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Research Article

Technology Adoption and Pedagogical Shifts in Central Sulawesi's Secondary Education

Dewi Satria Ahmar[1*], Muhammad Fath Azzajjad[2]
[1]Universitas Tadulako, Palu, Indonesia
[2]Universitas Sembilanbelas November Kolaka, Kolaka, Indonesia
*dewisatriaahmar@gmail.com

ABSTRACT
This research looks at the adoption patterns of educational technology in Palu City, Sigi Regency, and Donggala Regency, three areas in Central Sulawesi. Although there are notable differences between urban and rural settings, the quick incorporation of technology in education is essential to enhancing learning results. This study's main goal is to examine how secondary schools in these areas have used instructional technology from Education 1.0 to Education 5.0. Using a quantitative descriptive approach, the study gathers survey data from senior high school students attending Islamic, public, and private institutions as well as vocational schools. With 160 student responses, the analysis is arranged according to five major regions: Palu City, Sigi Regency, and Donggala Regency, according to the results, Sigi Regency exhibits a moderate adoption of Education 2.0 and early Education 3.0 tools, whereas Palu City exhibits the highest degree of technological integration, especially in Education 3.0 and 4.0. The biggest obstacles, however, are found in Donggala Regency, where most schools continue to use Education 1.0 and 2.0 approaches. The report identifies the primary obstacles, such as regional differences in digital resources, poor infrastructure, and insufficient teacher preparation. Considering the findings, it is evident that in order to close the digital gap and guarantee the successful integration of educational technology in all areas, a more equal allocation of resources and focused legislative initiatives are necessary.

Keywords: *Central Sulawesi; Educational Technology; Regional Disparities; Secondary Education; Technology Adoption*

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1. Introduction

Trends in educational technology have become a global issue in the rapidly changing 21st century (Muktiarni et al., 2019). Through platforms such as online learning, virtual classrooms, artificial intelligence (AI), and immersive media like augmented reality (AR) and virtual reality (VR), digital transformation is reshaping the way education is delivered worldwide, making learning more flexible, interactive, and accessible (Mansyur, et. al., 2022; Meng, et. al., 2023; Merelo et al., 2024). The use of cutting-edge educational technologies has been shown to significantly improve educational standards and student engagement in countries such as Finland, Singapore, and South Korea (Kabilan et al., 2023; van Dulmen et al., 2023).

After the COVID-19 outbreak accelerated the adoption of online education platforms, the Indonesian government launched several initiatives to support digital-based learning systems. Progress has been made through programs such as Merdeka Belajar, Platform Merdeka Mengajar (PMM), and the development of digital literacy courses for both educators and learners (Dewi et al., 2021; Nuryadi & Widiatmaka, 2023). However, the adoption and distribution of these programs remain uneven across the country, particularly in more remote provinces.

Keeping pace with these national and international developments poses significant challenges for educational institutions in Central Sulawesi. Many schools are ill-equipped to meet the demands of the digital age due to insufficient digital literacy, inadequate infrastructure, and a lack of systematic mapping of current trends in educational technology. Education systems risk stagnation or regression if these technological trends are not properly monitored and addressed (Siradjuddin, 2021). Without embracing necessary innovations, schools may fail to meet the requirements of contemporary learning. By effectively charting these patterns, schools can sustain their competitiveness, adaptability, and ability to deliver high-quality instruction aligned with modern international standards.

Mapping educational technology trends is crucial because it provides a clear picture of emerging technologies, their applications, and their impact on teaching and learning processes (Quach et al., 2022; Susilawati & Sugilar, 2021; Ulya et al., 2023). It serves as a diagnostic tool to identify the strengths, weaknesses, and potential of the educational system. Without such mapping, there is a risk of misallocated funding and outdated teaching practices, as policymakers and educational institutions may operate without strategic guidance (Li et al., 2022).

Currently, comprehensive data and studies on the integration and trend mapping of educational technology are lacking in Central Sulawesi. Most schools lag other regions because they rely on traditional teaching methods and have limited exposure to modern educational technologies (Lindsay et al., 2022; Sadi et al., 2023). The use of advanced platforms such as Learning Management Systems (LMS), virtual simulations, or AI-based learning tools remains minimal, with technological applications often confined to basic tools like PowerPoint presentations or online tests (Alannasir, 2020; Cesário & Nisi, 2023).

