

Understanding Geography Teachers' Assessment Challenges and Needs for Artificial Intelligence Supported Assessment Systems: Insights from Indonesia

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Abstract

Artificial Intelligence (AI) is transforming educational assessment by enabling more adaptive, data-driven, and personalised assessment practices. However, the successful implementation of AI-supported assessment systems depends on understanding teachers' pedagogical needs rather than technological capabilities alone. This study investigated geography teachers' assessment challenges, identified their needs for AI-supported assessment systems, and developed a teacher-centred conceptual framework to inform future AI-supported assessment design. An explanatory sequential mixed-methods design was employed involving 40 senior high school geography teachers in Surakarta, Indonesia. Quantitative data were collected using a 27-item questionnaire and analysed through descriptive statistics and Spearman's rank correlation, while qualitative data from Focus Group Discussions were analysed thematically to explain and enrich the quantitative findings. The results revealed that teachers were receptive to AI adoption but continued to experience challenges in providing timely feedback, conducting comprehensive assessment, and monitoring students' learning progress. Strong positive relationships among assessment practices, AI perceptions, assessment needs, and behavioural intention indicate that teachers' pedagogical challenges shape the functional requirements expected from AI-supported assessment systems. Integrating quantitative and qualitative findings, this study proposes the Teacher-Centred AI-Supported Assessment Framework, which translates teachers' pedagogical needs into AI system requirements for assessment design. The findings contribute to Artificial Intelligence in Education by advancing a teacher-centred, need-driven approach to AI-supported assessment and providing practical guidance for developing pedagogically aligned and context-responsive assessment systems, particularly in developing countries.

1. Introduction

Improving the quality of assessment has become one of the top priorities in global educational transformation. This is because assessment serves as the foundation for monitoring learning progress, providing meaningful feedback, and supporting continuous decision-making regarding learning [1]. This shift positions assessment not merely as a tool for measuring learning outcomes, but as an integral part of the learning process aimed at improving the quality of students' learning. Therefore, strengthening the quality of assessment is viewed as a key prerequisite for achieving Sustainable Development Goal 4 (SDG 4), particularly in providing inclusive, high-quality education that promotes lifelong learning opportunities [2], [3]. However, achieving high-quality assessment remains a challenge in many education systems. Teachers are expected to provide authentic assessments, offer timely feedback, and continuously monitor each student's learning progress; however, time constraints, heavy workloads, and the complexity of the assessment process often limit the implementation of these assessment practices [4]. In this context, advances in Artificial Intelligence (AI) are increasingly viewed as an opportunity to support teachers through more adaptive, personalized, and data-driven assessment systems [5]. In this context, Artificial Intelligence (AI) has emerged as one of the innovations projected to transform assessment practices into more adaptive, personalized, and data-driven systems.

Advances in Artificial Intelligence in the field of education have led to the emergence of intelligent assessment systems, systems that leverage AI capabilities to provide automated grading, immediate feedback, adaptive assessments, analysis of learning progress, and personalized learning recommendations tailored to students' characteristics [6]–[9]. Unlike conventional assessments, which are generally static and require a considerable amount of time for the evaluation process, intelligent assessment systems allow teachers to obtain real-time learning information, enabling them to make learning decisions more quickly and accurately. Nevertheless, various studies also emphasize that the successful implementation of Artificial Intelligence depends not only on technological sophistication but is also influenced by teacher readiness, ethical considerations, and the alignment of technology with pedagogical needs in the classroom [10].

The urgency of developing intelligent assessment systems is becoming increasingly evident in geography education. As a discipline that emphasizes spatial thinking, geographic reasoning, environmental problem-solving, and evidence-based decision-making, geography education requires an assessment approach capable of measuring complex thought processes, rather than merely mastery of facts or concepts [11]. Various studies indicate that formative assessment, authentic assessment, and self-assessment contribute to a deeper understanding of geographic concepts [12]–[14]. Furthermore, the development of geographic literacy, critical thinking, and creative thinking has become a primary focus of geography education to address the challenges of the 21st century [15]. However, in practice, teachers still face various challenges, including a heavy assessment workload, limited time to provide individualized feedback, difficulties in monitoring each student's learning progress, and limitations in implementing personalized and ongoing assessments.

Artificial Intelligence offers opportunities to address these challenges through its ability to conduct adaptive assessments, provide automated feedback, analyze learning errors, and generate personalized learning recommendations. Various studies report that the application of Artificial Intelligence can improve the quality of learning, higher-order thinking skills, spatial reasoning skills, and the effectiveness of adaptive learning in various educational contexts [16]–[19]. Although research on Artificial Intelligence in education is advancing rapidly, most studies still focus on the development of AI applications, the evaluation of the technology's effectiveness, user acceptance, and ethical issues surrounding the use of AI [8], [20]. These contributions enrich our understanding of AI technology's capabilities but do not yet fully address the assessment challenges faced by teachers or the pedagogical needs that AI-based assessment systems must meet before such technology is implemented in schools. As a result, empirical evidence on how assessment challenges shape teachers' needs for AI-supported assessment systems remains relatively limited, particularly in the context of geography education. Yet, understanding teachers' needs is a crucial step to ensure that the use of AI truly supports classroom assessment practices, rather than merely offering technological capabilities that may not align with the learning context.

Research gaps are also evident from a geographic perspective. Most research on Artificial Intelligence (AI) in education is still dominated by the context of developed countries, which have more established

digital infrastructure, strong institutional support, and relatively mature innovation ecosystems. In contrast, empirical evidence regarding the need for and implementation of AI in the context of developing countries remains limited. This is significant because developing countries face distinct challenges, such as digital infrastructure gaps, variations in teachers' digital competencies, limited educational resources, the dynamics of curriculum reform, and uneven institutional capacity to adopt AI technology [21]. Furthermore, the implementation of AI in low-income countries also requires special attention to access limitations, system readiness, and the relevance of the technology to local needs [22]. Other studies indicate that national AI strategies in developing countries need to be tailored to each country's social, economic, and institutional conditions [23]. Various studies also emphasize that the use of AI in developing countries cannot simply adopt approaches developed in developed countries but requires adaptation to user needs and the characteristics of local education systems [24]. Therefore, generating empirical evidence from developing countries is crucial for understanding how assessment challenges and teachers' pedagogical needs shape expectations regarding AI-supported assessment systems, so that the development and implementation of such technologies can be more contextual, relevant, and sustainable.

Indonesia is one of the developing countries currently undergoing a comprehensive educational transformation through the implementation of the Merdeka Curriculum, the promotion of deep learning, and the acceleration of educational digitization. This transformation is aimed at improving the quality of learning and assessment [25]. At the same time, the use of Artificial Intelligence (AI) is beginning to grow at various levels of education to support more adaptive learning and enhance the effectiveness of assessment [19]. These initiatives are also evident in various efforts to integrate AI into teaching and evaluation practices in schools [26]. These simultaneous transformations make Indonesia a relevant context for understanding how teachers' needs for AI-supported assessment systems emerge during the early phases of AI integration in education. Unlike many developed countries that already have relatively well-established digital ecosystems and AI policies, Indonesia's education system still faces challenges in aligning technological innovations with teachers' readiness, pedagogical practices, and curriculum implementation at the school level. Therefore, empirical evidence from Indonesia contributes to enriching the literature on how the context of developing countries influences teachers' needs regarding the use of AI in learning assessment. This becomes increasingly important in the subject of geography, which requires the assessment of spatial thinking, geographical reasoning, and problem-solving skills [27]. This perspective is also consistent with findings regarding the importance of geography teachers' pedagogical readiness in integrating deep learning approaches within the framework of Indonesia's Merdeka Belajar Curriculum [28].

