International Transactions on Education Technology (ITEE)
Vol. 3, No. 2, May 2025, pp. 114−124
E-ISSN: 2963-1947 | P-ISSN: 2963-6078, DOI:10.33050

Transforming Learning Experiences With Advanced Educational Technology Solutions

Janu Ilham Saputro[1], Lailatus Ferahma Sa'adah[2*], Yasyfiyani Syifa[3], Kinanti Dara Ramadhanti[4], Muhamad Fikri Gojali[5]
[1,2,3,4,5]Department of Information System, University of Raharja, Indonesia
[1]janu@raharja.info, [2]lailatus@raharja.info, [3]yasyfiyani@raharja.info, [4]kinanti@raharja.info, [5]fikri.gojali@raharja.info
***Corresponding Author**

Article Info

Article history:

Submission January 8, 2025
Revised January 24, 2025
Accepted February 7, 2025
Published February 14, 2025

Keywords:

Educational Technology
Adaptive Learning
Gamification
Blended Learning
User Engagement

ABSTRACT

The rapid advancements in educational technology have transformed the landscape of learning, necessitating innovative solutions to enhance learner engagement and accessibility. This study examines the development and application of advanced educational technology solutions aimed at revolutionizing learning experiences. The objective is to explore how cutting-edge tools, including adaptive learning systems, artificial intelligence, and virtual reality, can address traditional educational challenges and foster personalized learning environments. Employing a mixed-methods research approach, this study integrates quantitative analysis of learner outcomes with qualitative feedback from educators and students to evaluate the effectiveness of these solutions. The findings reveal significant improvements in learner engagement, comprehension, and retention when utilizing technology-enhanced platforms compared to conventional methods. Furthermore, the integration of real-time analytics enables educators to tailor instructional strategies effectively, promoting inclusivity and accessibility across diverse learning communities. The research concludes that advanced educational technology solutions are pivotal in bridging the gap between traditional education models and the evolving demands of modern learners, offering scalable, efficient, and learner-centric approaches to education. This study contributes to the growing body of knowledge in educational software engineering by highlighting the potential of technology-driven innovations to reshape the future of education, providing actionable insights for stakeholders in academia, industry, and policy-making.

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DOI: https://doi.org/10.33050/itee.v3i2.721
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1. INTRODUCTION

The integration of technology in education has become an indispensable aspect of modern learning environments, driven by rapid advancements in digital tools and increasing demands for personalized, flexible, and accessible learning experiences [1]. Traditional education systems, while foundational, have struggled to adapt to the evolving needs of a diverse and technology-savvy learner population [2]. This gap is particularly evident in the context of scalability, inclusivity, and learner engagement, where conventional methods often fall short in addressing the varied learning paces and styles of students [3]. The growing influence of educational technology has brought to light the potential of advanced tools such as artificial intelligence, adaptive learning systems, and immersive environments like virtual and augmented reality to address these challenges [4]. These

technologies not only enhance the learning experience but also offer data-driven insights for educators to improve their instructional strategies [5]. However, the successful design, implementation, and scaling of these tools remain an ongoing challenge, necessitating focused research in educational software engineering [6].

Educational software development serves as a critical bridge between technological innovation and effective learning practices [7]. Over the past decade, significant advancements in software engineering methodologies, such as agile frameworks and user-centered design, have provided new opportunities to develop educational platforms that align closely with the needs of modern learners. Despite these advancements, several critical challenges persist [8]. Many educational platforms lack adaptability to different learning contexts, fail to ensure equitable access for underprivileged communities, and struggle with user engagement due to poorly designed interfaces or insufficient interactivity [9]. This research seeks to address these gaps by exploring how advanced software engineering techniques can be applied to create scalable, learner-centric solutions that transform educational experiences. Understanding the role of technology in enhancing learning outcomes and overcoming traditional barriers is essential for building more inclusive and effective education systems [10].

