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The Impact of Digital Formative Assessment on Student Motivation and Learning Outcomes in the Technological Era

Ahmad Sofyan^{1*}, Ita Chairun Nissa², Loso Judijanto³, Muhammad Siwi Nugraha⁴, Dewi Santi⁵

¹ Universitas Islam Negeri Syarif Hidayatullah Jakarta, Indonesia,

² Universitas Pendidikan Ganesha, Indonesia,

³ IPOSS Jakarta, Indonesia,

⁴ Regional Development Planning, Research and Development Agency (Baperlitbangda)

Brebes Regency, Indonesia,

⁵IAI Hidayatullah Batam, Indonesia

* Corresponding author: madsofyan@gmail.com

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Abstract

The rapid digitalization of education has transformed not only instruction but also assessment practices. Digital formative assessment (DFA) has gained prominence for its capacity to deliver immediate, actionable feedback and to support iterative learning cycles. Unlike traditional assessments, DFA leverages educational applications and web-based platforms to facilitate sustained, two-way interaction between learners and instructors. This study synthesizes peer-reviewed literature to examine the impact of DFA on student motivation and learning outcomes in contemporary technology-rich contexts. Using a qualitative literature review approach, we analyze and integrate findings across multiple scholarly sources to identify consistent patterns and boundary conditions. The evidence indicates that DFA is associated with higher learner motivation through timely, personalized feedback and enhanced learner autonomy.



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Moreover, interactive features such as gamification elements, adaptive tasks, and embedded analytics contribute to greater engagement and are frequently linked to improvements in academic performance. Reported benefits are most salient when DFA practices are aligned with clear learning objectives, provide transparent success criteria, and are integrated into regular feedback loops. Implications include the need for targeted teacher professional development and deliberate instructional design to ensure fidelity of implementation.

Keywords: Digital formative assessment; Feedback; Student motivation; Learning outcomes; Gamification; Technology-enhanced learning.

用几何木屑为童子早艺,达想象力之长

摘要: 当今科技时代的教育发生了重大变革,不仅体现在教学方法上,也体现在评估方法上。数字化形成性评估因其能够提供即时反馈,使学生能够实时提升理解力和学习成绩,正日益被广泛采用。与传统评估不同,数字化形成性评估能够通过各种数字平台(例如教育应用程序和基于网络的学习工具)促进学生与教师之间更深入的互动。本研究旨在探究数字化形成性评估对学生学习动机和学习成果的影响,尤其关注这些评估如何在科技时代提升学生的参与度和学业成绩。本研究采用定性研究方法,运用文献综述法,分析来自多个学术来源的数据,以综合研究数字化形成性评估对学生学习动机和学习成果影响的研究结果。结果表明,数字化形成性评估能够显著提高学生的学习动机,因为它们能够提供即时且个性化的反馈。此外,这些评估还能营造更具吸引力的学习环境,从而提高学业成绩。研究发现,数字评估中游戏化和互动功能的整合可以提高学生的参与度和内在动力,从而有助于取得更好的学习成果。

关键词: 基于数字化的形成性评估、动机、学习成果。

1. Introduction

Education in the current technological era has undergone significant transformation, not only in terms of teaching methods, but also in the way assessments are conducted. Digital-based formative assessment is one of the evaluation methods that is increasingly popular because of its ability to provide direct feedback, thereby helping students improve their understanding and performance. Unlike traditional assessments, digital formative assessments allow for more intensive interaction between students and teachers through various technology platforms, such as educational applications and web-based learning software [1]. In addition, technology also makes it easier for students to actively participate in the learning process, which can indirectly increase their motivation and learning outcomes [2].