In this context, the city of Surakarta was selected as an information-rich case study because it provides a representative educational environment for examining teachers' needs regarding AI-supported assessment systems. Surakarta is also known as one of the cities that has consistently developed a smart city ecosystem through the strengthening of digital infrastructure, the utilization of data-driven technologies, and innovations in public services [29]. Other studies indicate that the smart city initiative in Surakarta continues to advance through the use of smart technologies and spatial analysis in the

development of a digital city [30]. This transformation is reinforced by a recent review that positions Surakarta as a key example in the optimization of digital services based on big data and real-time technology [31]. The use of geospatial technology is also an integral part of digital city development in Surakarta [32]. In the field of education, this digital transformation has also driven various initiatives involving the use of technology and AI [18]. This is supported by efforts to enhance teachers' capacity in digital learning and geospatial technology [33]. The strengthening of differentiated instruction also indicates that geography teachers in Surakarta have moved toward more adaptive pedagogical practices, particularly for students with lower proficiency in geography [34]. The application of deep learning approaches in geography education demonstrates that Surakarta has a relevant academic ecosystem for studying AI-based assessment [35]. Other findings regarding geography teachers' understanding of deep learning pedagogy in Surakarta also underscore the importance of teacher readiness in the curriculum transition in the digital age [36]. At the same time, schools in Surakarta continue to exhibit variations in assessment practices, digital readiness, and the implementation of learning innovations as strategies for implementing deep learning. The combination of a developing digital ecosystem and this diversity of learning practices makes Surakarta a rich context for understanding how teachers interpret assessment challenges and translate them into a need for AI-supported assessment systems. Thus, although this study focuses on a single city, its findings make a broader contribution to the international literature by demonstrating how the context of educational transformation in developing countries shapes teachers' needs prior to the wider implementation of AI.

Based on this description, this study aims to understand how the various assessment challenges faced by geography teachers shape their needs for AI-supported assessment systems. This study employs an explanatory mixed-methods design that integrates questionnaire results and focus group discussions to gain a more comprehensive understanding of teachers' needs. The contributions of this study lie in three main aspects. First, it expands the field of Artificial Intelligence in Education by elucidating the relationship between teachers' assessment challenges and their needs for AI-supported assessment systems a perspective that has received relatively little attention in the literature. Second, it enriches the empirical evidence regarding assessment challenges and geography teachers' needs for AI utilization in the Indonesian educational context, a topic that remains underrepresented in the international literature. Third, it provides evidence-based recommendations for educational technology developers, policymakers, and education practitioners in developing AI-supported assessment systems that are more responsive to teachers' assessment needs.

Source: Developed by the authors based on literature synthesis (2026).

Figure 1 presents a conceptual framework developed to understand the transformation of assessment practices in geography education, particularly in response to assessment demands that emphasize spatial thinking, spatial analysis, and context-based problem-solving. This framework provides an analytical foundation for examining the gap between the complexity of the geographic competencies that need to be measured and the limitations of existing assessment practices, while also identifying the potential contributions of artificial intelligence in supporting more adaptive and meaningful assessment

processes. By placing the needs and expectations of geography teachers at the center, this study contributes to a deeper understanding of how AI-based assessment systems can be designed and implemented in a contextually appropriate manner, taking into account the unique characteristics of geography education and the dynamics of the surrounding educational environment.

2. Methods

2.1. Research Design

This study employs an explanatory sequential mixed-methods design, which is a research approach that integrates quantitative and qualitative methods sequentially, whereby quantitative data collection and analysis are conducted in the first phase, followed by qualitative data collection and analysis to explain, deepen, and interpret the quantitative findings [37], [38]. This design was chosen because the study's objective is not only to identify the various assessment challenges faced by geography teachers and their needs regarding AI-supported assessment systems, but also to understand the reasons and context underlying those needs. The explanatory sequential mixed-methods approach allows researchers to obtain a general overview of empirical patterns through quantitative data, then enrich the interpretation of these findings through qualitative exploration, thereby yielding a more comprehensive understanding of complex educational phenomena [39].

The first phase of the study was conducted through a survey using a questionnaire designed to identify teachers' assessment practices, the assessment challenges they face, their technological readiness, their perceptions of Artificial Intelligence (AI), their needs for AI-supported assessment systems, and their intentions regarding their use. The results of the quantitative analysis were then used as the basis for determining the focus of discussion in the second phase through Focus Group Discussions (FGDs). Thus, the FGD did not serve as a standalone data collection method but rather as an effort to explain and provide context for the patterns identified in the questionnaire results, thereby yielding a deeper understanding of teachers' experiences and considerations in addressing assessment challenges in the classroom [40].

The integration of these two types of data was conducted during the interpretation phase of the research by linking quantitative findings with themes derived from the FGDs [41]. Quantitative data were used to identify general trends regarding assessment challenges and teachers' needs for AI-supported assessment systems, while qualitative data provided an explanation of the contextual factors shaping these trends in geography teaching practices in Indonesia. This integration yields a more comprehensive interpretation than if each approach were used separately, as it combines the generalizability of quantitative data with the depth of insight gained through qualitative exploration [42], [43]. Figure 2 presents the research design framework used in this study.

Source: Developed by the authors (2026)

As shown in Fig. 2, this research strategy combines quantitative and qualitative approaches in sequence to yield a deeper understanding of the issue under study. Through mechanisms that link the phases and integrate the results, this design allows for exploration that is not only confirmatory but also exploratory. This approach makes a methodological contribution by providing an analysis capable of bridging empirical patterns with contextual interpretations, thereby yielding more comprehensive and relevant meta-inferences for understanding assessment practices in geography education.

2.2. Research Context and Participants

This study was conducted at Senior High Schools (SMA) and Madrasah Aliyah (MA) in Surakarta, Central Java, Indonesia (see Fig. 3). Surakarta was chosen as the research context because its schools have been undergoing educational transformation through the implementation of the Merdeka Curriculum, which provides a relevant context for examining assessment challenges and teachers’ needs regarding AI-supported assessment systems [34], [36], [44], [45]. The academic justification for selecting Surakarta as an information-rich case was explained in the introduction; therefore, this subsection focuses on the methodological aspects of the study. This research was conducted from May 2026 to June 2026.

The study population consisted of all high school and Islamic high school geography teachers in Surakarta. To ensure that participants met the study’s objectives, a series of inclusion criteria were applied regarding teacher characteristics, grade level, curriculum implementation, teaching approaches, and school context. Details of the inclusion criteria are presented in Table 1. Based on this selection process, out of 39 high schools in Surakarta, 23 schools met all the research criteria. At these 23 schools, there were 40 geography teachers who met the inclusion criteria and constituted the accessible population for this study.

Table 1
Inclusion Criteria for Participant Selection

Criterion	Inclusion Requirement
Teaching subject	Geography
Teaching level	Phase F (Grades XI–XII)
Curriculum implementation	Merdeka Curriculum
Learning approach	Implementation of Deep Learning
School context	Schools offering the Geography Academic Competency Test

Source: Developed by the authors (2026).

Since all teachers who met the criteria were accessible, this study employed total sampling (census) in the quantitative phase, thereby including all 40 geography teachers as survey respondents. The use of this technique enabled the study to obtain a comprehensive overview of assessment practices, assessment challenges, technological readiness, perceptions of Artificial Intelligence (AI), the need for

AI-supported assessment systems, and the intention to use them. The demographic and professional characteristics of the participants involved in the study are presented in Table 2.

