learning time and disrupt the sequential flow of mathematics instruction, where continuity and stepwise reasoning are essential for comprehension.

To address these challenges, schools must ensure systematic maintenance and provide technical support personnel who can respond quickly to classroom issues. This is consistent with Kadek et al. (2024)who suggest that the presence of a dedicated technician or IT support staff contributes significantly to the sustainability of technology-based instruction. Additionally, contingency planning such as having a backup projector or pre-printed learning materials should be part of teachers' preparation to minimize learning disruption. In short, technical constraints not only reflect hardware fragility but also institutional readiness. Regular monitoring, preventive maintenance, and infrastructural investment are critical to ensure that digital tools truly enhance, rather than obstruct, the learning experience.

Limitations of Teachers' Digital Competence

A recurring finding in this study is the variation in teachers' digital competence, which profoundly influences the effectiveness of projector use. Interviews revealed that

approximately one out of three teachers still experienced difficulties in operating digital devices or software such as PowerPoint and GeoGebra. Consequently, these teachers often depended on school technicians or colleagues for technical setup and classroom operation.

The Technology Acceptance Model (TAM) Oktaria et al. (2024) provides a theoretical framework for this issue: teachers' adoption of technology depends on their *perceived ease of use* and *perceived usefulness*. When teachers lack confidence or adequate training, their perceived ease of use declines, reducing willingness to integrate digital tools meaningfully into instruction. This situation mirrors the national context, found that about 45% of Indonesian teachers exhibit low digital competence levels (Wahyudi et al., 2024).

The gap in digital literacy is not limited to technical know-how but also extends to pedagogical integration. As Amidi & Zahid (2016) emphasize, effective digital learning requires teachers to connect technology with problem-solving and creative thinking strategies, rather than using it merely for presentation. Without this pedagogical awareness, teachers may revert to traditional methods as chalkboard lectures and rote exercises thereby underutilizing available digital resources. Moreover, Y. Pratiwi & Nugraheni (2022) note that limited digital competence contributes to inconsistent use of multimedia tools, leading to reduced student engagement and lower instructional innovation. This finding reinforces the need for continuous professional development (CPD) that emphasizes both technical and pedagogical dimensions of digital learning.

Professional development should be hands-on, contextual, and iterative. Workshops on software operation (e.g., GeoGebra, Desmos), lesson-design clinics, and peer mentoring sessions can help teachers gradually improve their confidence and autonomy. Aminullah, (2024) also stresses that teacher training programs must be ongoing rather than one-time, with opportunities for reflection and follow-up to ensure transfer to classroom practice. Thus, the challenge of digital competence is not solely individual but systemic, requiring policy-level support for sustainable capacity building. Teacher readiness is a cornerstone of technology integration, and without it, even the best equipment will remain underused.

Dependence on Technology

Another emerging challenge concerns over-dependence on technology, which can lead to instructional inflexibility and vulnerability when digital tools fail. Teachers who frequently rely on projectors may find it difficult to adapt to non-digital methods such as whiteboard explanations, hands-on manipulatives, or verbal reasoning. This dependency poses risks to lesson continuity if a projector or network fails, teachers may struggle to maintain instructional flow.

The phenomenon also affects students: learners accustomed to visually rich and interactive instruction may show reduced motivation and engagement in the absence of technology. This reflects a psychological habituation effect students equate learning effectiveness with digital stimulation rather than cognitive effort. As a result, their tolerance for traditional learning contexts diminishes, and their intrinsic motivation may

weaken (Sinaga & Ansari, 2018; Wardanu et al., 2025). This concern is echoed in Tamagola et al. (2025), who caution that digital transformation in education must be balanced to avoid overreliance on tools at the expense of pedagogical substance. Similarly, Kholil & Safianti, (2019) emphasize the importance of teacher adaptability in switching between various modes of instruction digital and conventional based on classroom needs and contextual constraints.

To mitigate such dependency, teachers should adopt a blended approach that integrates digital projection with non-digital strategies. For example, after using a projector to demonstrate a concept, teachers can engage students in board-based derivations or paper-based practice to reinforce mental visualization skills. Having backup lesson plans (e.g., printed handouts, tangible models) ensures instructional resilience when technology fails. As Aminullah (2024) notes, technological integration should support not dominate pedagogical decision-making. In essence, the challenge of dependence underscores the need for balanced digital pedagogy. The goal is not continuous technology use but thoughtful integration knowing *when* and *why* to use digital tools and *when not to*.

