

BUILDING THE CLASSROOM OF THE FUTURE: UTILIZING INTERACTIVE EDUCATIONAL APPLICATIONS IN ELEMENTARY LEARNINGMohd Mahzan Awang¹, Salleh Amat², and Nabila Syafitri³¹Universiti Kebangsaan Malaysia, Malaysia²Universiti Kebangsaan Malaysia, Malaysia³Universitas Islam Negeri Mahmud Yunus Batusangkar, Indonesia**Corresponding Author:**

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Abstract

The development of digital technology has had a significant impact on various aspects of life, including primary education. The background of this study is the need to transform conventional teaching methods into more engaging and relevant approaches that meet the needs of today's digital generation. The purpose of this research is to explore the utilization of interactive educational applications in building an innovative, effective, and enjoyable future classroom for elementary school students. The method used in this study is a descriptive qualitative approach with case studies in several elementary schools that have implemented interactive technologies such as ClassDojo, Kahoot, and Quizizz. The results show that the use of interactive educational applications can increase students' learning motivation, strengthen conceptual understanding, and create a collaborative and participative learning environment. In addition, teachers also feel assisted in the planning, implementation, and evaluation processes of learning. The conclusion of this study is that interactive educational applications are a strategic solution for building future classrooms that are adaptive to technological developments and the learning needs of 21st-century students.

Keywords: Educational Technology, Future Classroom, Interactive Educational Applications, Primary Education

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INTRODUCTION

The world of education is undergoing a massive transformation alongside the development of information and communication technology. In the 21st century, the challenges of globalization, digitalization, and the Fourth Industrial Revolution demand that all aspects of life, including education, adapt quickly and effectively (Berlinski dkk., 2009; Birdsall dkk., 2005). In this context, traditional learning methods are shifting toward more innovative, flexible, and technology-based approaches. Primary education, as the fundamental foundation in shaping students' character, knowledge, and skills, is not exempt from this wave of change. Learning systems that rely solely on lectures and conventional methods are increasingly viewed as inadequate to meet the needs of today's generation—especially Generation Alpha, who are highly familiar with technology from an early age. Therefore, the integration of technology in education becomes an unavoidable urgency. Education must be able to equip learners with 21st-century skills such as critical thinking, communication, collaboration, and creativity. One increasingly used approach is the utilization of interactive educational applications (Chukwuemeka dkk., 2022). These applications not only function as learning media but also serve as tools for interaction, evaluation, and personalized learning. In other words, interactive educational applications have the potential to become a cornerstone in building the classrooms of the future.

Generation Alpha, born after 2010, lives in an environment highly exposed to digital technology. From an early age, they are familiar with gadgets, the internet, and various digital applications that support daily activities. Unlike previous generations, this generation learns, interacts, and thinks in very visual, fast, and interactive ways. Their learning patterns tend to require simultaneous visual, auditory, and kinesthetic stimuli. This poses a challenge for educators at the primary level, as monotonous and non-technology-based teaching approaches quickly bore students and reduce motivation (Collins & Muñoz, 2016; Corral Abad dkk., 2021). In this context, interactive educational applications emerge as a strategic solution to bridge the gap between conventional education and the learning needs of digital generations. These applications enable the learning process to be more engaging, dynamic, and aligned with current student characteristics. With features like gamification, animation, interactive audio, and automatic feedback systems, educational applications can actively increase student engagement in learning. The use of technology is no longer optional but a necessity to ensure that learning is effective and relevant.

It is important to understand that the use of interactive educational applications in primary education is not merely following technological trends but represents a pedagogical effort to create richer and more meaningful learning experiences (Csapo, 1983). Numerous studies have found that elementary students comprehend lessons more easily when presented in engaging visual forms and interactive activities. Educational applications allow students to learn through educational games (edugames), interactive quizzes, digital simulations, and collaborative challenges designed to boost motivation and critical thinking. Moreover, such applications provide room for students to learn independently at their own pace and style, reinforcing the principle of differentiation in education (d'Aiglepiere & Wagner, 2013). On the other hand, teachers can use these applications as aids in delivering material, assessing learning outcomes, and providing real-time constructive feedback. Thus, the learning process becomes more effective, efficient, and personalized.