Table 2
Demographic and Professional Characteristics of the Survey Participants

Characteristic	Category	Number (n)	Percentage (%)
Gender	Male	19	47.5
	Female	21	52.5
Age	≤ 30 years	14	35.0
	31–40 years	5	12.5
	41–50 years	8	20.0
	> 50 years	13	32.5
Highest educational qualification	Bachelor's (S1)	34	85.0
	Master's (S2)	6	15.0
School status	Public	24	60.0
	Private	16	40.0
Teacher certification	Certified	33	82.5
	Not certified	7	17.5
Deep Learning training	Yes	25	62.5
	No	15	37.5
Artificial Intelligence training	Yes	27	67.5
	No	8	32.5

Source: Authors' survey data (2026).

In the qualitative phase, all teachers who participated in the quantitative survey were again involved in Focus Group Discussions (FGDs) to provide a more in-depth explanation of the survey findings. This approach was chosen to ensure that the interpretation of the quantitative results was based on the direct experiences of the same participants, thereby enhancing the consistency and depth of integration between the research phases. In line with the characteristics of explanatory sequential mixed-methods, the results of the quantitative analysis were used as the basis for formulating the focus of the FGD discussions, while the qualitative data served to explain, confirm, and enrich the patterns identified in the survey [46]. The integration of these two types of data yields a more comprehensive understanding of the challenges faced by geography teachers in assessment and their needs regarding AI-supported assessment systems [42].

2.3. Research Instruments

This study used two complementary instruments in accordance with an explanatory sequential mixed-methods design: a structured questionnaire in the quantitative phase and a semi-structured Focus Group Discussion (FGD) guide in the qualitative phase. Both instruments were developed based on the study’s conceptual framework and adapted from various instruments previously used in research on assessment practices, self-evaluation, Artificial Intelligence (AI)-based assessment, and technology adoption in education. The use of the same conceptual constructs in both instruments aims to maintain a connection between the quantitative and qualitative phases so that the FGD data can explain, deepen, and interpret the survey findings more comprehensively [42], [47].

The research instrument was developed through the operationalization of five main theoretical constructs: Current Assessment Experience, Self-Assessment Practices, Perceived Usefulness of AI, AI-Based Assessment Needs, and AI Readiness and Acceptance. These five constructs were then operationalized into eight research dimensions, including assessment practices, feedback quality, self-assessment practices, technology readiness, perceived usefulness of AI, needs for AI-supported assessment features, needs for AI-generated feedback, and behavioral intention to use AI-supported assessment systems. A summary of the theoretical constructs, research dimensions, and sources used to develop the instrument is presented in Table 3.

Table 3
Theoretical Constructs and Development of Research Instruments

Theoretical Construct	Research Dimension	Questionnaire and FGD Items	Source
Current Assessment Experience	Assessment Practices	1–3	Van Orman et al. [48]
	Feedback Quality	4–6	
Self-Assessment Practices	Self-Assessment Practices	7–9	Nieminen & Boud [49]
AI Readiness and Acceptance	Technology Readiness	10–12	Kolade et al. [50]
Perceived Usefulness of AI	AI for Educational Assessment	13–15	Memarian & Doleck [51]
AI-Based Assessment Needs	AI-Supported Assessment Features	16–20	Memarian & Doleck [51]
	AI-Generated Feedback	21–23	
AI Readiness and Acceptance	Behavioural Intention to Use AI-Supported Assessment Systems	24–27	Kolade et al. [50]

Although the questionnaire was conceptually developed based on five overarching theoretical constructs, quantitative and qualitative analyses were conducted and reported at the level of the

research dimensions presented in Table 3. Each dimension represents a specific operational component of its underlying construct and was measured using a set of questionnaire items and specific FGDs. Reporting results at the dimension level allows for a more detailed analysis of teacher assessment practices, technological readiness, perceptions of AI, and assessment needs, thereby providing richer empirical evidence to address the research objectives.

The questionnaire consists of 27 statements measured using a five-point Likert scale, ranging from 1 = strongly disagree to 5 = strongly agree. The choice of a five-point Likert scale will influence the research outcomes sought and help respondents select the appropriate response [52]. This instrument was designed to gather information on teachers' assessment practices, the quality of feedback provided to students, student self-evaluation practices, readiness to use digital technology, teachers' perceptions of the benefits of AI in assessment, needs regarding features of AI-supported assessment systems, the need for AI-based automated feedback, and teachers' intentions to adopt such assessment systems in geography instruction.

As a follow-up to the quantitative phase, the FGD guide was developed based on the same constructs and dimensions as the questionnaire instrument. The aim was to explore teachers' experiences in conducting assessments, the obstacles they faced, their perceptions of AI use, their needs regarding the features of an AI-based assessment system, and the factors influencing their acceptance of this technology. The use of identical constructs in both instruments allows the qualitative data to provide a more in-depth explanation of the patterns found in the survey results while strengthening the validity of the interpretation through the integration of quantitative and qualitative data [53].

2.4. Instruments Validation and Reliability

Before being used in the study, the questionnaire and the Focus Group Discussion (FGD) guide underwent a content validation process through expert review to ensure the appropriateness of the content, clarity of the constructs, and relevance of each indicator to the study's objectives [54], [55]. The expert panel consisted of five validators representing expertise in the fields of geography education, educational evaluation and educational technology, leadership within the professional community of geography teachers, and secondary school management. The multidisciplinary composition of the panel allowed for a comprehensive evaluation of the instruments from conceptual, pedagogical, assessment, and implementation perspectives within the context of geography learning in schools.

Each validator assessed the relevance, clarity, and representativeness of each item in the instrument using a four-point scale. Content validity was then analyzed using the Item Content Validity Index (I-CVI) and the Scale Content Validity Index (S-CVI) [56], [57]. A summary of the validation results is presented in Table 4.

Table 4
Results of Content Validation of the Research Instruments

Validation Indicator	Result	Interpretation
Number of expert validators	5	Multidisciplinary expert panel
Number of questionnaire items	27	All items evaluated
I-CVI	0.80–1.00	All items met the acceptable threshold
S-CVI/Ave	0.933	Excellent content validity
S-CVI/UA	0.667	Acceptable universal agreement
Instrument revision	Minor revisions	Wording and terminology refined based on expert feedback
Final decision	Accepted	All items retained for data collection

Source: Authors' content validity analysis (2026).

The results of the analysis show that all items on the instrument obtained an I-CVI score between 0.80 and 1.00, indicating that each indicator meets the criteria for content validity. Furthermore, the S-CVI/Ave value of 0.933 indicates a level of excellent content validity, while the S-CVI/UA value of 0.667 indicates an acceptable level of universal agreement among the validators. Based on the feedback provided, several minor revisions were made to the wording of the items and to align technical terminology without altering the substance of the constructs being measured. All items were deemed suitable and were used in both the quantitative and qualitative data collection phases.

Before conducting the main analysis, the internal reliability of the instrument was evaluated using Cronbach's alpha. The test results showed a Cronbach's alpha value of 0.982, indicating a very high level of internal consistency (**see** Table 5). This value indicates that all 27 items of the instrument consistently measure the research construct and are therefore suitable for further analysis.

Table 5
Internal Reliability of the Research Instrument

Instrument	Number of Items	Cronbach's Alpha	Interpretation
Questionnaire	27	0.982	Excellent internal reliability

Source: Authors' analysis (2026).