To address this problem, a series of deliberate actions must be taken to ensure that educational technology in secondary schools in Central Sulawesi advances in line with both domestic and international trends (Gros & García-Peñalvo, 2023; Satria Ahmar & Fath, 2024). First and foremost, a comprehensive mapping assessment of current instructional technology trends in the region's secondary schools is necessary. Such mapping will provide valuable information on the technologies currently in use, challenges faced, and potential areas for development (Chakraborty et al., 2023; Zhang & Ibarra, 2024).

The development of digital infrastructure and equitable access to technology—including reliable internet connectivity and availability of digital devices in both urban and rural schools—are the second priorities (Ahmar & Azzajjad, 2023; Satria et al., 2025). Technology-based learning cannot be effectively implemented without this foundation. Thirdly, it is critical to plan regular professional development and training programs for educators, focusing on enhancing their digital proficiency and adaptability in using diverse instructional technologies (Biletska et al., 2021; Kumar et al., 2024; Li et al., 2019; Wang et al., 2021). This will enable educators to integrate technology effectively into their lesson plans (Ahmar et al., 2023; Lester et al., 2023; Tiken et al., 2023; Suherman, et al. 2025). Moreover, universities, private EdTech companies, government agencies, and schools should support collaborative initiatives. Through such partnerships, resources, technical assistance, and innovative solutions tailored to regional educational needs can be mobilized.

Finally, policies must be implemented based on insights gained from the mapping data. This will enhance the efficiency, sustainability, and impact of educational technology use in the region by ensuring that decisions regarding its integration align with the actual needs and capacities of students, educators, and schools.

Beyond improving educational quality, integrating and mapping educational technology trends is vital for advancing broader national and international development goals. In particular, the Sustainable Development Goals (SDGs), especially Goal 4: Quality Education, emphasize that technology is essential for delivering accessible, equitable, and high-quality education while promoting lifelong learning opportunities for all.

Moreover, developments in educational technology must be closely monitored and embraced as Indonesia progresses toward its Indonesia Emas 2045 vision, which aims to position the country among the world's leading economies supported by a highly skilled human resource base. Preparing a generation that is innovative, globally competitive, and technologically proficient requires an education system ready for future challenges.

Central Sulawesi faces the risk of widening educational disparities both domestically and internationally if it fails to adopt and effectively manage educational technology trends. Such failure would hinder its capacity to contribute to Indonesia's long-term development objectives. Therefore, to ensure that Central Sulawesi's education system remains forward-looking and aligned with both the SDGs and Indonesia's Golden Vision 2045, this research serves as a crucial step in mapping the current state and future potential of technology in education.

2. Methods

2.1 Type of Research, Design, and Sampling Technique

The survey research method employed in this study is appropriate for collecting quantitative data on current developments in educational technology and learning dynamics from a large population. The aim of the descriptive quantitative research design is to provide a comprehensive overview of the current state of educational technology in secondary schools across Central Sulawesi. To map and explain the observed trends, the design involves directly distributing structured questionnaires to respondents for data collection.

Students from secondary schools (including senior high schools) across Central Sulawesi constitute the research population. Proportional stratified random sampling was employed, drawing samples proportionally from several representative regions to ensure reliability and broad coverage. Samples were drawn from the following regions: Palu City, Donggala Regency, and Sigi Regency. A total of 160 students participated in the study.