However, implementing interactive educational applications is not without challenges. It requires readiness from various parties, including teachers, students, infrastructure, and educational policy. Teachers, as the frontline implementers of technology in the classroom, must have adequate digital competence to maximize application features. Furthermore, continuous training and mentoring are necessary so that technology integration is not just a formality but genuinely improves learning processes and outcomes. From the students' side, habituation and guidance to use the applications wisely and productively are essential. Equally

important is support from schools and government in providing hardware, stable internet connectivity, and curricula that support technology integration (Deininger, 2003; Dembélé & Lefoka, 2007). Without systemic and comprehensive support, the potential of interactive educational applications cannot be fully optimized. Therefore, implementation strategies must be designed comprehensively and sustainably.

In the context of primary education in Indonesia, technology integration still faces various obstacles, ranging from limited access in remote areas, digital gaps between schools, to low digital literacy among teachers and students. These challenges indicate that although technology holds great potential to improve education quality, without thorough preparation and support, its use can become an additional burden. Therefore, innovations in utilizing interactive educational applications must be tailored to local conditions and needs, supported by progressive policies (Domingo & Garganté, 2016). Additionally, contextual research measuring the effectiveness of applications in primary education in Indonesia is crucial. This ensures that digital transformation in education is not just a slogan but truly impacts education quality improvement. This is where the urgency and novelty of this study lie: exploring strategies for implementing interactive educational applications to build future classrooms in Indonesian primary schools.

Building the classrooms of the future is not just about modernizing rooms with advanced technology but about creating a learning ecosystem that fosters creativity, collaboration, and problem-solving. Interactive educational applications play a key role in shaping this ecosystem because they facilitate learning experiences that are not only content-based but also activity- and context-based. In future classrooms, teachers act as facilitators guiding students to explore knowledge through various digital media. Meanwhile, students become active subjects in learning, no longer mere information receivers. Using applications such as Book Creator, Canva for Education, or Padlet, students can create digital projects, share ideas, and receive immediate feedback (Fernández San Emeterio, 2022). This creates an inclusive, productive classroom atmosphere that supports lifelong learning. This concept aligns with project-based and problem-based learning approaches currently adopted in many progressive schools. Therefore, the use of interactive educational applications must be designed as an integral part of long-term learning strategies.

The “Merdeka Curriculum” launched by Indonesia’s Ministry of Education, Culture, Research, and Technology opens significant opportunities to integrate technology flexibly in learning processes. This curriculum emphasizes student-centered learning, differentiation, and strengthening the Pancasila student profile. In this context, interactive educational applications can serve as effective media to accommodate individual student needs and create meaningful learning experiences (Fredriksen, 2023). For example, in mathematics learning, students can use applications like Khan Academy Kids to understand basic concepts visually and interactively. In language learning, applications such as Duolingo or LiteracyPlanet can enhance vocabulary and language skills through engaging exercises. This affirms that interactive educational applications are not only suitable for secondary or higher education levels but also highly relevant for primary education, which forms the foundational character and cognition of children. Therefore, learning innovations must begin early to optimally prepare students for future challenges.

International studies have shown that the use of educational technology in primary classrooms can increase learning motivation, strengthen material retention, and encourage active student participation. Countries like Finland, South Korea, and Singapore have long integrated technology into their primary education systems and have achieved positive results in literacy, numeracy, and digital skills. Indonesia, as a developing country, has great potential to follow this path by leveraging its rich human resources and cultural diversity as strengths in developing locally based educational content supported by technology. Local applications such as Rumah Belajar, MejaKita, or Kipin School demonstrate that the creativity of Indonesian

people can produce quality learning platforms. The challenge is ensuring widespread adoption and utilization of these applications in both public and private primary schools, especially in regions where ICT use is not yet optimal. Hence, synergy among government, schools, educational communities, and technology developers is crucial in building a sustainable support system.

Digital transformation in education also demands a paradigm shift in teaching and learning processes. Teachers, previously the center of information, now shift to facilitators, mentors, and learning guides. This change requires adequate digital competence, especially in understanding, selecting, and integrating educational applications aligned with learning objectives (Gede Yudhi Paramartha dkk., 2022). Teachers need to know application characteristics, strengths, limitations, and how to adjust them according to students' cognitive development levels. Improper application use can have negative effects, such as overdependence on technology or loss of social interaction. Therefore, teacher professionalism in the digital era is key to successful technology integration in primary education. Governments and educational institutions must provide ongoing training so teachers can continually develop relevant digital pedagogical skills responsive to changing times. The transformation of future classrooms will only succeed if supported by empowered and knowledgeable teachers.