2.5. Data Collection Procedures

Data collection was conducted in stages following an explanatory sequential mixed-methods design, beginning with quantitative data collection, followed by qualitative data collection to explain, confirm, and deepen the findings from the previous phase [39], [58]. This approach was chosen because it allows

for a more comprehensive understanding of the research phenomenon through the integration of quantitative and qualitative evidence within a single analytical framework [38], [43]. Prior to data collection, all participants received an explanation of the research objectives, procedures, data confidentiality, and their right to participate voluntarily through informed consent.

In the quantitative phase, questionnaires were distributed to 40 geography teachers who met all the study's inclusion criteria. The instrument, which had undergone a validation process, was used to collect data on assessment practices, the quality of feedback, student self-assessment, technological readiness, perceptions regarding the use of Artificial Intelligence (AI) in assessment, the need for AI-supported assessment systems, and teachers' intentions to adopt such systems in geography instruction. After all responses were collected, the data were screened for completeness, coded, and organized into a single database prior to quantitative analysis.

The results of the quantitative analysis then served as the basis for determining the focus of discussion in the qualitative phase. All survey respondents participated again in Focus Group Discussions (FGDs) to provide more in-depth explanations regarding the patterns that emerged in the questionnaire results. The FGD guide was designed to be semi-structured based on the research constructs so that the discussion remained focused while still allowing participants the space to explain their experiences, challenges, and needs more comprehensively. This strategy aligns with the characteristics of explanatory sequential mixed-methods, in which qualitative data is used to interpret quantitative results in greater depth [59].

All FGD sessions were facilitated by the researcher as moderator, documented through field notes and audio recordings with the participants' consent, and then transcribed verbatim for analysis. The survey results and FGD findings were integrated during the final interpretation stage to produce a more comprehensive understanding of the challenges faced by geography teachers in assessment and their needs regarding AI-supported assessment systems in the context of educational transformation in Indonesia [60].

2.6. Ethical Considerations

This study received ethical approval from the Health Research Ethics Committee at Kusuma Husada University in Surakarta, under number 3469/UKH.L02/EC/V/2026. Ethical approval was granted after the research protocol was deemed to comply with research ethics principles based on the WHO Standards (2011) and CIOMS Guidelines (2016), including scientific merit, the balance of benefits and risks, data confidentiality, and informed consent. Before data collection began, all participants received an explanation regarding the research objectives, implementation procedures, benefits of the study, their right to participate voluntarily, and their right to withdraw at any time without consequences. Informed consent was obtained from all teachers before they completed the questionnaire or participated in the Focus Group Discussion (FGD). Additionally, to maintain the confidentiality of information, the identities of all participants were anonymized during the analysis and reporting of research results. All questionnaire data, FGD transcripts, and supporting documents were used solely for academic purposes and stored securely so that they could only be accessed by the research team. These procedures were

implemented to ensure that the study adhered to the principles of respect for participants, data confidentiality, and scientific integrity throughout the research process.

2.7. Data Analysis

Data analysis was conducted in stages according to an explanatory sequential mixed-methods design, beginning with quantitative data analysis, followed by qualitative data analysis, and then integrated to produce a comprehensive interpretation of the research phenomenon [58], [59]. Before the main analysis was conducted, the quality of the questionnaire was evaluated through an internal reliability test using Cronbach's Alpha. This test aimed to ensure consistency among items in measuring the research construct. A Cronbach's Alpha value of ≥ 0.70 indicates acceptable reliability, while a value above 0.90 indicates very high reliability [61].

Next, the quantitative data were analyzed using descriptive statistics including mean, standard deviation, frequency, and percentage to describe trends in teachers' responses across each research dimension. The mean values for each dimension were then used to rank the needs by priority, thereby identifying the aspects that teachers prioritized most highly in the development of AI-supported assessment systems. A descriptive approach was chosen because this study employed total sampling (census) of the entire accessible population; thus, the analysis was aimed at comprehensively describing the characteristics of the study population without making inferences about a broader population [47], [53]. In the stage of identifying relationships among the research constructs, Spearman's rank-order correlation (ρ) analysis was conducted. This nonparametric test was chosen because the data came from a Likert scale, which is ordinal in nature and does not require a normal distribution. Spearman's correlation was used to evaluate the strength of the relationships between assessment practices, feedback quality, self-evaluation, technological readiness, perceptions of AI, needs for features in AI-supported assessment systems, needs for AI feedback, and teachers' intentions to adopt such systems [62], [63].

Qualitative data obtained through Focus Group Discussions (FGDs) were analyzed using reflexive thematic analysis, which involves familiarization with the data, initial coding, theme development, theme review, theme definition, and the construction of thematic narratives [64]. This approach allows for the identification of patterns of meaning that explain the challenges teachers face in assessment as well as their needs regarding AI-supported assessment systems [65]. The final stage involved integrating quantitative and qualitative results using a "connecting and building" strategy, in which survey analysis results served as the basis for exploration in the FGDs, while qualitative findings were used to explain, confirm, and enrich the interpretation of the quantitative results [39], [58]. The integration of these two types of data yields a deeper understanding of the assessment challenges faced by geography teachers and their needs regarding AI-supported assessment systems within the context of educational transformation in Indonesia.

3. Results

3.1. Descriptive Overview

Descriptive statistics were then used to provide an overview of the eight dimensions examined in this study. Table 6 presents the descriptive statistics for the eight research dimensions. Among them, “Behavioral Intention to Use an AI-Supported Assessment System” received the highest average score ($M = 18.55$, $SD = 5.124$), followed by “Features of AI-Supported Assessment” ($M = 14.93$, $SD = 3.339$). These findings indicate that geography teachers generally express a strong willingness to adopt an AI-supported assessment system, while also emphasizing the importance of assessment features capable of supporting the assessment process in the classroom. The other dimensions—including AI for Educational Assessment, Assessment Practices, Feedback Quality, AI-Generated Feedback, Self-Assessment Practices, and Technological Readiness showed relatively comparable average scores, indicating that teachers view these aspects as interrelated components that influence the successful implementation of AI-supported assessment systems.

Table 6
Descriptive Statistics of the Research Dimensions

Research Dimension	Mean	SD	Rank
Behavioural Intention to Use AI-Supported Assessment Systems	18.55	5.124	1
AI-Supported Assessment Features	14.93	3.339	2
AI for Educational Assessment	11.38	2.959	3
Assessment Practices	11.23	2.878	4
Feedback Quality	11.10	3.045	5
AI-Generated Feedback	11.08	2.999	6
Self-Assessment Practices	11.05	2.943	7
Technology Readiness	10.78	2.636	8

Source: Authors' analysis (2026).

The findings in Table 6, show that “Behavioral Intention to Use AI-Supported Assessment Systems” received the highest average score, followed by “AI-Supported Assessment Features” and “AI for Educational Assessment.” These results indicate that geography teachers generally have a strong intention to adopt AI-based assessment systems and view AI as a technology with the potential to improve the quality of the assessment process. On the other hand, the dimensions of Assessment Practices, Feedback Quality, AI-Generated Feedback, Self-Assessment Practices, and Technology Readiness received relatively comparable scores. This pattern indicates that teachers view assessment practices, feedback quality, technology readiness, and AI support as interrelated components in supporting the implementation of AI-based assessment systems.

Overall, all dimensions of the study showed a trend toward high scores, indicating that teachers already have sufficient experience in conducting assessments while also demonstrating a positive attitude

toward the use of AI in education. However, differences in score levels across dimensions indicate that teachers’ readiness to adopt AI is not solely determined by the availability of technology but is also influenced by challenges they still face in daily assessment practices, particularly in providing feedback, conducting ongoing assessments, and monitoring students’ learning progress.