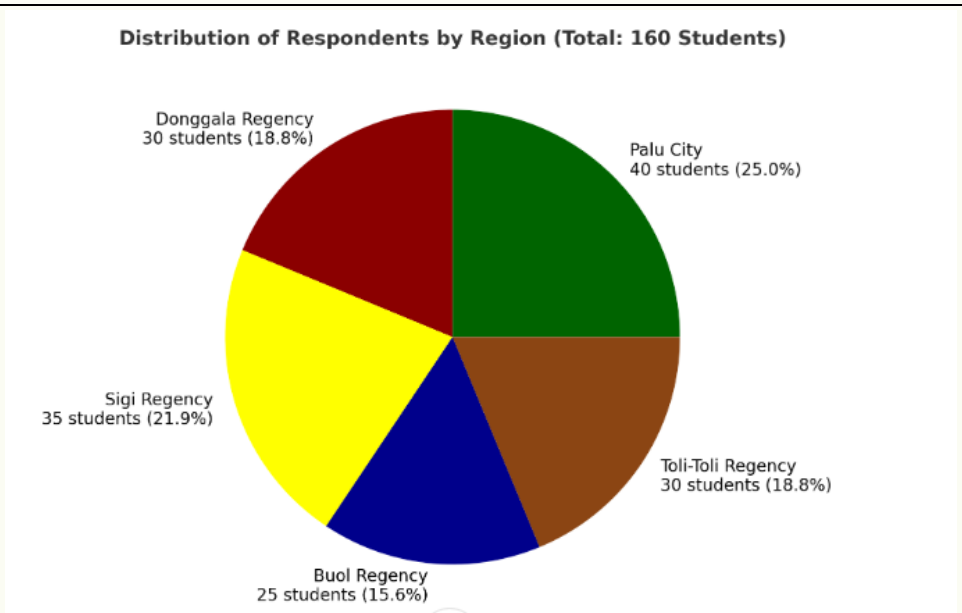

Figure 1. Distribution of Respondents by Region

2.2 Research Instrument

A questionnaire designed to map the implementation of educational technology developments from Education Technology 1.0 to 5.0 served as the primary research instrument in this study. The survey consisted of Likert-scale and structured multiple-choice items grouped according to the extent of instructional technology integration implemented by secondary school instructors. The categories are as follows: 1) Traditional, non-digital materials, such as textbooks and whiteboards, classified as Education Technology 1.0; 2) Basic digital tools, such as PowerPoint and multimedia presentations, categorized as Education Technology 2.0; 3) Internet-based learning resources, including learning management systems, online tests, and video conferencing, grouped under Education Technology 3.0; 4) Interactive and adaptive technologies, such as virtual reality (VR), augmented reality (AR), and artificial intelligence (AI) applications in education, encompassed by Education Technology 4.0; and 5) Education Technology 5.0, which represents individualized, human-centered learning supported by Internet of Things (IoT) integration and intelligent technologies. The purpose of the questionnaire was to identify the most frequently used category in each school and to explore how students are exposed to and perceive these technologies.

Table 1. Educational Technology Mapping

Types of Educational Technology	Category	Technology used in learning	Benefits experienced by students
Education Technology 1.0	Traditional	Chalkboards, Printed Books, Overhead Projectors	Limited interaction, mainly passive learning, relies on memorization and face-to-face instruction.
Education Technology 2.0	Digital	Computers, Online Learning Platforms (LMS), Email, Multimedia	Enhanced access to resources, improved communication, better collaboration through online tools.

Education Technology 3.0	Collaborative & Interactive	Interactive Whiteboards, social media, Educational Apps	Increased engagement, collaborative learning, active participation, personalized learning experience.
Education Technology 4.0	Smart Learning	AI-driven Tools, Virtual Reality (VR), Augmented Reality (AR), Big Data	Immersive experiences, real-time data analysis, personalized and adaptive learning paths, deeper understanding.
Education Technology 5.0	Human-Centered AI	AI-powered Platforms, Robotics, IoT in Education	More personalized learning, emotional and cognitive support, real-time feedback, and lifelong learning integration.

Source: Primary data, 2025

2.3 Data Analysis Technique

The data collected from the questionnaires were processed and analyzed using SPSS (Statistical Package for the Social Sciences) software. Descriptive statistical analysis was applied to summarize the frequency, percentage, and distribution of each educational technology trend category (1.0 to 5.0) utilized in secondary schools across the sampled regions. The analysis aimed to generate a comprehensive digitization map illustrating the prevalence, gaps, and regional variations in the adoption of educational technologies. The findings were presented in tables, charts, and distribution maps to visually depict the current state of educational technology integration in Central Sulawesi's secondary schools.