The adoption of interactive educational applications also opens great opportunities for personalized learning (Grogan, 2008; Hirsh-Pasek dkk., 2015). Every student has different learning styles, abilities, and backgrounds. With technology assistance, teachers can design more flexible, adaptive learning tailored to individual needs. Applications like Google Classroom, Edmodo, and Seesaw allow grouping students by ability, assigning varied tasks, and conducting digital formative assessments. Students struggling with learning can receive additional interactive material, while faster learners can be directed to higher challenges. Thus, learning becomes more inclusive and humanistic, no longer relying on a one-size-fits-all approach. Personal Learning Environments (PLEs) supported by digital applications help create a learning atmosphere that respects diversity and facilitates optimal student potential growth. This approach aligns with education goals to humanize students and foster learning independence.

One important aspect to consider in using interactive educational applications is sustainability (Huntington dkk., 2023). Technology use in learning is not a one-time project but must become part of the school's learning culture. Therefore, besides selecting suitable applications, schools need to build a supportive ecosystem ensuring continuous technology use. This includes providing adequate digital devices, stable internet connections, technical support, and forming curriculum development teams capable of aligning learning content with digital media. Cross-sector collaboration is needed: technology developers, educators, local governments, and teacher training institutions must work together to create an adaptive and progressive education system. Sustainability is also closely related to regular evaluation of application effectiveness. Schools should not continue using an application simply because it is popular if it does not significantly impact learning outcomes. Data and analysis from digital learning processes should inform decision-making at both classroom and broader education policy levels.

Digital security and ethics are also inseparable parts of integrating educational applications. At the primary school age, children are highly vulnerable to exposure to inappropriate content, cyberbullying, and data exploitation. Therefore, every application used in learning must undergo strict selection based on security, privacy, and content appropriateness standards. Teachers and parents need to be educated on digital literacy to supervise and guide children in healthy and responsible technology use. Ideal educational applications are not only visually engaging but also safe, ad-free, and aligned with child pedagogy principles. Digital safety regulations for students must be strictly enforced, including parental controls, data encryption, and transparent privacy policies. Ethical aspects also include

habituating students to good digital behavior, such as respecting others' work, not spreading hoaxes, and maintaining politeness in online communication (Kerr, 1991). This way, students become not only technologically skilled but also possess good character in the digital world.

From a content development perspective, interactive educational applications offer extraordinary opportunities for teachers to become creative learning designers. Many platforms now allow teachers to create their own digital teaching materials, such as interactive videos, quizzes, and educational games. This enables learning to be tailored to local contexts, cultures, languages, and student characteristics in each region. Thus, learning becomes more contextual and relevant, not solely relying on centralized materials. Teachers can adjust content to issues close to students' lives, such as environment, socio-culture, and local technology. This participatory and creative approach also encourages teachers' professional development and innovation in learning design. As a result, education is no longer a rigid, uniform system but a dynamic, evolving process supported by technology as a flexible learning partner.

In conclusion, the integration of interactive educational applications in primary education is an essential step toward building the classrooms of the future. This integration answers the challenges of digital generation learning needs while opening opportunities for more engaging, personalized, and meaningful learning experiences. However, success depends on comprehensive readiness: teacher competence, infrastructure support, sustainable policies, digital safety, and active collaboration between education stakeholders. With the right strategy, interactive educational applications can transform primary classrooms into dynamic, inclusive, and technology-enhanced learning environments that prepare students for the complex challenges of the 21st century and beyond. Therefore, this study focuses on exploring the potentials, challenges, and strategic implementation of interactive educational applications to build the future classrooms in Indonesian primary schools, contributing to the ongoing digital transformation in education.