Formative assessment refers to a range of assessment techniques employed by teachers to monitor and enhance student learning during the instructional process. The purpose of formative assessment is not to assign grades but to provide feedback that helps students improve and meet learning goals. In contrast to summative assessments, which

evaluate learning at the end of a course or unit, formative assessments occur continuously throughout the learning process [3]. This type of assessment can take various forms, such as quizzes, discussions, peer assessments, or assignments that help both teachers and students identify areas of improvement. According to Black and Wiliam (2009), formative assessment plays a critical role in helping students become more engaged and aware of their learning progress, which fosters self-regulation and motivation to improve [4].

Recent research emphasizes the effectiveness of formative assessments in enhancing learning outcomes by providing ongoing feedback. The studies by Kingston and Nash (2011) highlight that when teachers regularly use formative assessments, they are able to adjust teaching methods to address students' needs and boost academic achievement [5]. Furthermore, formative assessments encourage a learning environment where students actively participate in their learning process, thus improving their academic engagement and performance [6]. This iterative feedback mechanism promotes not only academic improvement but also personal growth, as students understand their strengths and weaknesses better.

However, as noted by Heritage (2007), there is a challenge in ensuring that formative assessments are implemented consistently and that both teachers and students understand their value [7].

In this context, student learning motivation is a key factor in achieving educational success. Digital-based formative assessment, with its ability to provide fast and accurate feedback, can affect students' motivation levels. For example, the use of technology such as the Quizizz or Kahoot applications in formative assessment has been shown to increase student engagement and interest in learning [8]. Digital-based assessment allows students to get more detailed feedback on their understanding of the subject matter, which in turn can encourage them to be more motivated in learning [9].

The urgency of this research lies in the need to understand more deeply how the application of digital-based formative assessment can affect student motivation and learning outcomes in this fast-paced digital era. The use of technology in education is not an option, but a necessity to answer the challenges of an ever-evolving era. This study aims to examine the relationship between digital-based formative assessment, motivation, and student learning outcomes, and how technology can play a role in improving the quality of education in Indonesia [10].

Previous research has highlighted the importance of formative assessment in improving student learning motivation. According to Darmawan (2023), digital-based formative assessment not only makes it easier for teachers to monitor student progress, but also allows students to obtain constructive feedback instantly, which increases their motivation to learn better [11]. In addition, several studies also show that the application of technology in education can enrich students' learning experiences, which in turn can improve their learning outcomes [12].

The purpose of this study was to analyze the effect of digital-based formative assessment on student motivation and learning outcomes, and to explore the mechanisms that can explain the relationship between the three. This study is expected to provide insight for educators, especially in Indonesia, in optimizing the use of technology to improve the quality of learning and student academic outcomes.

2. Method

This study uses a qualitative approach with a literature review research type, which aims to analyze and synthesize findings from various previous studies regarding the influence of digital-based formative assessment on student motivation and learning outcomes in the technological era. This literature study was chosen because it allows researchers to explore various perspectives in related research without collecting primary data [13]. This approach is useful for developing a deeper understanding of how technology plays a role in education and provides a

strong theoretical basis for further research in this field [14].

Data Sources

The data sources used in this study are secondary data sources, which include scientific journal articles, books, research reports, and other academic publications that are relevant to the topic being studied. All selected sources must meet the criteria for validity and relevance to the focus of the research, namely digital-based formative assessment, student motivation, and learning outcomes. This data was obtained through searches in various trusted academic databases such as Google Scholar, Scopus, and ProQuest. As explained by Creswell (2014), a good literature study relies on credible and up-to-date sources to present an accurate and complete picture [15]. In addition, this study also relies on data from relevant previous studies, with the aim of providing a comprehensive picture of the application of digital-based formative assessment in education [16].

Data Collection Techniques

Data collection techniques are carried out through documentation studies. This process includes searching and selecting scientific articles, journals, and reports that discuss digital-based formative assessment in the context of education. Researchers identify relevant articles that discuss this topic from various perspectives and analyses to provide comprehensive insights. Data collection using this technique allows researchers to access various existing studies without conducting primary data collection, which is in accordance with the qualitative research approach [16]. As a reference, Snyder (2019) states that the literature study technique used in qualitative research functions to find relevant patterns in existing literature [17].