These preliminary findings suggest that teachers’ need for AI-supported assessment systems stems from the assessment challenges they experience in the classroom, rather than solely from an interest in using technology. Therefore, the following section details the assessment challenges faced by teachers, their prioritized needs for AI features, and the relationships among the dimensions that shape these needs.

3.2. Assessment Challenges Experienced by Geography Teachers

The statistical results (see Table 5) show that the dimensions of Assessment Practices, Feedback Quality, and Self-Assessment Practices obtained relatively similar mean scores of 11.23 (SD = 2.878), 11.10 (SD = 3.045), and 11.05 (SD = 2.943), respectively. These findings indicate that assessment challenges are not only related to the implementation of the assessment itself but also to the quality of feedback and the development of students’ self-assessment skills. To further explain these quantitative findings, an analysis of the Focus Group Discussion (FGD) results was conducted. A summary of the FGD findings is presented in Table 7.

Table 7
Summary of FGD Findings on Assessment Challenges

Theme	Representative Findings	Interpretation
Assessment Practices	Teachers routinely conduct formative and summative assessments, but the use of assessment results as a basis for adjusting instruction has not been optimized due to time constraints.	Assessment has been implemented regularly, but assessment for learning has not been fully optimized.
Feedback Quality	Teachers have difficulty providing individual feedback to all students due to the large number of students and their administrative workload.	Personalized feedback remains one of the main assessment challenges.
Self-Assessment Practices	Students are not yet accustomed to reflecting on their learning outcomes and still need guidance from their teachers.	Students' self-assessment skills are still developing and require instructional support.

Source: Focus Group Discussion analysis (2026).

Findings from the FGD indicate that teachers have generally implemented formative and summative assessments in geography instruction. However, most teachers reported that assessment results have not been fully utilized as a basis for follow-up instruction due to time constraints, heavy administrative burdens, and large class sizes. These conditions have prevented the provision of individualized feedback

from being carried out optimally. In addition, teachers also explained that students’ ability to engage in self-evaluation remains relatively low. Although the deep learning approach and the Merdeka Curriculum encourage learning reflection, most students still require teacher guidance to identify their strengths, weaknesses, and strategies for improving their learning. Thus, the challenges of assessment lie not only in the evaluation process but also in the effort to make assessment a tool for learning (assessment for learning). Overall, the integration of quantitative and qualitative results indicates that the main challenges for Geography teachers do not lie in the implementation of assessment, but rather in providing high-quality feedback, utilizing assessment results sustainably, and strengthening students’ self-evaluation skills. These findings serve as a crucial foundation for identifying teachers’ needs regarding AI-supported assessment systems, which are discussed in the following section.

3.3. Teachers' Needs for AI-Supported Assessment Systems

The results of the descriptive statistics indicate that geography teachers have a high need for the development of AI-supported assessment systems, as reflected in two main dimensions: AI-Supported Assessment Features (M = 14.93; SD = 3.339) and AI-Generated Feedback (M = 11.08; SD = 2.999) (see Table 6). Furthermore, the “Behavioral Intention to Use AI-Supported Assessment Systems” dimension received the highest mean score among all research dimensions (M = 18.55; SD = 5.124), indicating that teachers are ready to adopt AI-based assessment systems if such systems can address real needs in classroom assessment practices. These findings suggest that teachers view AI not only as a technological innovation but also as a potential solution for improving the effectiveness of the learning assessment process. Table 8, presents teachers’ priority needs regarding AI-based assessment systems based on the survey results.

Table 8
Quantitative Priorities for AI-Supported Assessment Systems

Priority	Research Dimension	Mean	SD	Interpretation
1	Behavioural Intention to Use AI-Supported Assessment Systems	18.55	5.124	Teachers demonstrate a strong willingness to adopt AI-supported assessment systems.
2	AI-Supported Assessment Features	14.93	3.339	Teachers prioritize intelligent assessment features that support classroom assessment.
3	AI for Educational Assessment	11.38	2.959	Teachers perceive AI as beneficial for improving assessment quality.
4	AI-Generated Feedback	11.08	2.999	Teachers expect AI to provide immediate and meaningful feedback to students.

Source: Authors' analysis (2026).

These quantitative findings were then explored in greater depth through Focus Group Discussions (FGDs). Teachers explained that the AI-based assessment system they envisioned should not only be capable of automatic scoring but also support the entire assessment cycle—from instrument development and analysis of learning outcomes to providing feedback and formulating recommendations for follow-up learning activities. A summary of teachers’ key needs regarding AI features is presented in Table 9.

Table 9
Summary of FGD Findings on Teachers' Needs for AI-Supported Assessment Systems

Theme	Representative Findings	Educational Implication
Intelligent Question Bank	Teachers expect a question bank that is varied, contextual, and aligned with the Geography learning outcomes.	AI should assist teachers in generating curriculum-aligned assessment items efficiently.
Learning Analytics	Teachers need automated analysis of learning outcomes, conceptual weaknesses, and changes in student learning over time. Furthermore, simplifying and optimizing this feedback helps reduce teachers’ administrative workload.	AI should provide learning analytics to support evidence-based instructional decisions.
AI-Generated Feedback	Teachers hope the system will be able to provide immediate feedback, explain why an answer is incorrect, and recommend material that needs to be reviewed.	AI should facilitate timely, personalized, and formative feedback for students.
Student Progress Monitoring	Teachers want to see a continuous visualization of students' competency development.	AI should support continuous monitoring of student learning trajectories.
Ease of Use and Integration	The teacher emphasized that the system must be easy to use, in line with the Merdeka Curriculum, and not add to the administrative burden.	User-centered design and pedagogical alignment are essential for successful implementation.

Source: Focus Group Discussion analysis (2026).

The FGD findings indicate that teachers view AI as assistive technology designed to enhance the quality of assessment, rather than to replace the teacher’s professional role in evaluating learning. The most frequently expressed needs relate to the system’s ability to automate administrative tasks, provide comprehensive analysis of learning outcomes, and generate rapid and personalized feedback for each student. Teachers also emphasized that AI-based assessment systems must be able to generate information that is easy to interpret so that it can be used as a basis for developing subsequent learning strategies. Interestingly, teachers not only expect efficiency through automation but also want AI systems to support the process of assessment for learning. This is reflected in the high demand for features that can explain incorrect answers, provide recommendations on material that needs to be reviewed, and continuously track students’ competency development. Thus, AI is perceived as a tool to

strengthen the formative assessment function while improving the quality of pedagogical decision-making.

Overall, the integration of quantitative results and FGD findings indicates that teachers' needs regarding AI-supported assessment systems center on the development of systems that are pedagogically meaningful, easy to use, and instructionally actionable. Teachers expect AI not only to improve assessment efficiency but also to generate information that can be directly used to improve the learning process. These findings demonstrate that the success of AI implementation in assessment is determined more by its alignment with teachers' pedagogical needs than by technological sophistication alone, thereby providing an empirical basis for the development of user-need-driven AI-supported assessment systems).

3.4. Relationships among Assessment Challenges, AI Perceptions, and Teachers' Needs

This study identified the relationships among the research constructs; therefore, an analysis was conducted using Spearman's rank-order correlation. The results of the analysis showed that all relationships among the dimensions were positive and significant ($p < 0.001$), with correlation coefficients ranging from $\rho = 0.772$ to 0.901 , indicating strong to very strong relationships among the research constructs. A summary of the main relationships is presented in Table 10, and Fig. 4 presents an 8×8 correlation heatmap. This visualization shows that nearly all relationships fall within the range of $0.80\text{--}0.90$.