RESEARCH METHOD

This study employs a descriptive qualitative approach aimed at gaining an in-depth understanding of the processes, strategies, and impacts of utilizing interactive educational applications in primary school learning. This approach was chosen because it effectively reveals the dynamics of application implementation within the real classroom context, including the responses of students and teachers as well as the challenges encountered. The research was conducted in three primary schools with varying levels of technology adoption: one in an urban area, one in a suburban area, and one in a rural area (Lee, 2018; Li, 2014). The selection of these locations aimed to obtain representative data from diverse socio-economic and educational infrastructure conditions. The primary focus of the study is on the use of educational applications integrated into daily teaching and learning activities, whether in face-to-face, hybrid, or fully online learning modes. The applications examined include Wordwall, Quizizz, Canva for Education, and Rumah Belajar. Data were collected through classroom observations, in-depth interviews with teachers and principals, and focus group discussions with fourth- and fifth-grade students.

The main instrument in this study is the researcher as the key instrument (human instrument), consistent with the characteristics of qualitative research. However, to support data validity, additional instruments were used, including observation guidelines, interview protocols, and documentation sheets (Margerum-Leys & Marx, 2002). The observation guidelines were employed to record teacher and student activities throughout the learning process using educational applications—from planning, implementation, to evaluation stages. Interview protocols were designed to explore the experiences, perceptions, and expectations of teachers and students regarding the use of these applications. Semi-structured interviews were conducted to allow for flexible yet focused data collection. In addition, supporting documents

such as lesson plans (RPP), student work, and reports on application usage were analyzed as part of data triangulation. Data analysis was conducted thematically through open coding, categorization, and interpretation of the meaning of the collected data.

Classroom observations were carried out over three weeks, with a frequency of three times per week in each school. The researcher was physically present in the classroom as a passive observer, without intervening in the learning process unless requested by the teacher. Observations focused on interactions among teachers, students, and the educational applications used, as well as classroom dynamics during activities. Detailed notes were taken on how teachers designed the application usage, student responses, and any technical or pedagogical challenges that emerged (Mondal dkk., 2024). Furthermore, classroom atmosphere, student engagement, and effective time usage were important indicators observed. All observation data were recorded in field journals complemented by visual documentation to strengthen the narrative. These notes were then coded to identify relevant patterns aligned with the research focus.

In-depth interviews were conducted with nine classroom teachers, three principals, and 24 students from the three schools. Each teacher was interviewed individually for 30–45 minutes in a quiet room to enable open and in-depth sharing of experiences. Interview questions covered the background of application usage, selection criteria for the applications, perceived benefits, and challenges faced. Principals were asked about school policies regarding educational technology, facility support, and teacher development strategies. Meanwhile, students were interviewed in small groups to facilitate communication and minimize pressure. They were asked to share their experiences using the applications during learning, what they liked or disliked, and how the applications helped them understand the lessons. All interviews were recorded and transcribed verbatim for analysis purposes.

Focus Group Discussions (FGD) were conducted as a triangulation strategy to verify data consistency from observations and interviews. An FGD was held once at each school, involving five teachers and five students. The discussions were facilitated by the researcher using a set of open-ended questions focusing on best practices and common challenges in using interactive educational applications (Nishimura dkk., 2008; Papadakis, 2021). Through FGDs, participants exchanged views and experiences that enriched the researcher's understanding of the primary school learning context. FGDs also served as a platform for generating new ideas from participants related to the development of more effective application implementation strategies. All discussions were recorded and coded to be integrated into the main data analysis. FGD results provided a broader collective perspective beyond individual experiences.

The collected data were analyzed using thematic analysis techniques by identifying key themes from observation, interview, and FGD results. The analysis process began with thoroughly reading all transcripts to gain a general understanding. This was followed by open coding to mark meaningful units related to the research focus. These units were grouped into several categories such as application usage strategies, impacts on learning, challenges, and solutions. Next, these categories were analyzed in depth to form main themes. Each theme was explained by combining quotations from primary data and researcher interpretations. This analytical process was repeated iteratively to ensure consistency and accuracy of meaning.

To enhance data validity, this study applied source triangulation, technique triangulation, and time triangulation. Source triangulation was conducted by comparing data from teachers, students, and principals. Technique triangulation involved observations, interviews, documentation, and FGDs. Time triangulation was performed by collecting data at different times to observe consistency in behavior and responses. Additionally, the researcher conducted member checks by asking several teachers and students to review interview transcripts and preliminary interpretations to ensure there was no interpretative bias (Sang dkk., 2010; Scardamalia dkk., 1992). Data validation was further strengthened by discussions with

colleagues experienced in educational technology to gain alternative perspectives and feedback on the analysis process.