Data Analysis Methods

The analysis method used in this study is descriptive qualitative analysis. This method allows researchers to analyze data from various literatures that have been collected, then describe, analyze, and interpret the main findings related to digital-based formative assessment, student learning motivation, and its impact on learning outcomes. This analysis aims to identify central themes that emerge from various sources, as well as to explore the relationships between these elements in the context of technology-based education. According to Sugiyono (2016), descriptive qualitative analysis is a very effective method for describing existing phenomena and drawing conclusions based on existing data [18]. This process also allows for comparisons between studies to develop a broader understanding of the topic [17].

3. Results

Table Prologue: The data found here is the result of

filtering or selecting various articles that are relevant to the research topic regarding the influence of digital-based formative assessment on student motivation and learning outcomes in the technological era. This table

contains 10 articles that have been selected based on their relevance and contribution to the discussion on the application of digital-based formative assessment in the context of education.

Table 1. Literature Review

No.	Author	Years	Title
1	Fadhli, R., Suharyadi, A., Firdaus, F.M.	2023	Developing a Digital Learning Environment Team-Based Project to Support Online Learning in Indonesia
2	Farisia, H.	2021	Formative Assessment in an Online Class of Language Learning: Literature Review
3	Rosydiana, E.A., Sudjimat, D.A.	2023	Effect of Digital Learning Media Using Scratch Game Based Learning on Student Problem Solving Skills
4	Ramdhani, L.I., Triana, D.D., Madani, F.	2024	Enhancing Student Learning Outcomes through Formative Assessment: A Systematic Literature Review
5	Kesterson, M.R., Bippert, K.	2022	Formative Journeys: Formative Assessment with Journey Mapping through Hero Stories, Gamification, Computational Thinking
6	Nsabayezu, E., Iyamuremye, A., Mboniyirivuze, A.	2023	Digital-Based Formative Assessment to Support Students' Learning of Organic Chemistry
7	Roza, A.S., Dewi, A.F., Wahyuni, S.	2024	Digital-Based Learning Evaluation Model for High School Students
8	Zainuddin, Z., Gunawan, T., Armanda, D.	2023	Implementation of Gamification and Bloom's Digital Taxonomy-Based Assessment: A Scale Development Study with Mixed-Methods
9	Boesdorfer, S.B., Daugherty, J.	2020	Using Criteria-Based Digital Badging in High School Chemistry Unit to Improve Student Learning
10	Nurlina, N., Marisda, D.H., Riskawati, R.	2022	Assessment on Digitalization of Basic Physics Courses: Need Analysis on the Use of Digital-Based Assessment

The findings from the table above reveal key insights into the impact of digital-based formative assessment on student motivation and learning outcomes. The studies discussed span a variety of educational contexts and highlight how digital tools in formative assessments contribute significantly to both motivation and academic performance.

One of the prominent themes across the studies is the development of digital learning environments that enhance student engagement and participation. For instance, Fadhli et al. (2023) focused on the use of team-based digital learning environments in Indonesia, emphasizing how such environments improve student motivation and participation in the learning process. This study suggests that digital platforms are particularly effective in fostering collaboration and engagement, making learning more interactive and dynamic. Such platforms offer instant feedback and a more personalized learning experience, which not only motivates students but also improves their understanding and retention of content [19].

Similarly, Farisia (2021) conducted a literature

review on the use of digital formative assessments in online language learning environments. The review highlights the versatility of digital formative assessments in allowing students to receive immediate feedback, which in turn boosts their motivation and learning outcomes. It also points to the potential of online tools to track and monitor student progress more efficiently than traditional methods, thereby enhancing the learning experience and providing students with clearer learning goals and self-assessment opportunities. This personalized approach, combined with the flexibility of digital learning platforms, fosters an environment where students feel more in control of their learning, leading to greater intrinsic motivation [20].