Table 10
Spearman Correlation among Research Dimension

Relationship	Spearman's ρ	Strength	p-value
Assessment Practices ↔ Feedback Quality	0.822	Very strong	< 0.001
Assessment Practices ↔ Self-Assessment Practices	0.862	Very strong	< 0.001
Assessment Practices ↔ Technology Readiness	0.880	Very strong	< 0.001
Assessment Practices ↔ AI for Educational Assessment	0.871	Very strong	< 0.001
Assessment Practices ↔ AI-Supported Assessment Features	0.845	Very strong	< 0.001
Assessment Practices ↔ AI-Generated Feedback	0.830	Very strong	< 0.001
Assessment Practices ↔ Behavioural Intention	0.879	Very strong	< 0.001
Feedback Quality ↔ AI-Supported Assessment Features	0.889	Very strong	< 0.001
AI for Educational Assessment ↔ Behavioural Intention	0.887	Very strong	< 0.001
AI-Supported Assessment Features ↔ Behavioural Intention	0.901	Very strong	< 0.001
Note: Spearman's rank-order correlation (n = 40); all correlations were significant at the 0.01 level (two-tailed).			

Source: Authors' analysis (2026).

The findings indicate that Assessment Practices have a very strong relationship with all other dimensions, including Feedback Quality ($\rho = 0.822$), Self-Assessment Practices ($\rho = 0.862$), Technology Readiness ($\rho = 0.880$), AI for Educational Assessment ($\rho = 0.871$), AI-Supported Assessment Features ($\rho = 0.845$), AI -Generated Feedback ($\rho = 0.830$), and Behavioural Intention to Use AI-Supported Assessment Systems ($\rho = 0.879$). These patterns indicate that teachers' experiences in conducting assessments are closely linked to their technology readiness, perceptions of AI, and their needs and intentions to adopt AI-based assessment systems. A very strong relationship was also found between Feedback Quality and AI-Supported Assessment Features ($\rho = 0.889$), indicating that the greater the challenges teachers face in providing quality feedback, the higher their need for AI features capable of supporting the assessment process. These findings reinforce the results of the focus group discussions (FGDs), which showed that teachers need a system that can automate the analysis of learning outcomes while providing feedback that is prompt, personalized, and easy to act upon.

Among all the relationships analyzed, the highest correlation was found between AI-Supported Assessment Features and Behavioural Intention to Use AI-Supported Assessment Systems ($\rho = 0.901$). These results indicate that teachers' intention to adopt AI-based assessment systems is strongly influenced by the extent to which these systems provide features that align with learning needs, such as adaptive question banks, automated analysis of learning outcomes, visualization of students'

competency development, and recommendations for follow-up learning activities. Furthermore, the very strong relationship between AI for Educational Assessment and Behavioural Intention ($\rho = 0.887$) indicates that positive perceptions of the benefits of AI also strengthen teachers' readiness to integrate this technology into their assessment practices. Overall, the results of the correlation analysis show that assessment challenges, technological readiness, perceptions of AI, the need for AI features, and usage intentions form an interconnected ecosystem. These findings suggest that the adoption of AI-supported assessment systems is not solely determined by the availability of technology but is also influenced by teachers' experiences in conducting assessments and the extent to which AI systems can address the pedagogical needs arising from teaching practices. Therefore, the development of AI-based assessment systems must prioritize a teacher-centered and need-driven approach, ensuring that the technology developed truly supports the improvement of assessment quality in the classroom.

3.5. Integrated Implications for AI-Supported Assessment Systems

The research findings indicate that teachers' needs for AI-supported assessment systems are shaped by the interplay between assessment challenges, technological readiness, perceptions of Artificial Intelligence (AI), and the need for assessment features that support teaching practices. The integration of quantitative results and findings from Focus Group Discussions (FGDs) indicates that teachers view AI not as a replacement for the teacher's role, but rather as assistive technology that can improve the quality of assessment more effectively and efficiently.

Quantitative analysis shows that teachers have a strong intention to adopt AI-based assessment systems, accompanied by a strong need for intelligent assessment features and automated feedback. These findings are reinforced by the results of the focus group discussions (FGDs), which revealed that teachers expect AI systems to assist in the development of assessment instruments, the analysis of learning outcomes, the provision of personalized feedback, the monitoring of students' competency development, and the formulation of recommendations for follow-up learning activities. Thus, teachers' needs regarding AI are not only oriented toward administrative efficiency but also toward improving the quality of pedagogical decisions resulting from the assessment process. To clarify the integration between the two phases of the research, Table 11, presents a joint display linking the quantitative findings, FGD results, and their implications for the development of AI-supported assessment systems.

Table 11
Joint Display of Quantitative and Qualitative Findings

Quantitative Findings	Supporting FGD Findings	Implications for AI-Supported Assessment Systems
Assessment practices were implemented consistently, but teachers experienced challenges in maximizing assessment quality.	Teachers explained that limited instructional time, administrative workload, and large class sizes constrained the implementation of meaningful assessment.	AI should automate routine assessment processes, allowing teachers to focus on instructional improvement.
Feedback quality showed one of the greatest assessment challenges.	Teachers reported difficulties providing timely and individualized feedback for every student.	AI should generate immediate, personalized, and formative feedback after assessment completion.
Students' self-assessment practices remained limited.	Teachers indicated that students still required substantial guidance to reflect on their own learning progress.	AI should facilitate reflective learning through automated feedback and personalized learning recommendations.
Teachers demonstrated positive perceptions of AI in educational assessment.	Teachers viewed AI as a professional support tool rather than a replacement for teachers' roles.	AI systems should be designed to complement teachers' pedagogical decision-making rather than replace human judgment.
High demand for AI-supported assessment features and behavioural intention to use AI.	Teachers prioritized intelligent question banks, learning analytics, competency mapping, and progress monitoring.	AI-supported assessment systems should integrate adaptive assessment, learning analytics, and curriculum-aligned reporting within a single platform.

Source: Integrated analysis of quantitative survey and Focus Group Discussion (2026).

The integration of the two phases of the study reveals that the relationship between assessment challenges and the need for AI is systemic. Teachers who face difficulties in providing feedback, monitoring learning progress, and conducting ongoing assessments tend to express a greater need for AI systems capable of supporting these tasks. Therefore, the need for AI cannot be understood merely as a consequence of digital technology advancements, but rather as a response to the complexities of assessment that teachers face in their daily teaching practices.

These findings suggest that the development of AI-supported assessment systems should adopt a teacher-centered and need-driven approach, in which system design is based on teachers' pedagogical needs rather than solely on technological capabilities. In the context of geography education, an AI-based assessment system should ideally integrate an adaptive question bank, analysis of learning outcomes, visualization of competency development, automated formative feedback, and recommendations for follow-up learning. Thus, AI not only enhances the efficiency of assessment but also strengthens the role of assessment as a tool to support learning (assessment for learning) and data-driven pedagogical decision-making.