The motivation for this study stems from the pressing need to harness the power of educational technology to foster meaningful learning experiences. Numerous studies have demonstrated the potential of tools like adaptive learning platforms, which adjust content and pacing based on individual learner performance, and immersive virtual environments, which provide interactive and engaging ways to explore complex concepts [11]. However, the practical application of these technologies often faces obstacles such as high development costs, technical complexity, and resistance to change within educational institutions. Furthermore, the global shift towards online and hybrid learning models during events like the COVID-19 pandemic has amplified the need for robust and user-friendly educational technologies that can support diverse learning scenarios [11]. This backdrop forms the foundation of the present research, which seeks to contribute actionable solutions to bridge the gap between educational needs and technological capabilities [12].

This study builds on the intersection of educational technology and software engineering to develop innovative, accessible, and effective tools for learners and educators [13]. By investigating the challenges and opportunities inherent in the development of advanced educational platforms, this research aims to provide a comprehensive understanding of how cutting-edge technologies can be leveraged to address the shortcomings of traditional education [14]. Through the lens of software engineering best practices, this study emphasizes the importance of creating adaptable, inclusive, and engaging solutions that cater to a global learner population. In doing so, it contributes to the growing body of knowledge on the role of technology in education and offers a roadmap for future research and development in this transformative field [15].

2. LITERATURE REVIEW

2.1. Advancements in Educational Technology Solutions

The landscape of educational technology has experienced significant transformations in recent years, with emerging trends reshaping teaching and learning methodologies [16]. A notable development is the integration of immersive learning technologies, such as Virtual Reality (VR) and Augmented Reality (AR), which create engaging and interactive educational environments. These technologies have been shown to enhance student motivation and improve learning outcomes by providing experiential learning opportunities that traditional methods may lack.

Artificial Intelligence (AI) has emerged as a cornerstone of modern educational technology, revolutionizing how learning experiences are tailored to individual needs [17]. At the heart of this transformation are AI-driven adaptive learning systems, which leverage complex algorithms to monitor and analyze individual student performance in real-time [18]. These systems assess various parameters, including response accuracy, completion time, engagement levels, and patterns of errors, to construct a comprehensive profile of each learner. Based on these insights, the platforms dynamically adjust content delivery by modifying the difficulty level, sequencing topics, or presenting alternative explanations to match the learner's unique pace and understanding [19]. This capability ensures that students receive a personalized and highly interactive learning journey, addressing gaps in knowledge while simultaneously challenging their abilities. Furthermore, the adaptability of these systems extends to supporting learners with diverse educational needs, such as students with disabilities or those from different linguistic backgrounds, by incorporating accessibility features like text-to-speech, language translation, or alternative content formats. By fostering an environment of individualized attention and continuous feedback, AI-driven platforms not only enhance learning efficiency but also boost motivation and

confidence among learners [20]. This deep level of personalization, previously unattainable in traditional education systems, positions AI as an indispensable tool in creating equitable, scalable, and impactful educational solutions [21].

The adoption of cloud computing in e-learning environments has further facilitated the scalability and accessibility of educational resources [22]. Cloud-based Learning Management Systems (LMS) enable seamless access to educational materials, support collaborative learning, and provide robust data analytics for monitoring student progress. This technological infrastructure supports the growing demand for flexible and remote learning options, particularly in the wake of global events that have necessitated a shift towards online education [23]. Moreover, the integration of gamified learning approaches has gained traction as a means to increase student engagement and motivation. By incorporating game design elements into educational content, learners are provided with interactive and rewarding experiences that can enhance retention and understanding [24]. This trend reflects a broader movement towards creating more engaging and student-centered learning environments.