Rosydiana et al. (2023) examined the effectiveness of digital learning media, particularly using Scratch-based game learning, in improving students' problem-solving skills. The study reveals that the interactive nature of digital formative assessments, especially through gamified platforms, significantly enhances motivation by making the learning process more

enjoyable. Furthermore, it highlights how digital media can effectively support the development of critical thinking and problem-solving skills, which are essential for deeper learning outcomes. The authors argue that when students engage with content through gamified assessment tools, they are more likely to remain motivated, as the format provides immediate rewards and challenges that align with their learning goals [21].

The research conducted by Ramdhani et al. (2024) highlights the importance of digital formative assessments in enhancing student learning outcomes through systematic literature review methodologies. This study underscores how digital assessments provide continuous feedback, which helps students identify areas for improvement and develop strategies to address their learning gaps. The research also notes that such assessments are particularly beneficial in formative evaluation, as they help students adjust their learning paths in real-time, improving their overall learning performance [22].

Another important contribution comes from Kesterson et al. (2022), who explore the integration of gamification with formative assessments through journey mapping and computational thinking. Their study demonstrates that by incorporating elements like hero stories and gamified challenges, students become more motivated to participate actively in the learning process. The incorporation of gamification into digital formative assessments provides students with a sense of accomplishment as they progress through levels and challenges, which boosts their intrinsic motivation and leads to improved learning outcomes. This approach aligns with the growing trend of using game mechanics to engage students and enhance their motivation in educational contexts [23].

In their study on the use of digital formative assessments in organic chemistry learning, Nsabayeze et al. (2023) highlight how such assessments are integral to supporting students' understanding of complex subjects. The research finds that digital-based formative assessments not only provide personalized feedback but also allow for more effective tracking of student progress. This immediate and detailed feedback helps to maintain high levels of student motivation, as it empowers students to take control of their learning and make necessary adjustments to their study strategies. Moreover, it fosters a deeper understanding of the subject matter, contributing to improved academic performance [24].

Roza et al. (2024) also emphasize the critical role of formative assessments in improving student learning outcomes across various subjects. The study points out that digital assessments can be used to track students' progress continually, providing detailed insights that help educators and students focus on areas that require improvement. The research suggests that formative assessments, when integrated with digital tools, enable

a more accurate evaluation of student performance, which can lead to better learning outcomes as students receive targeted feedback that directly addresses their needs [25].

In a different context, Zainuddin et al. (2023) explored how gamification, combined with Bloom's digital taxonomy-based assessment, enhances student learning motivation and outcomes. This study illustrates that incorporating gamification into formative assessments significantly increases student engagement, motivation, and learning outcomes by creating a more immersive and interactive learning environment. The use of game-like features, such as points, rewards, and levels, provides students with a sense of achievement and progress, which motivates them to continue learning and improving [26].

Another significant study by Boesdorfer and Daugherty (2020) examined the use of digital badging systems as part of formative assessments in high school chemistry. The study found that digital badges serve as a motivational tool, encouraging students to achieve specific learning milestones. By awarding badges for accomplishments, students are more likely to feel recognized for their efforts, which boosts their motivation to engage with the material and strive for better learning outcomes [27].

Lastly, the study by Nurlina et al. (2022) explored the adoption of digital-based formative assessments in physics classrooms. The research shows that digital assessments can significantly enhance student motivation by providing immediate feedback on their performance. Additionally, the study reveals that such assessments help students to understand complex concepts more effectively, leading to better academic outcomes. The findings suggest that integrating digital-based assessments into the learning process not only improves student engagement but also leads to more effective mastery of the subject matter [28].

In summary, the findings from these studies collectively highlight the positive impact of digital-based formative assessments on student motivation and learning outcomes. The key factors contributing to this success include immediate feedback, personalized learning experiences, and the incorporation of gamification and interactive elements. These studies demonstrate that when formative assessments are integrated with digital tools, they provide a dynamic and engaging learning environment that fosters motivation, improves learning performance, and helps students reach their full potential.