4. Discussion

4.1. Assessment Challenges Beyond Assessment Implementation

The findings of this study indicate that the challenges faced by Geography teachers in assessment no longer center on the ability to conduct assessments, but rather on how assessments can be utilized as part of a continuous learning process. This shift reflects a paradigm shift from assessment as a tool for measuring learning outcomes to assessment as a means of supporting learning (assessment for learning), making the quality of follow-up actions after assessment more important than the assessment itself. This perspective aligns with the concept of “intelligent accountability,” which emphasizes that the value of assessment lies in its ability to generate information used to improve the learning process, rather than merely fulfilling academic evaluation requirements [66]. One of the main issues that has emerged is the limitation of teachers in providing high-quality and sustained feedback to each student. This finding is consistent with the “teacher feedback literacy” framework, which explains that the effectiveness of feedback is influenced not only by the quality of the information provided but also by teachers’ capacity to design, deliver, and utilize feedback as part of the learning process [67]. Thus, the main challenge does not lie in teachers’ lack of understanding regarding the importance of feedback, but rather in time constraints, workload, and the complexity of managing classroom assessments.

These findings also support the view that the effectiveness of feedback requires active learner engagement, not merely the transmission of information from the teacher. Carless [68], emphasizes that modern assessment positions learners as the primary agents in interpreting and using feedback to enhance learning. However, this study indicates that this process has not yet been optimized because learners’ ability to reflect on their learning outcomes remains limited. The limitations of self-assessment practices identified in this study align with the results of a meta-analysis by Yan et al. [69], which showed that the benefits of self-assessment are highly dependent on the presence of explicit guidelines, a clear assessment structure, and feedback support throughout the learning process. In other words, self-assessment cannot develop effectively if students are merely asked to reflect without receiving adequate scaffolding.

Furthermore, Panadero et al. [70], suggest that self-evaluation skills develop through a process of self-feedback that is, learners’ ability to interpret information about their learning outcomes and use it as a basis for improving their future learning. This perspective reinforces the findings of this study that assessment challenges are not only related to teachers’ ability to provide feedback but also to the learning system’s ability to help students develop self-regulated learning. The findings of this study also show that assessment challenges are becoming increasingly complex amid the digital transformation of education. While the digitization of assessment opens opportunities to improve the efficiency of the evaluation process, it simultaneously presents new challenges in data management, the provision of feedback, and the adaptation of assessment practices [71], [72]. Therefore, the need for assessment

innovation is driven not only by technological advancements but also by the increasing complexity of the pedagogical demands faced by teachers.

In this context, the findings of this study contribute by demonstrating that the assessment challenges faced by Geography teachers in Indonesia are better understood as pedagogical challenges rather than technical challenges. This means that the main issue does not lie solely in the implementation of assessments or the use of technology, but rather in how teachers can provide meaningful feedback, encourage student reflection, and utilize assessment information to support instructional decision-making. These findings serve as a crucial foundation for the development of an Artificial Intelligence-based assessment system oriented toward teachers' pedagogical needs, which is discussed in the following subsection.

4.2. Teachers' Needs for AI-Supported Assessment Systems

The findings of this study indicate that teachers' need for AI-supported assessment systems is not driven solely by technological advancements, but by the need to improve the quality of assessment a need that cannot yet be fully met through conventional practices. Teachers view AI as a means to strengthen the assessment process, particularly in providing faster feedback, more comprehensive analysis of learning outcomes, and continuous monitoring of students' competency development [73], [74]. Thus, the need for AI reflects an effort to improve the quality of pedagogical decisions rather than merely automating administrative tasks. This interpretation aligns with the concept of the digital transformation of assessment, which positions digital technology as a tool to strengthen the role of assessment in supporting learning, rather than merely replacing conventional evaluation procedures [75], [76]. From this perspective, effective digital transformation must generate information that is relevant, easy to interpret, and usable by teachers as a basis for making instructional decisions [77]. The findings of this study indicate that teachers' expectations regarding AI are also moving in this direction toward supporting assessment that is more adaptive, informative, and learning-oriented.

Teachers' need for features such as automated learning achievement analysis, content recommendations, and personalized feedback is also consistent with the latest developments in Generative Artificial Intelligence in the field of education. Ahmed et al. [78], explain that the primary value of Generative AI lies not only in its ability to automatically generate content but also in its potential to provide a more personalized learning experience through data analysis and recommendations tailored to students' needs. This perspective supports the findings of this study that teachers expect AI to serve as an instructional assistant that helps interpret assessment results and guide follow-up learning. Interestingly, the teachers in this study did not show a tendency to delegate the assessment process entirely to AI. Instead, they viewed AI as a supportive tool that still requires professional oversight from teachers. This finding aligns with the research by Nikolic et al. [79], which shows that although Generative AI has a high capacity for completing various forms of assessment, its use in education still requires human oversight to maintain validity, academic integrity, and the quality of evaluation. Thus,

teachers' acceptance of AI in this study leans more toward a human-AI collaboration model than toward the full automation of the assessment process.

This perspective is also consistent with Kooli's discussion [80], which emphasizes that the implementation of AI in education must take into account ethical, transparency, and accountability considerations. AI-based assessment systems are not only required to generate accurate recommendations but must also be able to explain the basis for their decision-making so that teachers can still verify the results and exercise their professional judgment. Teachers' need for features that explain the reasons for incorrect answers and provide learning recommendations in this study indicates that explainability is one of the key characteristics expected of AI systems in education. Conceptually, the findings of this study expand the literature on AI in Education by demonstrating that teachers' needs for AI-based assessment systems stem from the pedagogical challenges they face in their daily teaching practices. Unlike many previous studies that focused on the technical capabilities or performance of AI algorithms, the results of this study indicate that the success of AI implementation is more determined by its alignment with teachers' assessment needs. Therefore, the development of AI-supported assessment systems must adopt a teacher-centered and need-driven approach, ensuring that every feature developed genuinely supports the formative assessment process, strengthens pedagogical decision-making, and continuously improves the quality of learning.

4.3. From Technology Acceptance to Teacher-Centred AI Design

The findings of this study indicate that technological readiness and positive perceptions of Artificial Intelligence (AI) do not automatically guarantee the effective implementation of AI in assessment practices. Although most teachers have participated in various training programs on digital transformation, the implementation of the Merdeka Curriculum, and the use of AI in learning, they still face challenges in translating that knowledge into assessment practices capable of providing high-quality feedback, supporting learning reflection, and generating data-driven learning decisions. These findings suggest that the adoption of AI in education is influenced not only by the level of technology acceptance but also by the alignment between the system's capabilities and teachers' pedagogical needs. This interpretation expands upon the research by Velli & Zafiroopoulos [81], which indicated that perceptions of benefits and ease of use are key factors in teachers' acceptance of AI. This study indicates that although both factors have shown positive development, teachers still require systems capable of addressing the assessment challenges they face in the context of daily teaching. Thus, the relationship between technology acceptance and AI implementation is contextual and influenced by the relevance of AI features to pedagogical practices.

These findings also support a teacher-centered AI design approach, which positions teachers as the primary actors in the process of designing and implementing educational technology. Lawrence et al. [82] emphasize that the success of AI systems in schools depends on the extent to which teachers have control over learning decisions, while AI serves as a partner supporting the orchestration of the learning

process. This perspective aligns with the results of this study, which show that teachers want AI to assist with assessment analysis and the provision of feedback, while still maintaining the teacher's professional role in interpreting learning outcomes and determining follow-up learning activities. Furthermore, the results of this study indicate that teachers' needs are not only related to AI literacy but also to the ability to integrate AI into learning strategies. This finding is consistent with the review by Ng et al. [83], which explains that the development of AI literacy in secondary schools needs to go beyond technological proficiency and include an understanding of how AI can be used responsibly to support learning and assessment processes. Therefore, efforts to enhance teachers' competencies should not stop at training in the use of AI applications but should also include strengthening their pedagogical competencies in designing assessments that effectively utilize AI.