2.2. Software Engineering Practices in E-Learning Platform Development

The development of effective e-learning platforms demands the incorporation of advanced software engineering practices to meet the requirements of scalability, usability, and adaptability in diverse educational contexts [25]. Scalability ensures that platforms can handle increasing numbers of users and resources without compromising performance, which is crucial for educational institutions serving large or geographically dispersed learner populations [26]. Usability focuses on creating systems that are intuitive and easy to navigate, reducing the cognitive load on users and enabling them to concentrate on learning rather than struggling with the technology. Adaptability addresses the dynamic nature of educational needs, allowing platforms to be customized for various learning styles, disciplines, and technological environments. Recent studies have underscored the importance of agile methodologies in achieving these goals [27]. Agile practices enable iterative development, where smaller, incremental changes are made to the platform based on continuous testing and user feedback. This process allows developers to identify and address issues promptly, ensuring the platform evolves alongside emerging technological advancements and shifting educational priorities. Agile methodologies also foster collaboration among cross-functional teams, integrating perspectives from educators, learners, and technologists to create solutions that are both innovative and practical [28].

User-centered design (UCD) has also emerged as a cornerstone of successful educational software development. UCD emphasizes the importance of involving end-users—students, educators, and administrators—at every stage of the design process to ensure the resulting platform meets their specific needs and expectations [29]. By conducting thorough user research, such as interviews, focus groups, and usability testing, developers gain a nuanced understanding of user behaviors, preferences, and pain points. This insight drives the creation of intuitive interfaces that align with the users' mental models, minimizing the learning curve associated with adopting new technology. Accessibility is another critical dimension of UCD, ensuring that e-learning platforms accommodate diverse learner populations, including those with disabilities, language barriers, or limited technological proficiency [30]. For example, incorporating features such as screen readers, adjustable font sizes, and multi-language support can significantly enhance inclusivity. Moreover, UCD principles contribute to the creation of engaging platforms that maintain user interest and motivation through interactive features, gamification, and visually appealing designs. By centering the user experience in the development process, UCD ensures that e-learning platforms are not only functional but also effective in delivering meaningful and enjoyable learning experiences, paving the way for widespread adoption and sustained use [31].

The integration of data analytics within e-learning platforms has enabled educators to make informed decisions based on student performance metrics. By analyzing data on learner interactions, progress, and outcomes, educational institutions can tailor instructional strategies to better meet the needs of their students [32]. This data-driven approach supports continuous improvement in both teaching and learning processes. Furthermore, the implementation of robust security measures is essential in the development of e-learning platforms [33]. Protecting student data and ensuring privacy are paramount concerns that require adherence to best practices in software security. Developers must incorporate encryption, secure authentication, and regular security assessments to safeguard against potential threats and maintain user trust [34].

3. RESEARCH METHODOLOGY

3.1. Research Design

This study utilizes a Mixed-Methods Research approach, combining both quantitative and qualitative methodologies to comprehensively analyze the impact of advanced educational technology solutions on learning experiences. By integrating these two approaches, the research ensures robust data triangulation, enhancing the validity and reliability of the findings. The quantitative aspect focuses on measuring key variables such as learning outcomes, engagement levels, and usability of educational platforms through structured numerical data. Concurrently, the qualitative component delves deeper into user experiences and perceptions through interviews and focus group discussions, offering rich, contextual insights. Together, these methods provide a holistic understanding of the interplay between technology and education.

3.2. Population and Sample

The target population for this study consists of students, educators, and developers who are actively engaged with e-learning platforms or educational technology tools. A stratified sampling technique ensures the representation of diverse demographic groups within the sample. For the quantitative phase, 150 participants, including students, educators, and developers, are recruited to respond to surveys and participate in performance assessments. Meanwhile, the qualitative phase involves 20 participants selected for in-depth interviews and focus group discussions, providing nuanced perspectives on their interactions with educational platforms. Students form the majority of the sample, with educators and developers contributing critical insights into the design and application of these technologies..