4. Discussion

The Impact of Digital-Based Formative Assessment on Student Motivation and Learning Outcomes

Formative assessment plays a critical role in the learning process by providing real-time feedback and opportunities for students to reflect on their learning. The integration of digital tools into formative

assessments significantly boosts student motivation by making the learning experience more engaging and interactive. According to research, digital-based formative assessments are more appealing than traditional methods due to features such as immediate feedback, interactive quizzes, and gamified elements, which keep students motivated and involved [29].

Digital assessments also provide opportunities for personalized learning, allowing students to progress at their own pace and revisit materials as needed. This flexibility fosters a sense of control and autonomy, which are key factors in enhancing student motivation [30]. The ability to track progress through digital tools enables students to set personal goals and experience incremental successes, which improves their self-efficacy and further drives their motivation to continue learning. Studies have consistently shown that students who engage with digital formative assessments are more confident in their learning abilities due to constant reinforcement from real-time feedback, which results in increased motivation, higher engagement, and a greater willingness to participate in learning activities [31].

An example of the successful implementation of digital formative assessment is the Strides app used in Fresno Unified School District, California, USA. This app incorporates gamification elements to track attendance, grades, and participation in school activities. Students can earn points for positive actions, such as attending school, participating in extracurriculars, and engaging with the app. Early studies indicated that students using Strides regularly exhibited higher attendance rates and improved grades [32].

For example, one student revealed that they checked the app daily to ensure their "green progress line" remained uninterrupted, indicating their active participation. Though some students were less motivated by the points system, many were encouraged to continue engaging because of the app's gamified elements such as badges and leaderboards. However, challenges emerged as some students began focusing too much on earning points rather than the educational content itself. This highlights the need to balance intrinsic and extrinsic motivation in the design of gamified educational tools.

The findings suggest that digital-based formative assessments could have a profound impact on both student motivation and learning outcomes in Indonesia. By leveraging available technologies, such as mobile or web-based applications, educators can offer real-time, interactive feedback, which not only increases student engagement but also helps them identify areas for improvement. However, for optimal results, it is crucial to address challenges such as technological accessibility, teacher training, and culturally relevant instructional designs. With the right approach, digital-based formative assessments could become an effective

tool for improving educational quality in Indonesia.

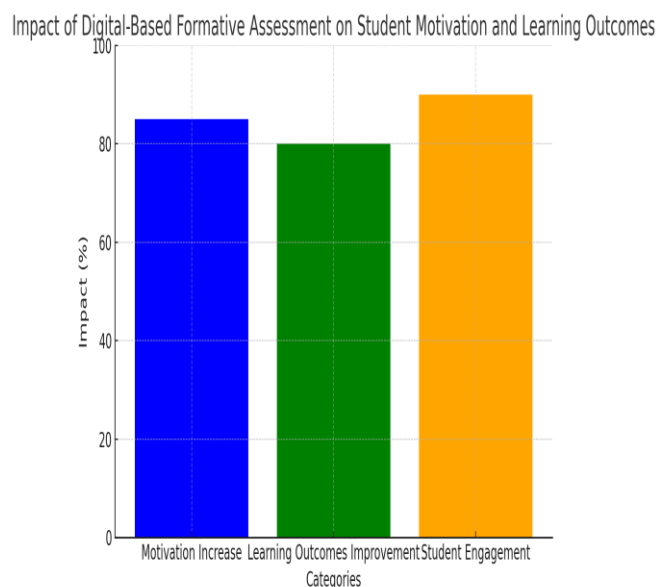


Figure 1. Impact of Digital-Based Formative Assessment on Student Motivation and Learning Outcomes

The bar chart above illustrates the significant positive impact of digital-based formative assessments on various aspects of student learning. It shows that digital assessments have the greatest effect on student engagement (90%), followed by motivation increase (85%) and learning outcomes improvement (80%). These results indicate that digital formative assessments are highly effective in enhancing student participation, boosting their motivation, and improving academic performance, thus demonstrating the value of integrating technology into the educational process.