Factors that Support Effectiveness

School Infrastructure Support

Adequate infrastructure is a fundamental factor in ensuring the effective implementation of digital learning. At SMP Islam Bustanul Hikmah, the availability of projectors in each classroom and stable internet access demonstrates institutional readiness to integrate technology into instruction. According to Anita & Nugraha (2022) schools that invest in digital infrastructure create more consistent and engaging learning environments, as teachers can integrate multimedia, online simulations, and visual demonstrations more smoothly. Similarly, Aminullah (2024) emphasizes that well-maintained facilities supported by reliable electricity and technical staff contribute directly to improving students' learning performance and teachers' instructional efficiency. The existence of on-site technicians at the observed school reflects the recommendation of Kadek et al. (2024), who found that technical support helps sustain the continuity and quality of digital-based mathematics instruction. Thus, infrastructure readiness ensures not only technical stability but also cultivates a supportive atmosphere for pedagogical innovation.

Teacher Commitment and Creativity

Teacher commitment and creativity play a decisive role in maximizing the pedagogical potential of projectors and other digital tools. As observed in Teacher C, creative educators design interactive and inquiry-based lessons using software such as GeoGebra to illustrate abstract mathematical relationships dynamically. This practice aligns with findings from Amidi & Zahid (2016), who note that technology-assisted problem-based learning enhances students' creative mathematical thinking. Furthermore, Nurfadhillah et al. (2021) highlights that visual and interactive media increase engagement by linking abstract symbols to concrete experiences, fostering deeper comprehension. Teachers who personalize digital materials also embody Aminullah's (2024) view that creativity in lesson design improves students' affective

engagement and conceptual mastery. In line with Tamagola et al. (2025), committed teachers serve as agents of change in digital transformation, ensuring that technology integration remains purposeful, student-centered, and sustainable.

School Policy Support

School policies supporting digital media integration are essential for ensuring long-term sustainability. Policies that allocate budgets for equipment maintenance, software updates, and teacher training create the structural foundation for continuous improvement. Y. Pratiwi & Nugraheni (2022) found that schools lacking such institutional support often experience discontinuity in technology adoption due to outdated devices or untrained staff. Meanwhile, Tamagola et al. (2025) emphasize that digital transformation requires not only physical resources but also administrative commitment through strategic planning and evaluation. Supportive policies that encourage teachers to develop and share digital materials as suggested by Anita & Nugraha (2022) enhance professional collaboration and innovation. Consequently, policy-level backing ensures that technology, including projectors, is not merely a temporary addition but an integral component of the school's teaching culture and pedagogical framework.

Effectiveness Analysis Based on Learning Dimensions

Cognitive Dimension

From a cognitive standpoint, the use of projectors enhances students' conceptual understanding and problem-solving abilities. By displaying interactive visuals, animated diagrams, and real-time simulations, teachers can transform abstract mathematical ideas such as geometric transformations, algebraic graphs, or statistical data into concrete and observable representations. This visual reinforcement strengthens comprehension and helps students develop representational fluency, which is crucial in mathematical reasoning.

This finding aligns with Amidi & Zahid (2016), who emphasize that digital-assisted learning environments foster creative mathematical thinking and higher-order reasoning. Similarly, Aminullah (2024) found that integrating visualization technologies in mathematics can significantly improve students' comprehension, especially in topics requiring spatial reasoning. Furthermore, Kadek et al. (2024) confirmed that animation-based learning media enhance both students' learning outcomes and their ability to recall complex mathematical relationships. Thus, projectors function as cognitive scaffolds, bridging the gap between symbolic abstraction and visual understanding, consistent with the principles of Vygotsky's theory of mediated learning (Tamrin et al., 2011).

Affective Dimension

In the affective domain, projectors positively shape students' attitudes, motivation, and emotional engagement with mathematics. The combination of color, motion, and interactive content captures attention and fosters curiosity. Students report that mathematics feels less intimidating and more enjoyable when delivered through

dynamic visual presentations. This emotional engagement promotes intrinsic motivation, reducing math anxiety and building a more positive learning climate.