3. Results and Discussion

This section presents the findings of an extensive mapping study on educational technology trends in Central Sulawesi's secondary schools. From Education Technology 1.0 to 5.0, the results provide a comprehensive overview of how various institutions—such as public senior high schools, private senior high schools, public vocational schools, and public Islamic senior high schools—utilize educational technology. Based on responses from 160 students, the analysis is organized according to three major regions: Palu City, Sigi Regency, and Donggala Regency. After a detailed discussion of the trends observed within each school type, data from each area are illustrated using graphs to depict the distribution of technology use.

The objectives of this section are to describe the current state of digital technology integration in secondary schools, highlight geographical variations, and discuss potential factors influencing these trends. Understanding how prepared Central Sulawesi's educational institutions are to meet the demands of digital education and future learning ecosystems aligned with national and international goals relies on these findings.

3.1 Results of Mapping the Use of Educational Technology in Palu City

One of the most dynamic regions for technology use in secondary education is Palu City, the educational and administrative center of Central Sulawesi. This city provides a valuable case study of digital transformation implementation at the school level, based on responses from 40 students representing various types of secondary schools, including Public Senior High Schools (SMA Negeri), Private Senior High

Schools (SMA Swasta), Public Vocational Schools (SMK Negeri), and Public Islamic Senior High Schools (Madrasah Aliyah Negeri).

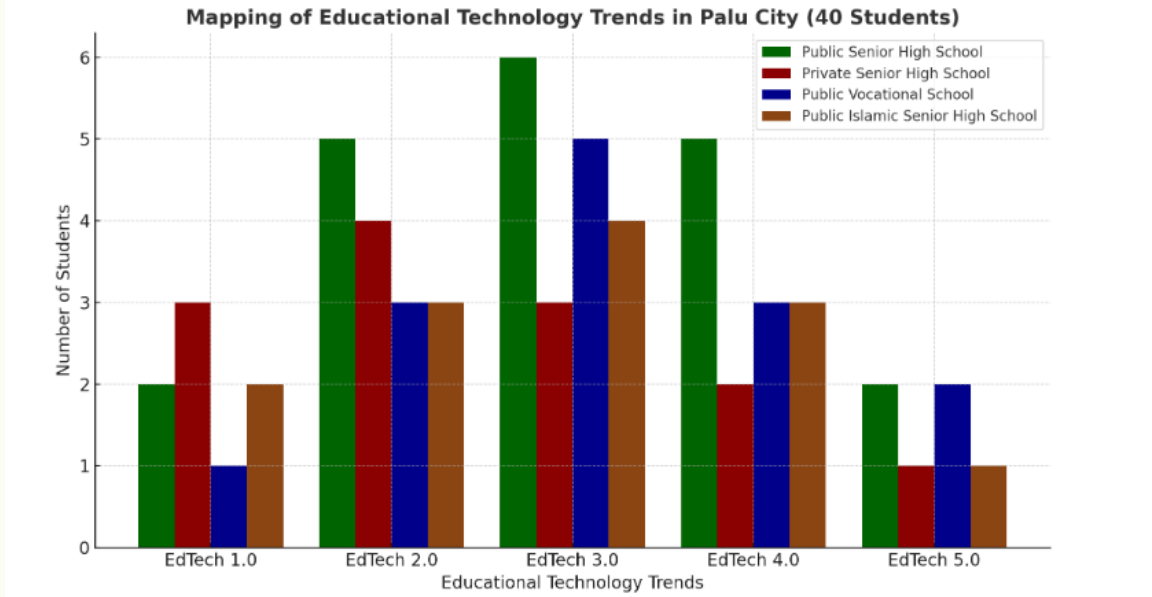

Figure 2. Results of Mapping the Use of Educational Technology in Palu City

The findings of Palu City's educational technology mapping reveal a varied pattern of technology use across different types of secondary schools. Among the 40 student respondents, Public Senior High Schools (SMA Negeri) demonstrated the highest degree of integration in Education Technology 3.0 (6 students) and Education Technology 4.0 (5 students) categories. This suggests that Palu's public senior high schools are comparatively proficient in utilizing contemporary digital technologies, including online tests, video conferencing, and Learning Management Systems (LMS). As these institutions progress toward Education Technology 4.0, they have also begun experimenting with advanced resources such as AI-powered applications and virtual simulations.