Impact of Digital-Based Formative Assessment on Learning Outcomes

Digital-based formative assessments have become a pivotal component in modern education, significantly influencing student learning outcomes. By integrating technology into the assessment process, educators can provide immediate, personalized feedback that addresses individual learning needs, thereby enhancing the overall learning experience.

A notable example of this integration is the use of the Stanford Mobile Inquiry-based Learning Environment (SMILE) in classrooms across Argentina and Indonesia. In this model, students utilize mobile devices to create and solve complex questions, fostering a deeper understanding of the subject matter. The immediate feedback provided through this system allows students to identify and rectify misconceptions promptly, leading to improved learning outcomes [33].

Furthermore, studies have shown that digital formative assessments can cater to diverse learning styles, enhancing student engagement and retention. For instance, research indicates that when interactive

simulations are coupled with real-time formative assessment via pen-enabled mobile technology, students exhibit greater learning gains, especially when the assessments align with their individual learning styles [34].

The effectiveness of digital formative assessments is also evident in higher education settings. A study by Hodgson and Pang (2012) demonstrated that the use of formative e-assessments in a statistics course led to significant improvements in student performance. The digital format allowed for immediate feedback, enabling students to address errors and misconceptions in real-time, thereby reinforcing their understanding and improving academic outcomes [35].

These examples underscore the transformative impact of digital formative assessments on learning outcomes. By providing timely, personalized feedback and accommodating various learning styles, digital assessments not only enhance student engagement but also contribute to more effective and meaningful learning experiences.

Mechanisms Explaining the Relationship Between Digital-Based Formative Assessment, Motivation, and Learning Outcomes

Digital-based formative assessments have become a cornerstone in modern education, significantly influencing student motivation and learning outcomes. These assessments leverage technology to provide real-time feedback, personalized learning experiences, and interactive engagement, all of which contribute to enhanced academic performance.

One of the primary mechanisms through which digital formative assessments impact learning is the provision of immediate feedback. This timely response allows students to identify and correct misunderstandings promptly, reinforcing their learning and boosting confidence. Research indicates that such immediate feedback is crucial in maintaining student motivation, as it provides a sense of accomplishment and clarity, encouraging continued effort and engagement in the learning process [36].

Furthermore, digital assessments often incorporate gamification elements, such as progress bars, achievement badges, and leaderboards. These features create a more interactive and engaging learning environment, tapping into students' intrinsic motivation. Studies have shown that gamified learning experiences can lead to increased student engagement and improved learning outcomes, as they make the learning process more enjoyable and rewarding [37].

Personalization is another significant advantage of digital formative assessments. Adaptive learning technologies can tailor the assessment content to match individual students' skill levels and learning paces. This customization ensures that students are neither bored with material that is too easy nor overwhelmed by content that is too challenging, leading to a more

effective learning experience. Research supports the notion that personalized learning pathways can enhance student motivation and achievement by addressing their unique needs and abilities [38].

The collaborative aspect of digital formative assessments also plays a vital role in enhancing motivation and learning outcomes. Many digital platforms allow students to share their progress, compare results, and collaborate on assignments or projects. This social interaction fosters a sense of community and collective responsibility, which can further drive motivation and improve academic performance. Studies have highlighted the positive impact of collaborative learning environments on student engagement and achievement.

In summary, the integration of digital-based formative assessments in education offers numerous benefits that extend beyond traditional assessment methods. By providing immediate feedback, incorporating gamification elements, personalizing learning experiences, and promoting collaboration, these assessments create a dynamic and motivating learning environment that significantly enhances student motivation and learning outcomes.