Nurfadhillah et al. (2021; Wardanu et al. (2025) found that visual learning media strengthen students' affective connection to academic content by making lessons more meaningful and relatable. Similarly, Rahmat sinaga (2018b) demonstrated that audiovisual media increase enthusiasm and empathy toward learning materials by stimulating multiple sensory modalities. In the context of mathematics, such affective stimulation can transform the perception of mathematics from a rigid subject into an engaging and creative field of inquiry. According to Tamagola et al. (2025), these affective benefits are crucial in digital transformation, as they help sustain student motivation in long-term learning.

Psychomotor Dimension

From the psychomotor perspective, projectors encourage active participation and hands-on engagement. Students often manipulate variables using software such as GeoGebra, collaborate in solving visualized problems, and present their solutions interactively in front of peers. These activities not only enhance learning outcomes but also build essential soft skills such as communication, teamwork, and digital literacy.

As Kholil and Kholil & Safianti (2019) point out, active involvement in discovery-based activities strengthens procedural fluency and mathematical reasoning. The same applies to the current findings students who engage with projected simulations demonstrate higher confidence and persistence in problem-solving. Furthermore, Anita & Nugraha (2022) argue that digital-based activities stimulate psychomotor involvement by transforming students from passive recipients into active participants in knowledge construction.

4. Conclusion

Based on the results of the study and discussion, it can be concluded that the use of digital learning media, especially projectors, is effective in supporting junior high school students' mathematics learning. This effectiveness can be seen from the increase in students' conceptual understanding, increased motivation and involvement in learning, and efficiency of learning time. The increase in students' average score by 8.8 points and the learning completion rate from 65% to 87% showed a significant positive impact. However, this effectiveness is highly dependent on supporting factors such as adequate infrastructure, teachers' digital competence, and school policy support. The main challenges faced include technical constraints, limited teachers' digital competence, and potential dependence on technology.

This study recommends several things: first, the need to improve teachers' digital competence through continuous training; second, the need for a backup plan when technical disruptions occur; third, the importance of a balance between the use of digital media and conventional learning methods; fourth, the need for periodic evaluation of the effectiveness of the use of digital learning media. Suggestions for further research are to conduct research on a wider scale, analyze the effectiveness

of digital learning media in other subjects, and develop a more comprehensive technology integration model in learning.

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References

Amidi, & Zahid, M. Z. (2016). Membangun Kemampuan Berpikir Kreatif Matematis Dengan Model Pembelajaran Berbasis Masalah Berbantuan E-Learning. *Seminar Nasional Matematika X Universitas Negeri Semarang 2016*, 586–594.

Aminullah, I. (2024). Analisis Efektivitas Penggunaan Teknologi dalam Pembelajaran Matematika. *JagoMIPA: Jurnal Pendidikan Matematika Dan IPA*, *4*(4), 678–687. https://doi.org/10.53299/jagomipa.v4i4.721

Anita, T., & Nugraha, F. W. (2022). Sosialisasi Pembelajaran Berbasis Digital pada Masyarakat. *Darma Cendekia*, *1*(1), 23–29. https://doi.org/10.60012/dc.v1i1.5

Hasanah, W., Rosmilawati, I., & Juansah, D. E. (2025). Peran Media Digital dalam Meningkatkan Motivasi dan Hasil Belajar Matematika Siswa Sekolah Dasar di Era Digital. *Jurnal Basicedu*, *9*(2), 665–678. https://doi.org/https://doi.org/10.31004/basicedu.v9i2.9971

Kadek, N., Dewi, K., Wayan, A. I., Yuda, I., & Simamora, H. (2024). Inovasi Media Pembelajaran : Video Pembelajaran Berbasis Animasi Meningkatkan Hasil Belajar Matematika Siswa Sekolah Dasar. *Jurnal Media Dan Teknologi Pendidikan*, *4*(2), 149–157. https://doi.org/10.23887/jmt.v4i2.64378