Private Senior High Schools (SMA Swasta), on the other hand, tended to rely more heavily on Education Technology 2.0 (four students) and Education Technology 1.0 (three students). This implies that conventional and semi-digital teaching methods, such as PowerPoint presentations, offline videos, and printed materials, continue to dominate in many private schools within the region. This delayed transition may be attributed to factors including limited resources, inadequate digital infrastructure, and insufficient digital literacy training for teachers.

Public Vocational Schools (SMK Negeri) showed good adaptation with notable use of Education Technology 3.0 (5 students) and Education Technology 4.0 (3 students). Vocational schools are more inclined to embrace digital platforms and technologies that facilitate interactive, industry-relevant learning environments, as their curricula are inherently aligned with practical, skill-based education.

Similar trends were observed in Madrasah Aliyah Negeri, a public Islamic senior high school, where most students reported using Education Technology 3.0 (4 students) and Education Technology 4.0 (3 students). This reflects a positive trend among Islamic educational institutions to integrate digital technologies with religious instruction to modernize their learning processes.

The availability of infrastructure, quality of internet connectivity, school administrative practices, and teachers' proficiency with digital technologies were identified as key factors influencing these findings. While private schools may face challenges related to funding and digital literacy training, public schools typically benefit from government-supported programs and infrastructure (Lang, Špernjak, & Šorgo, 2024).

Considering these findings, it is evident that although Palu City has made significant progress in adopting Education Technology 3.0 and 4.0, advancement toward Education Technology 5.0 remains limited. To accelerate the transition to future-ready education systems, focused interventions are necessary, including improved infrastructure, professional development for teachers, and supportive legislation. To bridge the digital divide across different school types and ensure equitable opportunities for all students throughout the city, local policymakers and school administrators should seriously consider these results.

3.2 Results of Mapping the Use of Educational Technology in Sigi Regency

Ranging from Education Technology 1.0 to 5.0 is illustrated in the graph above. The purpose of this mapping was to assess the region's current level of technology integration in education as well as its adoption rates. The analysis includes four types of schools: public senior high schools, private senior high schools, public vocational schools, and public Islamic senior high schools. Through this data analysis, the study aims to identify the educational technology phases most frequently used across different school types, providing valuable insights into the future potential and digital readiness of educational institutions in Sigi Regency.