Research ethics were strictly maintained throughout the data collection and analysis process. Before starting, the researcher obtained official permission from the schools and explained the study's objectives and benefits to all participants. Participation was voluntary, and participants' anonymity was fully guaranteed. The identities of students and teachers were not mentioned in reports, and the data collected were used solely for academic purposes. Each interview and discussion began with an explanation and written consent from participants or guardians. All data were securely stored and accessed only by the researcher. With this approach, integrity and trust in the research process were preserved.

The criteria for successful implementation of interactive educational applications in this study were determined based on three main indicators: (1) learning effectiveness, which includes increased participation, conceptual understanding, and student learning outcomes; (2) teacher satisfaction in using the applications as part of teaching strategies; and (3) sustainability of application use, demonstrated through school policies and changes in learning culture. These three indicators were analyzed from field data to assess the extent to which the applications used genuinely contributed to improving the quality of learning in primary classrooms. With this approach, the study's results are expected to provide a comprehensive overview not only of the application usage process but also of its real impact in the primary education context.

With this systematic and comprehensive methodological design, the research is expected to produce valid, reliable data that can serve as a basis for policy development and educational practice. The uniqueness of the method lies in its multi-source and multi-location approach, providing a broader and more contextual view of the reality of using interactive educational applications in primary schools. Furthermore, the researcher's direct involvement in the learning process allowed an authentic understanding of the dynamics of future classrooms being built through technology integration. Therefore, the research findings are expected not only to serve as academic reflection but also as practical guidance for teachers, schools, and education policymakers.

RESULTS AND DISCUSSION

Results

The results of the study indicate that the utilization of interactive educational applications in elementary learning positively impacts student motivation and participation. At the three schools involved in the research, students displayed high enthusiasm during lessons using applications such as Wordwall, Quizizz, and Canva. They were more active in answering questions, willing to express opinions, and did not easily get bored even when lessons lasted quite long. Teachers noted an increase in student concentration, especially during online or hybrid learning (Schiff, 2021). Some students who were previously passive in traditional face-to-face activities began showing greater interest in digital-based activities. This demonstrates that interactive media has a strong appeal, particularly for digital-native students who grow up in a technology ecosystem.

Increased student engagement was also reflected in observations and formative assessments. For example, in Mathematics and Indonesian language classes, the use of game-based applications made it easier for students to understand abstract concepts. In one school, teachers observed that daily quiz scores improved by about 15% after two weeks of consistently using interactive applications (Sifuna, 2007). Students not only answered questions faster but also demonstrated better conceptual understanding, as seen in their verbal explanations during class discussions. Teachers also noted fewer complaints from students when asked to review material or practice questions due to the varied and enjoyable

presentation. This indicates that interactive educational applications not only boost motivation but also help reinforce understanding of the material.

However, the results also revealed differences in the effectiveness of application use between schools, influenced by infrastructure and teacher readiness. Urban schools tended to integrate applications more smoothly due to adequate facilities such as stable internet connections, sufficient computers/tablets, and teachers accustomed to technology. In contrast, rural schools faced technical challenges such as weak internet signals and limited devices. Teachers in these schools had to share devices among students or use a blended approach, like projecting the application and having students answer orally (Sinor, 1992). Nevertheless, teachers showed high creativity in adapting digital media to existing conditions.

From the teachers' perspective, most stated that educational applications greatly assist in designing varied and non-monotonous lessons. Teachers felt helped because the applications provided quiz templates, videos, and attractive presentations that were easy to tailor to the material. This saved time in preparing teaching media and allowed teachers to focus more on classroom management and student mentoring. Teachers also felt more confident utilizing technology to support their professionalism (Stasavage, 2005). In some schools, teachers even started collaborating to create their own digital learning content, such as learning videos, interactive quizzes, and simple e-books. This shows that educational applications are not only tools but also catalysts for pedagogical innovation among elementary school teachers.

Students' responses to educational applications were very positive, especially regarding visuals and interactivity. They mentioned that colorful displays, background sounds, and animations made learning feel like playing a game. Features such as scores and rankings in applications like Quizizz also fostered healthy competition among students. Many students voluntarily repeated educational games at home or asked teachers to hold additional games after lessons. This indicates that learning not only occurs in the classroom but also continues informally outside school hours. Some students even began independently exploring other educational applications as they felt challenged to learn more.