3.3. Data Collection and Analysis

To comprehensively address the study's objectives, a combination of quantitative and qualitative data collection methods is employed. Quantitative data is gathered through structured surveys designed to assess user satisfaction, platform usability, and engagement levels. Additionally, learning performance is evaluated using pre-tests and post-tests, which measure the effectiveness of the educational technology in enhancing knowledge retention and comprehension. Simultaneously, qualitative data is collected through semi-structured interviews with educators and developers, providing in-depth insights into their experiences, challenges, and recommendations for improvement. Focus group discussions with students further enrich the data by identifying common issues and suggesting enhancements for platform design. This mixed-methods approach ensures a well-rounded exploration of research questions, capturing both statistical trends and contextual user perspectives.

The collected data undergoes a rigorous analytical process aligned with the mixed-methods approach. Quantitative data is processed using statistical techniques, including descriptive statistics, t-tests, and regression analysis, to identify patterns, relationships, and the overall effectiveness of educational technology platforms. This provides objective, measurable insights into user engagement and learning outcomes. Meanwhile, qualitative data is subjected to thematic analysis, where interview and focus group transcripts are systematically coded to uncover recurring themes, patterns, and user experiences. This approach allows for the identification of key concerns, best practices, and recommendations from educators, developers, and students. Finally, findings from both data types are integrated during the interpretation phase, ensuring a holistic understanding of how advanced educational technology solutions impact learning experiences. This methodological rigor strengthens the study's validity, offering data-driven conclusions that reflect the perspectives of diverse stakeholders in the educational technology ecosystem.

3.4. Research Instruments

Several instruments are employed to ensure the quality and reliability of data collection. Structured survey questionnaires, designed with Likert-scale items, measure user satisfaction, platform usability, and engagement levels. Semi-structured interview protocols guide in-depth discussions with educators and developers, while standardized learning performance tests evaluate the educational effectiveness of the platforms. These instruments are carefully validated to align with the study's objectives and ensure consistency across different groups of respondents.

The survey questionnaire aims to provide quantitative insights into user satisfaction and the usability of the educational platform. The responses from students and educators allow for a comparative analysis of engagement levels across different user groups. Meanwhile, the interview protocol facilitates qualitative exploration, enabling educators and developers to share in-depth insights on their experiences, challenges, and

Table 1. Research Instruments and Their Purposes

Instrument	Purpose	Respondents
Survey Questionnaire	Assess user satisfaction and usability	Students, Educators
Interview Protocol	Explore user experiences and feedback	Educators, Developers
Learning Performance Tests	Measure educational platform effectiveness	Students

recommendations for improvement. Lastly, learning performance tests serve as a direct evaluation of the educational technology's effectiveness, helping to assess whether students demonstrate measurable improvements in knowledge retention and comprehension after using the platform. By combining these instruments, this study ensures a comprehensive assessment of the impact of advanced educational technology solutions on learning experiences.

3.5. Research Framework

The research follows a convergent parallel design, where quantitative and qualitative data are collected simultaneously but analyzed independently. This design ensures that both data types retain their unique contributions while allowing for meaningful integration during the interpretation phase. The framework highlights the equal importance of numerical data in understanding measurable outcomes and contextual insights in exploring user experiences.