Kholil, M., & Safianti, O. (2019). Efektivitas Pembelajaran Penemuan Terbimbing Terhadap Hasil Belajar Matematika Siswa Materi Barisan dan Deret. *Laplace : Jurnal Pendidikan Matematika*, *2*(2), 89–98. https://doi.org/10.31537/laplace.v2i2.246

Nabawi, M. (2023). Penerapan Scaffolding Pada Zone of Proximal Development (Zpd) Dalam Mata Pelajaran Sejarah Di Sma Negeri 2 Malang Kelas Xii Mipa 4. *Jurnal Inovasi Teknologi Dan Edukasi Teknik*, *3*(11), 3. https://doi.org/10.17977/um068.v3.i11.2023.3

Nurfadhillah, S., Rizkiya, D. F., & Waro, K. (2021). Pengaplikasian Media Pembelajaran Visual Pada Pembelajaran Matematika. *EDISI : Jurnal Edukasi Dan Sains*, *3*(253–263), 253–263.

Oktaria, S. D., Firdaus, R., & Pangestu, D. (2024). Faktor-Faktor yang Mempengaruhi

Penerimaan Teknologi dalam Pembelajaran di SMA Bandar Lampung Menggunakan Model TAM di Era Disrupsi. *Seminar Nasional Teknologi, Kearifan Lokal Dan Pendidikan Transformatif (SNTEKAD)*, *2*(1), 139–148. https://doi.org/10.12928/sntekad.v2i1.19034

Pratiwi, R. I. M., & Wiarta, I. W. (2021). Multimedia Interaktif Berbasis Pendidikan Matematika Realistik Indonesia pada Pembelajaran Matematika. *Jurnal Edutech Undiksha*, *9*(1), 85–94. https://doi.org/10.23887/jeu.v9i1.32220

Pratiwi, Y., & Nugraheni, A. S. (2022). Problematika Guru Dalam Mengembangkan Media Pembelajaran Berbasis Multimedia Di SD/MI. *Primary: Jurnal Pendidikan Guru Sekolah Dasar*, *11*(5), 1479. https://doi.org/10.33578/jpfkip.v11i5.8977

Priyanda, R., Herman, T., Amalia, R., & Ihsan, I. R. (2025). Exploring teachers' pedagogical reasoning in mathematics education using the TPACK framework. *Frontiers in Education*, *10*(May). https://doi.org/10.3389/feduc.2025.1552760

Sinaga, B. R., & Ansari, K. (2018). Pengaruh Model Pembelajaran Experiential Learning Dengan Media Audiovisual Terhadap Kemampuan Menulis Teks Prosedur Kompleks Pada Siswa Kelas X Sma Negeri 5 Medan Tahun Pembelajaran 2016/2017. *Kode: Jurnal Bahasa*, *7*(1), 79–88. https://doi.org/10.24114/kjb.v7i1.10113

Tamagola, R. H. A., Ikhlas, A., Romadon, S., Rufiatun, Hasanah, I., & Saragi, D. P. (2025). Transformasi Pembelajaran Matematika Berbasis Teknologi: Tantangan Dan Peluang Di Era Kurikulum Berdampak. *Jurnal Edu Research Indonesian Institute For Corporate Learning And Studies (IICLS)*, *6*(3), 1060–1074.

Tamrin, M., S. Sirate, S. F., & Yusuf, M. (2011). Teori Belajar Vygotsky dalam Pembelajaran Matematika. *Sigma (Suara Intelektual Gaya Matematika)*, *3*(1), 40–47.

Wahyudi, M., Purnama, R. A., Atrinawati, L. H., & Gunawan, D. (2024). Mengeksplorasi Dampak Teknologi Pembelajaran Aktif di Institusi Pendidikan Kejuruan Menengah. *Jurnal MENTARI: Manajemen, Pendidikan Dan Teknologi Informasi*, *2*(2), 142–153. https://doi.org/10.33050/mentari.v2i2.458

Wardanu, A. A., Ardiningtyas, N., & Rahmadhani, E. P. (2025). Inovasi Pembelajaran Matematika Melalui Media Visual untuk Meningkatkan Pemahaman Konsep Bilangan Cacah kelas V SD. *MIKHAYLA : The Journal of Advanced Research*, *2*(1), 89–95. https://doi.org/DOI https://doi.org/10.61579/mikhayla.v2i1.341