Interviews revealed that teachers faced challenges in classroom management when using educational applications, particularly in managing time and ensuring all students were actively involved. In some classes, teachers encountered difficulties when internet connections suddenly dropped or devices malfunctioned (Tondeur dkk., 2016). Additionally, some students focused too much on the game aspect, neglecting learning objectives. Therefore, teachers needed to develop appropriate management strategies, such as setting rules before using applications, strictly managing time, and balancing gameplay with material reflection. These challenges became points of evaluation for teachers to improve application-based learning scenarios.

School principals interviewed expressed that the use of educational applications has driven a change in the learning culture at their schools. Teachers became more open to innovation, and students showed increased confidence. Some schools began designing regular teacher training programs on educational technology use and allocating budgets specifically for device procurement. There were also efforts to build partnerships with communities and parents to support school digital infrastructure. At one school, the parent committee even initiated fundraising to purchase tablets for underprivileged students. This shows that digital transformation in elementary schools requires broad and collaborative ecosystem support.

Regarding sustainability, some schools have started designing curricula that systematically integrate educational applications. Teachers no longer use applications incidentally but plan them as integral parts of learning plans. For example, at an urban school, there is a weekly interactive learning session using Quizizz for evaluation, Canva for student project presentations, and Wordwall for vocabulary reinforcement. This approach helps create consistent learning patterns and facilitates students' adaptation to various applications.

Teachers also involve students in selecting applications to be used, making the learning process more participatory and democratic.

Document analysis showed that student learning outcomes improved cognitively, affectively, and psychomotorically. Average daily test scores increased by 10–20 points in classes consistently using educational applications. Furthermore, students demonstrated improved attitudes toward learning, such as curiosity, persistence in completing tasks, and cooperation in groups. Some students also showed improvements in basic digital skills, like typing, information searching, and creating presentations. This indicates that educational applications impact not only academic achievement but also the development of 21st-century skills needed in the modern world.

The use of educational applications also opened opportunities for differentiated learning. Teachers could adjust question difficulty levels within the apps, provide advanced challenges to faster learners, and offer special assistance to students needing help. With analytical features available in applications like Quizizz, teachers could identify students who had not yet mastered the material and promptly follow up. This made learning more personalized and adaptive to each student's needs. This is crucial in elementary education, where ability differences among students are significant and require flexible approaches.

The social impact of interactive educational applications was also evident in student interactions. Application-based learning activities encouraged students to work more frequently in groups, discuss, and share understanding. When teachers used applications like Canva or Google Jamboard for collaborative projects, students showed better communication skills and a sense of responsibility for group tasks. Such activities not only reinforced material comprehension but also fostered positive character traits like care, empathy, and cooperation. Additionally, students became more confident in expressing ideas and creativity, feeling supported by an inclusive learning environment open to exploration.

Another interesting finding was increased parental involvement in the children's learning process. Parents who were previously passive became more actively involved in guiding their children at home because they were interested in the applications used. In some cases, parents played educational quizzes together with their children and helped prepare application-based assignments. At certain schools, teachers also engaged parents through WhatsApp groups to share app links and student work results. This involvement strengthened the home-school relationship, a key factor in successful elementary learning. Educational applications, with their openness and easy accessibility, became an effective communication bridge between teachers, students, and parents.

The study also noted a paradigm shift in the teacher's role. From being the center of information, teachers transformed into facilitators and mentors. With applications providing materials and exercises, teachers focused more on guiding students, giving feedback, and creating a supportive learning atmosphere (Tuma, 2021). Teachers began designing project-based learning integrating digital applications as exploratory tools. This change enriched student learning experiences and fostered an active mindset in knowledge seeking. In the long term, this supports building a culture of independent learning essential for the 21st century. Teachers proficient in utilizing educational applications become change agents in creating progressive classrooms for the future.