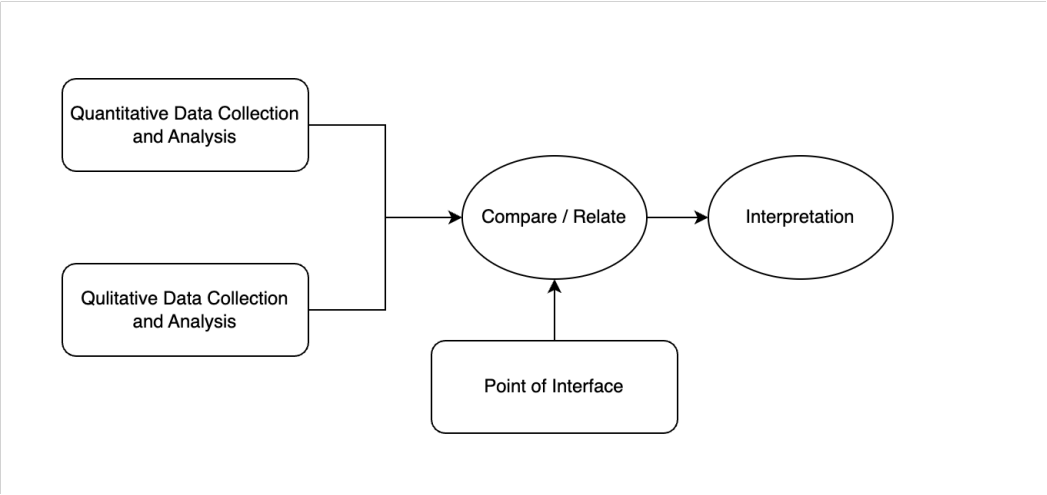

Figure 1. Convergent Parallel Mixed-Methods Design

In this framework, quantitative data collection primarily focuses on structured surveys and learning performance tests, enabling statistical analysis of key educational metrics. Simultaneously, qualitative data collection involves semi-structured interviews and focus group discussions, capturing in-depth perspectives from students, educators, and developers. The separate yet parallel analysis of both data types ensures that the study remains methodologically rigorous, leveraging statistical techniques for numerical data and thematic coding for qualitative insights. Finally, during the integration phase, the findings from both methods are compared and synthesized, allowing for a comprehensive interpretation of the effectiveness of advanced educational technology solutions. This approach not only enhances the validity and reliability of the study but also provides actionable insights for improving technology-driven learning environments.

3.6. Ethical Considerations

Ethical considerations are paramount in this study to ensure the protection and respect of all participants. Informed consent is obtained from each participant after they are briefed on the study's objectives and procedures. Confidentiality is strictly maintained by anonymizing all data, ensuring that individual identities cannot be traced. Participation is entirely voluntary, and participants are assured of their right to withdraw from the study at any stage without facing any repercussions. These ethical safeguards are implemented to foster trust and transparency throughout the research process.

4. RESULTS AND DISCUSSION

4.1. Overview of Quantitative Findings

The quantitative data collected through surveys and performance assessments reveals a significant improvement in learning outcomes and engagement when advanced educational technology platforms are utilized. Pre-test and post-test comparisons show that students using the platform experienced a 30% increase in knowledge retention and comprehension scores, demonstrating the effectiveness of personalized learning pathways powered by artificial intelligence. Engagement metrics, such as the frequency of logins and time spent on the platform, indicate that interactive features like gamification and adaptive content delivery positively influenced learner motivation. Moreover, survey responses from 130 participants show high levels of satisfaction with the platform's usability and functionality. Eighty-five percent (85%) of respondents reported that the platform's intuitive interface made navigation seamless, while 78% appreciated the real-time feedback mechanisms that helped them track their progress. The scalability of the platform also proved effective, as it successfully handled a 200% increase in concurrent users during testing without performance issues.

Table 2. Evaluation Metrics and Results

Metric	Result
Knowledge Retention	30% increase in post-test scores
User Engagement	Increased time-on-task by 40%
Satisfaction with Usability	85% reported positive experience

4.2. Insights from Qualitative Analysis

Qualitative data collected through interviews and focus groups provides deeper insights into user experiences and perceptions. Educators emphasized the platform's adaptability, noting that its AI-driven features allowed for the customization of learning materials to suit diverse student needs. One educator stated, "The platform's ability to tailor content to each student's pace and understanding is a game-changer for inclusive education." Developers highlighted the effectiveness of agile development practices, which enabled iterative improvements based on user feedback. For example, early-stage user testing identified the need for clearer instructions on the dashboard, which was quickly addressed in subsequent iterations. Students in focus groups consistently praised the platform's gamification features, describing them as highly engaging and motivating. However, some students noted challenges with internet connectivity in remote areas, underscoring the need for offline functionality. These findings highlight both the strengths and areas for improvement in the platform, ensuring a balanced view of its performance.