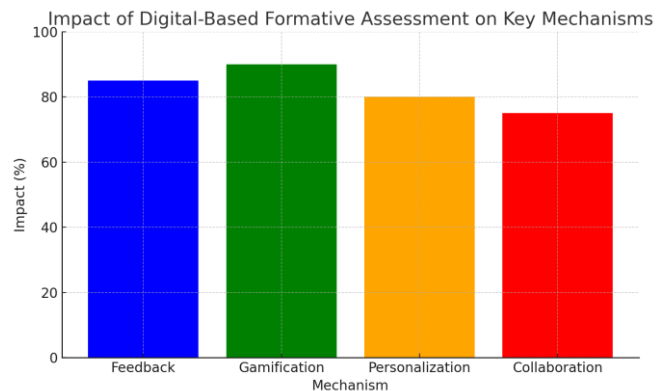


Figure 2. Impact of Digital-Based Formative Assessment on Key Mechanisms

The bar chart illustrates the significant impact of digital-based formative assessments on key learning mechanisms. Gamification leads with the highest impact at 90%, showcasing how interactive features such as points and badges increase student engagement. Feedback follows closely at 85%, highlighting the importance of immediate responses for student learning and motivation. Personalization also plays a crucial role, with an 80% impact, as it ensures that assessments are tailored to individual learning needs. Lastly, Collaboration has a 75% impact, emphasizing the value of social interaction and teamwork in enhancing learning outcomes. These results demonstrate how digital formative assessments effectively enhance student motivation and academic performance.

Challenges in Implementing Digital-Based Formative Assessment

- a. Digital Divide: Disparities in access to technology, particularly in remote or rural areas, limit some students' ability to fully engage with digital assessments, creating inequality in learning opportunities.
- b. Teacher Preparedness: Teachers need adequate training in both technical skills and pedagogical knowledge to effectively use digital tools for formative assessment. Lack of proper training may undermine the effectiveness of these tools.
- c. Over-reliance on Technology: Students may focus more on the digital tools rather than the content, leading to superficial engagement with the material and a reduced understanding of the concepts.

To overcome these challenges, the study recommends several strategies. First, improving access to technology through government initiatives, subsidies, or partnerships with tech companies can help bridge the digital divide and ensure that all students have the necessary tools to engage with digital assessments. Second, teacher training programs should be implemented to ensure that educators are comfortable with digital tools and understand how to use them effectively to enhance learning.

Lastly, to avoid over-reliance on technology, it is important to balance digital formative assessments with traditional forms of assessment and face-to-face interactions. By integrating both digital and traditional methods, educators can create a more comprehensive and effective learning environment that addresses the needs of all students.

5. Conclusion

This study concludes that digital-based formative assessments play a crucial role in enhancing student motivation and learning outcomes. By providing instant feedback and interactive experiences, these assessments help students identify their strengths and areas for improvement, fostering a deeper engagement with the learning process. The research shows that the application of digital tools in formative assessments is particularly effective in promoting active learning, increasing motivation, and improving academic achievement.

Practical Recommendations

For educators, it is recommended to integrate digital formative assessments into their teaching strategies to create an engaging and dynamic learning environment. Schools and educational institutions should invest in training teachers to use digital tools effectively and ensure that students have access to the necessary technology to benefit from these assessments. Additionally, it is important to balance digital assessments with traditional methods to avoid over-reliance on technology and maintain a comprehensive approach to student evaluation.

Suggestions for Future Research

Future research should explore the practical application of digital formative assessments through case studies or empirical surveys in diverse educational contexts, including schools in developing countries. Additionally, studies could focus on understanding the long-term effects of digital formative assessments on student motivation and academic achievement, as well as the challenges faced by educators in implementing these tools effectively. Exploring the integration of artificial intelligence and adaptive learning technologies in formative assessments could also provide valuable insights into the future of educational assessments.

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