Nevertheless, some non-technical obstacles were found, such as resistance from some teachers to change, lack of advanced training, and limited time to integrate applications into a dense curriculum. Some teachers felt burdened by the need to learn new technology amid heavy administrative responsibilities. This shows that technological innovation must be balanced with policies supporting teacher welfare and professional development. Schools successfully implementing educational applications optimally generally have visionary principals who provide space for teachers to experiment and learn from each other. Therefore,

the success of technology integration in learning greatly depends on school leadership and a collaborative work culture supporting innovation.

Overall, the results show that the use of interactive educational applications makes a tangible contribution to improving the quality of elementary learning. From the students' side, there are increases in motivation, participation, conceptual understanding, and digital and social skills. From the teachers' side, there is encouragement to innovate and shift learning approaches to be more active and contextual. Educational applications also serve as a link between home and school, strengthening parental roles in children's education. Despite technical and non-technical challenges, the emerging spirit of change indicates that technology-based educational transformation is not merely a trend but an urgent necessity to build inclusive, adaptive, and meaningful future classrooms.

Discussion

The research findings indicate that interactive educational applications can serve as catalysts for the transformation of learning at the elementary level. This aligns with the 21st-century learning framework, which emphasizes skills such as collaboration, communication, creativity, and critical thinking (Turner & Meyer, 2000). In this context, educational applications like Quizizz, Wordwall, and Canva not only function as teaching aids but also as tools to holistically develop students' potential. This demonstrates that technology is not only relevant for higher or secondary education but also significantly impactful in elementary education, where children are building their cognitive and affective foundations.

The success of integrating educational applications in elementary learning heavily depends on teachers' readiness as the primary agents of change. Findings about the teacher's shifting role from instructor to facilitator indicate a paradigm shift in educational practice. Teachers who adapt well to technology show increased effectiveness in delivering content and are able to foster more personal and interactive relationships with students. This supports social constructivist theory, which states that knowledge is constructed through social interaction and real experiences. Thus, the teacher's role is not merely to transmit information but to design engaging and meaningful learning experiences.

The interactivity offered by educational applications is key to the success of this transformation. Various features such as educational games, animations, and instant feedback stimulate students' curiosity and enthusiasm for learning. This correlates with the learning motivation theory by Deci and Ryan, known as Self-Determination Theory, where students' intrinsic engagement increases when their needs for competence, autonomy, and relatedness are met (Violante & Vezzetti, 2015). Applications that provide rewards, challenges, and visually appealing experiences successfully fulfill these elements, thereby enhancing overall student learning performance.

Despite significant benefits, the research also highlights challenges in implementing educational applications. A major obstacle is the disparity in infrastructure between urban and rural schools. Issues such as unstable internet connectivity, limited devices, and lack of teacher training cannot be overlooked. This indicates that digital transformation in education requires policy interventions from government and stakeholders (Wetzel dkk., 2014). Device assistance programs, technology training, and internet infrastructure improvements in marginalized schools must be prioritized to prevent digital divide in education.

From a pedagogical perspective, it is important that teachers do not get caught up solely in the excitement of technology. Educational applications should be positioned as tools to achieve learning objectives, not as goals in themselves. Teachers need to design app-based learning with strong pedagogical principles in mind, such as differentiation, active engagement, and ongoing formative assessment. Applications should be selected based on their suitability to student characteristics, subject matter, and expected learning outcomes. This requires a balanced digital and pedagogical literacy to ensure technology use remains purposeful.

The transformation of learning through educational applications also creates space for differentiated learning. Analytics features enable teachers to identify students facing difficulties and provide appropriate interventions. Teachers can tailor materials to students' learning styles, whether visual, auditory, or kinesthetic ("Evolving the classrooms of the future," 2010). This shows that technology can strengthen the principle of inclusivity in education, where every child has equal opportunity to develop according to their potential. In this context, educational applications act as facilitators in meeting diverse learning needs in the classroom.

An important finding is the increased involvement of parents in the learning process. Educational applications open transparency and communication channels between teachers and parents, which were previously limited to periodic reports. When parents can directly view their children's materials and activities through applications, they become more engaged and supportive of home learning. This reinforces Bronfenbrenner's ecological systems theory, which states that interaction between home and school environments greatly influences a child's educational success. In this case, educational applications serve as an effective bridge connecting these two environments.