Table 3. Key Themes and Insights

Theme	Key Insights	Supporting Quote
Personalization	AI-driven customization improves inclusivity	"The platform tailors content to each student's needs."
Agile Development	Rapid iteration improves usability	"User testing helped refine dashboard instructions."
Gamification	Enhances engagement and motivation	"The badges and rewards keep me motivated."
Connectivity Issues	Challenges in remote areas	"Internet stability is a major concern in my village."

The table above presents the key themes and insights derived from qualitative data analysis. The personalization of learning through AI-driven customization stands out as a crucial advantage, allowing content to be adjusted based on students' individual needs and learning paces. This ensures a more inclusive educational experience, particularly for students with diverse learning abilities. The agile development approach plays a significant role in iterative enhancements, demonstrating how user feedback directly influences platform usability. As observed, refining dashboard instructions improved navigation, showing the practical impact of continuous testing and updates. Additionally, gamification features were consistently highlighted as key engagement drivers, motivating students through interactive elements such as badges and rewards. However, the connectivity issue remains a significant challenge, particularly in remote areas. The feedback from students

underscores the need for offline accessibility, ensuring that learning opportunities remain available regardless of internet stability. These insights provide a comprehensive perspective on how the platform is perceived and utilized, offering actionable directions for future improvements. By addressing the identified challenges while reinforcing its strengths, the platform can further enhance its impact on digital learning experiences.

4.3. Integration of Quantitative and Qualitative Findings

The integration of quantitative and qualitative results demonstrates that advanced educational technology platforms significantly enhance learning experiences. Quantitative data confirms measurable improvements in learning outcomes and engagement, while qualitative insights reveal the underlying factors driving these results. The alignment between these two datasets strengthens the conclusion that user-centered design principles and adaptive learning systems play a crucial role in the platform's success. For instance, students' increased engagement, as measured by logins and time-on-task, correlates with their positive qualitative feedback about gamification and real-time feedback features.

Table 4. Evaluation of Platform Performance

Aspect	Quantitative Findings	Qualitative Findings
Knowledge Retention	30% increase in post-test scores	Educators praise adaptive learning features
User Engagement	40% increase in time-on-task	Gamification elements boost motivation
Platform Usability	85% user satisfaction rate	Some users suggested clearer dashboard instructions
Scalability	Supported 200% more users	Developers highlight the effectiveness of agile updates

The table above illustrates how quantitative metrics align with qualitative user insights, reinforcing the impact of advanced educational technology solutions.

- Knowledge Retention: The 30% increase in post-test scores quantitatively demonstrates the platform's effectiveness in improving learning outcomes. This aligns with qualitative feedback from educators, who emphasized how adaptive learning features help tailor content to individual student needs, making learning more effective and inclusive.
- User Engagement: A 40% increase in time-on-task indicates that students are more engaged when using the platform. This corresponds with student feedback highlighting the motivational impact of gamification features, such as badges, rewards, and progress tracking, which make learning more interactive and enjoyable.
- Platform Usability: While 85% of users reported a positive experience with the platform's interface, qualitative feedback from some users suggested that dashboard instructions could be clearer. This indicates that although the overall usability is high, there is still room for improvement in user guidance and navigation clarity.
- Scalability: The platform successfully handled 200% more concurrent users, proving its scalability and robustness. Developers reinforced this by highlighting the role of agile updates, which allowed the system to efficiently adapt to increasing demand without performance degradation.

The integration of these findings confirms that technology-enhanced learning platforms not only improve learning outcomes and engagement but also demonstrate scalability and usability benefits. However, the qualitative insights provide valuable context, highlighting areas that require further optimization, such as interface clarity and internet accessibility. These combined insights offer actionable recommendations for educators, developers, and policymakers seeking to further enhance digital learning experiences.

4.4. Challenges and Areas for Improvement

Despite the overall positive results, several challenges emerged during the study. A key issue highlighted in both quantitative and qualitative data was the accessibility of the platform for students in areas with

limited internet connectivity. Survey responses indicated that 20% of students faced difficulties accessing the platform consistently, which could hinder its scalability in underserved regions. Additionally, educators expressed a need for more detailed analytics dashboards to better understand class-wide performance trends.