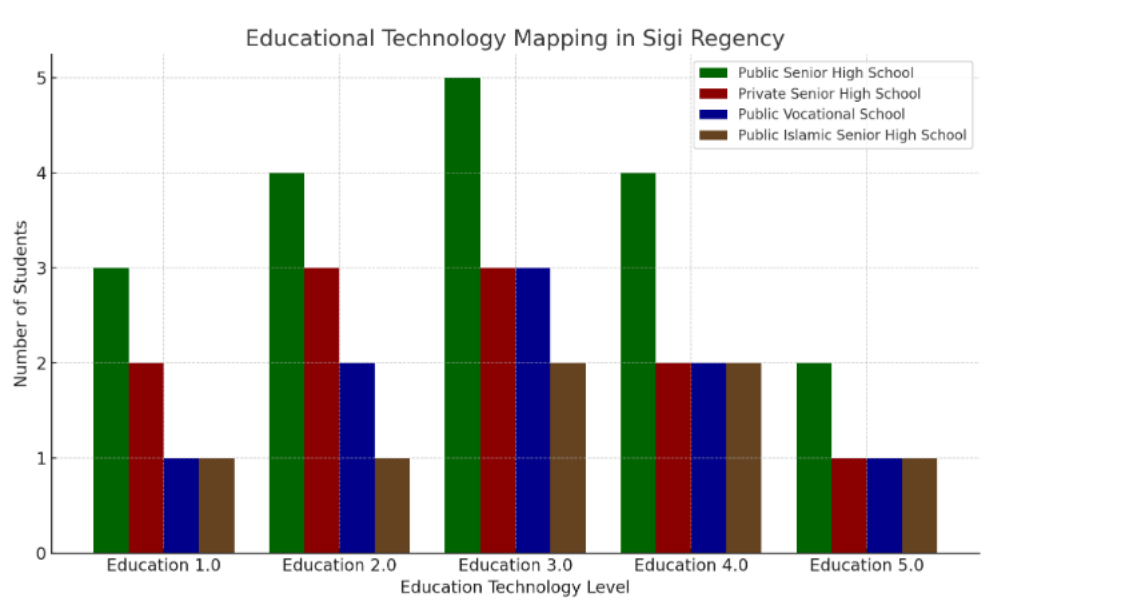

Figure 3. Results of Mapping the Use of Educational Technology in Sigi Regency

The mapping findings in Sigi Regency reveal a diverse distribution in the usage of educational technology from Education Technology 1.0 to 5.0, based on responses from 35 students representing four different types of secondary schools.

The highest participation rates were observed in Education Technology 3.0 (5 students) and Education Technology 4.0 (4 students) at Public Senior High Schools (SMA Negeri). This indicates that public high schools in Sigi Regency have begun transitioning toward interactive, digital learning environments by leveraging resources

such as virtual classrooms, online learning platforms, and video conferencing. These successes are supported by government-facilitated initiatives and comparatively improved facilities.

Education Technology 2.0 (3 students) and Education Technology 3.0 (3 students) were moderately utilized in Private Senior High Schools (SMA Swasta). Their reliance on semi-digital teaching methods, including slideshows, offline videos, and a limited number of online platforms, suggests a slower pace of transition, likely due to varying levels of digital literacy among instructors and financial constraints.

As expected, Public Vocational Schools (SMK Negeri) demonstrated significant use of Education Technology 3.0 (3 students) and Education Technology 4.0 (2 students). Vocational schools naturally align with hands-on, technologically advanced learning environments, utilizing cloud-based tools, simulations, and digital workshops to enhance students' educational experiences.

Although fewer in number, Public Islamic Senior High Schools (Madrasah Aliyah Negeri) showed promising trends, with Education Technology 3.0 (2 students) and Education Technology 4.0 (2 students) garnering interest. This reflects a growing awareness among religious schools of the need to modernize instructional methods through the integration of digital platforms alongside religious principles.

These trends can be attributed to disparities in policy enforcement, infrastructure availability, and instructors' varying levels of technological adoption. While private schools and some religious institutions face financial and technological challenges, public schools often benefit from greater infrastructure and resources provided through government programs.

Considering this, although Sigi Regency is making progress—particularly in public schools—a disconnect remains among different school types regarding their technological readiness. To foster inclusive, technology-driven education aligned with Education Technology 4.0 and beyond, urgent efforts are needed to promote cross-sector collaboration, enhance teachers' digital competencies, and ensure equitable resource allocation.