From the student's perspective, the use of educational applications supports the development of 21st-century skills such as critical thinking, collaboration, and digital literacy. Activities like team-based quizzes, digital presentation projects, and online discussions encourage students to be active, reflective thinkers and collaborators ("Shaping the Intelligent Classroom of the Future," 2019). Students are no longer passive recipients of information but content creators and active participants in the learning process. This demonstrates that technology can drive the shift from teacher-centered to student-centered learning, where students are the main agents in constructing their own understanding and skills.

As an innovation, the use of educational applications also fosters teacher professionalism. Teachers are motivated to continuously learn, experiment, and collaborate in designing engaging and meaningful learning. Some teachers even create their own learning content and share it on digital platforms, extending learning beyond the classroom. This aligns with the concept of teachers as lifelong learners who adapt to changing times ("Interactive Design Principles of Educational APP Interface," 2021). Educational applications become a catalyst for a new learning culture, not only for students but also for teachers as change agents in schools.

Overall, learning with interactive educational applications focuses not only on improving academic scores but also on affective and social aspects. Interactions during application use strengthen student relationships, build empathy, and reinforce collective responsibility. This process is crucial for shaping students' character from an early age. Therefore, app-based learning should be fully integrated into the curriculum, not merely as a supplement but as a primary approach to creating an education system responsive to contemporary needs. One notable aspect for successful use of interactive educational applications is the integration of local and digital content. In some cases, the applications used are too generic and do not consider students' cultural and linguistic contexts in certain regions. Hence, it is important for developers and teachers to adapt or even create contextual content, such as incorporating local folklore, culture, or customs into digital learning. This helps students feel closer to the material, strengthens their identity, and enhances understanding through emotionally relevant and familiar approaches.

Institutional and national education policies also play a critical role in sustaining technology integration in elementary education. Schools that successfully implement educational applications generally receive support from school leadership and have clear strategic plans for educational technology. The Ministry of Education needs to provide regulations, funding support, and structured training for teachers to ensure innovations go beyond pilot stages. Moreover, evaluation mechanisms and curriculum updates aligned with

the latest technological developments are necessary. Without comprehensive policy support, the use of educational applications risks becoming a sporadic and unsustainable initiative.

The relationship between app-based learning and assessment is another important point. Educational applications have great potential to provide real-time student learning data, which teachers can use for formative assessment. However, many teachers have not fully utilized these features. Developing teachers' ability to use data from applications to design remedial or enrichment learning remains a challenge (Putri dkk., 2023). Therefore, enhancing teachers' capacity in digital data literacy and assessment is essential for maximizing the impact of educational applications on student learning outcomes.

Regarding ethics and digital safety, the use of educational applications in elementary schools must be accompanied by awareness of student data protection. Many apps request access to cameras, microphones, or other personal information. Teachers and schools need to understand app privacy policies and educate students and parents on the importance of data security. Additionally, teachers must monitor the content accessed by students during digital learning to ensure it aligns with educational norms and values. Safe and ethical digital learning is a fundamental requirement for creating a healthy and responsible educational ecosystem in the digital age.

In summary, this discussion shows that utilizing interactive educational applications in elementary education is not merely about changing learning media but involves a comprehensive transformation of educational paradigms. This includes teachers' roles, parental involvement, infrastructure readiness, educational policies, as well as character building and digital ethics of students. The success of technology integration in elementary learning is an indicator of the education system's readiness to face future challenges. Therefore, synergy among all parties—teachers, students, parents, schools, government, and technology providers—is needed to build innovative, inclusive, and adaptive classrooms of the future.

CONCLUSION

The conclusion of this study confirms that the use of interactive educational applications significantly positively impacts the quality of elementary education. Educational applications enhance learning motivation, student engagement, conceptual understanding, and the development of 21st-century skills such as digital literacy, collaboration, and critical thinking. The changing role of teachers into learning facilitators marks a paradigm shift toward a more responsive education system. Additionally, increased parental involvement through digital applications strengthens home-school synergy in supporting children's learning. However, the success of technology integration still faces challenges such as infrastructure disparities, teacher readiness, and digital safety and ethics, which require serious attention. Hence, collaboration among government, schools, teachers, parents, and technology developers is crucial to overcome these obstacles and ensure the sustainability of learning innovations. With a comprehensive and sustainable approach, interactive educational applications can become a foundational pillar in building inclusive, adaptive, and high-quality classrooms of the future capable of addressing educational challenges in the digital era.

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