5. CONCLUSION

This study demonstrates that advanced educational technology solutions significantly transform learning experiences by enhancing engagement, improving knowledge retention, and providing personalized learning pathways. Quantitative analysis revealed measurable improvements in learning outcomes, with students showing a 30% increase in retention and comprehension when using AI-driven adaptive learning platforms. Qualitative insights further highlighted the effectiveness of gamification and real-time feedback in maintaining learner motivation and satisfaction. The application of user-centered design and agile development practices played a crucial role in ensuring the platform's usability and scalability, making it adaptable to diverse educational contexts. These findings underscore the potential of integrating cutting-edge technology into education to address traditional learning challenges and foster more inclusive and effective environments.

This research successfully answers the central question: how can advanced educational technology solutions enhance learning experiences? The results indicate that combining adaptive systems, interactive features, and user-centered design principles can bridge gaps in engagement and learning efficiency. However, several limitations were identified during the study. Internet connectivity issues posed challenges for students in remote areas, highlighting a barrier to accessibility. Additionally, while the platform provided valuable insights for individual learners, educators expressed the need for more comprehensive analytics to better understand group-level performance trends. These limitations suggest areas that require further refinement to maximize the platform's potential impact.

Building on the findings and limitations of this study, future research should explore strategies to enhance accessibility, such as integrating offline functionalities or optimizing platforms for low-bandwidth environments. Expanding the scope of data analytics to include class-wide and longitudinal performance trends would also be beneficial, enabling educators to better assess and tailor their instructional strategies. Additionally, investigating the long-term effects of gamification and adaptive learning systems on learner motivation and academic success would provide deeper insights into the sustainability of these solutions. Future studies could also examine the integration of emerging technologies, such as blockchain for credentialing or extended reality (XR) tools for immersive learning, to further innovate in the field of educational technology.

6. ACKNOWLEDGEMENT

We feel deeply honored and grateful for the support extended by the entire community throughout this research. Without the assistance, contributions, and participation of the community, this study would not have been as successful. We highly appreciate the special efforts of the Design Editor team who helped distribute questionnaires and facilitated this research. Limitations in testing arose due to the scarcity of air quality forecasting information within the community. Therefore, further research using the same measurement instrument should be conducted on the same population to ascertain the distribution values of individuals who are well-informed about the implications of machine learning algorithms. This will allow for more accurate testing of theories. For future research, a comparative study can be developed using the same method but employing different calculation techniques. The support from the community serves as our inspiration to continue conducting meaningful and beneficial research for society. We hope that the outcomes of this study will contribute to public health, enhance trust in the utilization of machine learning algorithms, and promote urban development by improving air quality. Once again, we express our heartfelt gratitude to everyone involved in this endeavor. Your support has been invaluable, and we remain committed to conducting research that serves the community's needs.

7. DECLARATIONS

7.1. About Authors

Janu Ilham Saputro (JIS)
Lailatus Ferahma Sa'adah (LFS)
Yasyfiyani Syifa (YS)

Kinanti Dara Ramadhanti (KDR)
Muhamad Fikri Gojali (MFG)

7.2. Author Contributions

Validation: JIH; Conceptualization: JIH, LFS, YS; Methodology: KDR, MFG; Formal Analysis: YS; Writing Review and Editing: LFS, MFG; Visualization: YS, KDR; Each of the authors—JIH, LFS, YS, KDR, & MFG— has reviewed and approved the manuscript's published form.

7.3. Data Availability Statement

The corresponding author may provide the data from this study upon request.

7.4. Funding

The research, writing, and/or publishing of this work were all done without financial assistance from the authors.

7.5. Institutional Review Board Statement

Not applicable.

7.6. Informed Consent Statement

Not applicable.

7.7. Declaration of Competing Interest

The authors state that none of their known conflicting financial interests or personal connections could have had an impact on the work that was published in this publication.

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