3.3 Results of Mapping the Use of Educational Technology in onggala Regency

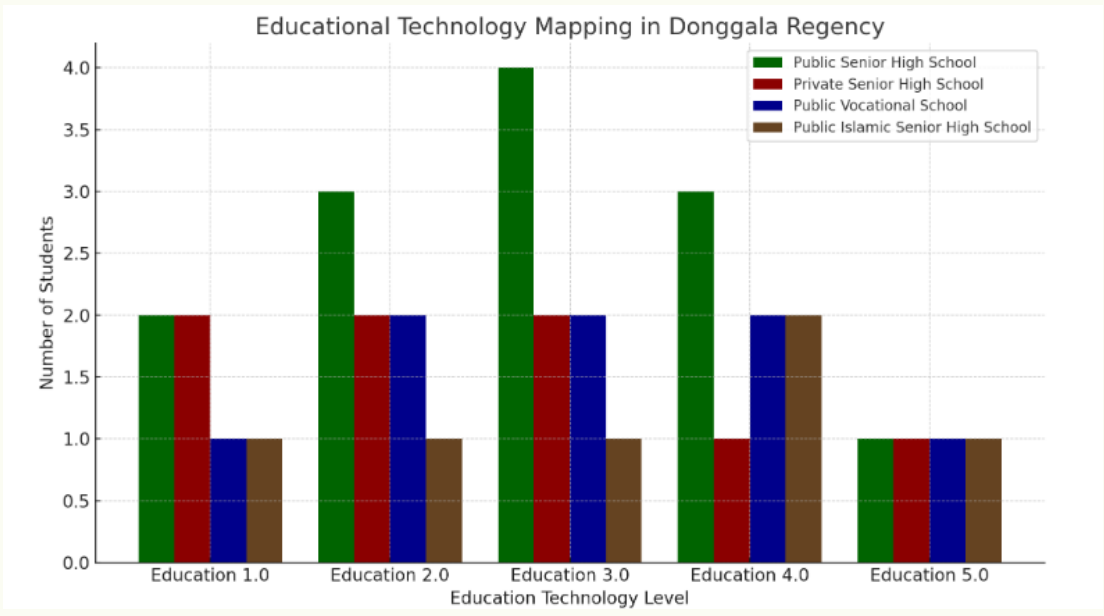

Figure 4. Results of Mapping the Use of Educational Technology in Donggala Regency

Based on data from 30 students across four types of secondary schools, the mapping of educational technology adoption in Donggala Regency reveals several notable patterns. Most students in public senior high schools (SMA Negeri) are engaged with Education Technology levels 2.0 (3 students) and 3.0 (4 students). This indicates a shift toward interactive and semi-digital learning practices, even as traditional teaching methods continue to be used. Public schools increasingly utilize tools such as projectors, PowerPoint presentations, offline educational videos, and basic internet-based exercises.

In private senior high schools (SMA Swasta), the distribution of adoption across Education Technology levels 1.0, 2.0, and 3.0 is balanced, with two students in each category. However, there is minimal engagement with Education 4.0 and 5.0 technologies, highlighting challenges such as limited infrastructure and insufficient readiness. Budgetary constraints and a lack of human resources continue to hinder the adoption of more advanced digital and AI-based learning methods.

Public vocational schools (SMK Negeri) show a more even distribution of students engaged in Education 2.0, 3.0, and 4.0, reflecting the hands-on and applied learning environment typical of vocational education. These schools often adopt new technologies more rapidly to support skill-based learning. However, issues related to infrastructure and teacher training remain barriers to fully implementing Education 5.0 technologies.

Among public Islamic senior high schools (Madrasah Aliyah Negeri), enrollment is lower across all categories, with the highest number of students (2) engaged at the Education 4.0 level. This suggests a cautious but positive trend toward incorporating modern technologies such as virtual classrooms, online learning platforms, and multimedia religious instruction without compromising traditional values.

The disparities observed in the adoption of educational technologies are influenced by factors including unequal access to reliable internet, availability of digital devices, varying levels of teacher digital competency, and institutional policies. While government initiatives often support public schools, private and religious schools frequently rely on limited self-funding, which restricts their technology integration efforts.

In summary, schools in Donggala are gradually integrating technology-based instruction, but progress is uneven. To accelerate the adoption of Education 4.0 and 5.0 technologies, it is essential to improve digital infrastructure, promote inclusive digital literacy training, and foster cooperative programs involving educational technology companies, local governments, and schools.

3.4. Critical Analysis of Educational Technology Trends in Palu City, Sigi Regency, and Donggala Regency

Significant regional variations in the use and integration of educational technology across secondary schools are evident from the mapping of trends in Palu City, Sigi Regency, and Donggala Regency. The study, which utilized survey data from various types of schools, provides valuable insights into the current state of educational technology and its impact on teaching and learning in these areas.

Several schools in Palu City demonstrate a high level of engagement with Education 3.0 and 4.0 technologies. Learning Management Systems (LMS), online learning platforms, and multimedia resources are moderately to highly integrated in both public and private senior high schools, as well as vocational institutions. However, only a small number of institutions have begun exploring Education 5.0 technologies, which focus on individualized learning and artificial intelligence. Palu's greater access to infrastructure, along with teacher training programs and local policies supporting the use

of digital technologies in classrooms, are among the reasons for the relatively higher levels of technology adoption in the city.

Nonetheless, inconsistent use of these technologies remains one of the biggest challenges faced by Palu's schools. While schools in metropolitan areas often have the resources to adopt more advanced digital learning strategies, many rural schools continue to rely on traditional teaching methods due to outdated technology and limited internet access. This digital divide reflects the unequal distribution of resources and a lack of structural support for ongoing teacher professional development.

Sigi Regency, on the other hand, exhibits a more gradual progression from Education 1.0 to 3.0. While there is some adoption of technology, it is largely concentrated on Education 2.0 tools such as online learning platforms and multimedia presentations, particularly in public senior high schools and vocational institutions. The transition to Education 3.0—which emphasizes interactive teaching methods, critical thinking, and collaborative learning—is still in its early stages. Technological integration in Sigi's public Islamic senior high schools is notably lower, with many students continuing to receive instruction through conventional methods.

The region's weak digital infrastructure, compounded by limited teacher preparedness, is the primary factor behind this slow adoption. Many teachers in Sigi have not yet received adequate training to effectively utilize digital tools, and schools frequently face financial constraints in acquiring necessary software and equipment. Moreover, the lack of infrastructure and curricular adjustments aligned with newer educational paradigms has hindered the use of advanced Education 4.0 technologies, such as virtual reality and data-driven personalized learning.

Both Palu and Sigi are ahead of Donggala Regency in terms of educational technology usage. Most schools in Donggala still heavily rely on Education 2.0 (basic multimedia technologies) and Education 1.0 (traditional teaching methods). More advanced tools typical of Education 3.0 and beyond—such as video conferencing and LMS platforms—are notably absent. Challenges including geographical remoteness, inadequate teacher training, and insufficient government support for technology integration have significantly limited Donggala's progress in embracing digital educational resources.

Donggala's inadequate infrastructure is one of the main causes of its technological stagnation. Electricity problems are still prevalent, particularly in more rural locations, and many schools still lack dependable internet connectivity. Schools in Donggala are at risk from the digital divide since there is no clear policy in place to address it. The few schools that have made efforts to use technology frequently struggle with antiquated equipment and a lack of curriculum-aligned digital content. This problem is exacerbated by the absence of a solid pedagogical framework that incorporates technology into the teaching process.

Considerable differences in the rate and scope of educational technology use are highlighted when comparing findings from Palu, Sigi, and Donggala. Palu has made significant progress toward Education 4.0, whereas Sigi and Donggala are still grappling with the fundamentals of Education 2.0, with Donggala lagging the most. This disparity can be attributed to variations in government activities, infrastructural accessibility, and regional development. Palu's urban infrastructure and government support have established a strong foundation for technological integration, but Sigi and Donggala face more substantial obstacles such as limited resources and challenging topography.

One of the main advantages of this research is its capacity to provide a clear regional comparison, which can assist policymakers in more precisely targeting

initiatives. The findings emphasize the importance of addressing regional disparities in access to technology and the need for tailored solutions. According to the research, educational technology has the potential to transform learning, but only if support systems, infrastructure, and training are adequately provided.

However, the study has several limitations, including a limited sample size and a regional focus, which may hinder the ability to fully represent educational technology developments in other countries. Furthermore, to thoroughly understand the challenges and opportunities in instructional technology, qualitative insights into the unique difficulties and success stories of each school are required, despite the valuable quantitative data provided by this study.

4. Conclusion

This study identifies significant disparities in the adoption of educational technology across Palu City, Sigi Regency, and Donggala Regency. Palu demonstrates advanced implementation of Education 3.0 and 4.0, facilitated by robust infrastructure and ongoing professional development for educators. Sigi shows moderate progress primarily at Education 2.0 level but is constrained by infrastructure limitations and insufficient teacher readiness. Donggala remains predominantly reliant on Education 1.0 approaches due to inadequate access to digital tools, unreliable internet connectivity, and lack of training.

These findings highlight a persistent digital divide between urban and rural schools, underscoring the urgent need for targeted investments in digital infrastructure, equitable teacher training programs, and inclusive policy interventions to foster technology integration. Future research should focus on longitudinal studies assessing the effectiveness of such interventions and develop scalable models for integrating educational technology in rural settings.

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