In the context of developing countries, the findings of this study have broader implications. Various studies indicate that the implementation of AI in developing countries still faces limitations in digital infrastructure, human resource readiness, institutional support, and access to high-quality educational technology [84]. This study shows that even when teachers have received training and hold positive attitudes toward technology, implementation challenges persist if the AI system has not been designed to meet the actual needs of the classroom. Thus, barriers to AI adoption are not merely technical but also stem from the gap between technological innovation and pedagogical needs. These findings reinforce Landa-Blanco's [85], argument that AI implementation in low- and middle-income countries must account for local characteristics, resource constraints, and teachers' professional capacities. In the Indonesian context, these needs are becoming increasingly relevant because the implementation of the Merdeka Curriculum and deep learning requires assessments that are more formative, adaptive, and oriented toward competency development. Therefore, the development of AI systems cannot directly adopt models developed in developed countries but requires adaptation to the local educational context.

The findings of this study also contribute to the discourse on human-centered Artificial Intelligence in education. Creely & Carabott [86] emphasize that AI should function as part of a pedagogical ecosystem that strengthens collaboration between technology and teachers, rather than replacing professional decision-making. The results of this study show that teachers are more receptive to AI when the technology reduces the administrative burden of assessment while simultaneously improving the quality of information used to support learning. Thus, acceptance of AI evolves from a "technology acceptance" paradigm toward "pedagogical acceptance" that is, acceptance based on the added value AI brings to teaching practices. Conceptually, this study proposes that the design of AI-supported assessment systems needs to shift from a technology-driven approach toward a teacher-centered and need-driven design. This shift positions teachers' assessment challenges as the starting point for AI system development, ensuring that every feature developed has direct relevance to classroom assessment practices. This conceptual framework is summarized in Fig. 4, which illustrates how assessment challenges, pedagogical needs, AI features, teacher readiness, and usage intentions form a model for developing AI-based assessment systems oriented toward teachers' needs, particularly in the context of education in developing countries.

4.4. Translating Teachers' Needs into AI System Requirements

To highlight the practical implications of these findings for Artificial Intelligence (AI) research and the development of educational technology, the assessment challenges identified in this study can be interpreted as appropriate AI capabilities and expected learning outcomes. Rather than viewing AI as a standalone technological innovation, these findings suggest that AI functions should be designed as a direct response to the pedagogical challenges faced by teachers. This aligns with recent research indicating that interpretation can serve as a practical bridge between empirical evidence and AI system design, while also providing guidance for the future development of teacher-centered AI-based assessment systems [73], [84], [87].

Table 12
Translating Teachers' Assessment Challenges into AI System Capabilities

Teacher Challenge	Required AI Capability	Expected Educational Benefit
Delayed and inconsistent feedback due to limited instructional time	Generative AI-based feedback generation capable of producing immediate, contextual, and formative feedback	Immediate formative feedback that supports learning while reducing teachers' workload
Heavy administrative workload during assessment	Automated assessment analytics for scoring, summarising performance, and generating reports	Reduced administrative burden, allowing teachers to focus on instructional improvement
Difficulty monitoring individual students' learning progress over time	Learning analytics and student progress dashboards that continuously visualise competency development	Early identification of learning difficulties and timely pedagogical intervention
Limited ability to personalise assessment and follow-up instruction	AI recommendation engine that suggests adaptive assessment items and personalised learning pathways	More personalised assessment and adaptive learning support
Difficulty identifying students' conceptual misconceptions	Natural Language Processing (NLP) and misconception detection to analyse student responses	Faster identification of learning misconceptions and evidence-based instructional decisions
Difficulty constructing curriculum-aligned assessment tasks	AI-assisted intelligent item generation aligned with curriculum standards and learning outcomes	More efficient development of valid, contextual, and curriculum-aligned assessments
Limited use of assessment results for instructional planning	AI-supported pedagogical decision support integrating assessment analytics with instructional recommendations	Data-informed instructional planning and continuous improvement of classroom assessment

Source: Summary of Research Findings, (2026)

Based on Table 12, demonstrates that teachers' assessment challenges can be systematically translated into specific AI functionalities rather than generic technological solutions. The findings indicate that AI adoption should be conceptualised as a problem-driven rather than technology-driven process, where each AI capability directly addresses a pedagogical need identified by teachers. This perspective extends previous studies that primarily focused on AI acceptance, technological performance, or the capabilities of generative AI in educational assessment [88], [89]. Recent studies have argued that the educational value of AI depends not only on algorithmic performance but also on its alignment with authentic teaching practices, transparency, and teachers' professional decision-making [72], [90]. Consistent with these arguments, the present findings demonstrate that teachers prioritise AI functionalities that directly support formative assessment, including personalised feedback, learning analytics, adaptive assessment, and curriculum-aligned instructional recommendations. Consequently, successful AI-supported assessment systems should prioritise pedagogical relevance, explainability, and usability alongside technological sophistication, ensuring that AI serves as an instructional partner rather than merely an automation tool. Furthermore, educators can employ artificial intelligence in the classroom to deliver individualized instruction, thereby augmenting students' competencies and cultivating 21st-century capabilities [91], [92].

4.5. Implications for AI-Supported Assessment Systems in Developing Countries

The findings of this study indicate that the successful implementation of AI-supported assessment systems is not determined solely by technological advancements or user readiness, but by the extent to which these systems can address teachers' pedagogical needs in their daily assessment practices. Based on the integration of quantitative and qualitative results, this study proposes the Teacher-Centered AI-Supported Assessment Framework (Fig. 5), a conceptual framework that positions teachers' assessment challenges as the starting point for the development of Artificial Intelligence (AI)-based assessment systems.

Within this conceptual framework (Fig. 5), AI is positioned as an assistive technology that enhances teachers' pedagogical decision-making, rather than as a substitute for the teacher's professional role in the assessment process. The proposed conceptual framework broadens our understanding of AI adoption in education. Most previous research has examined the acceptance of AI based on factors such as perceived benefits, ease of use, or technological readiness. However, the results of this study indicate that acceptance of AI increases when the technology is able to provide solutions to the real assessment challenges faced by teachers, such as providing rapid feedback, analyzing learning outcomes, monitoring competency development, and generating recommendations for follow-up learning activities. Thus, pedagogical needs serve as the mechanism linking assessment challenges to teachers' intentions to adopt AI.

These findings align with the concept of teacher-centered AI design proposed by Lawrence et al. [82], which emphasizes that teachers must remain the primary decision-makers in the learning process, while

AI functions as a partner supporting the orchestration of learning. This study extends that concept to the context of assessment by demonstrating that the AI features teachers expect are not intended to replace the evaluation process, but rather to enhance the quality of information generated from assessments so that it can be utilized in instructional decision-making. The findings of this study also support the AI-based pedagogical model proposed by Creely & Carabott [86], which asserts that the success of AI integration depends on its ability to become part of pedagogical practice, not merely as a technological innovation. In the context of this study, teachers expect AI to be able to integrate various assessment functions such as learning achievement analysis, competency mapping, automated feedback, and learning recommendations into a single system that supports the continuous implementation of formative assessment.

The implications of this research are particularly significant in the context of developing countries. Various studies indicate that the implementation of AI in developing countries still faces numerous obstacles, such as limitations in digital infrastructure, human resource readiness, institutional capacity, and disparities in access to educational technology [84]. Nevertheless, the results of this study suggest that the challenges of implementing AI are not only related to technical aspects but also to the alignment of the technology with teachers' needs in the classroom. Therefore, investment in the development of educational AI must be accompanied by a deep understanding of assessment practices and teachers' professional needs. This perspective reinforces the argument put forth by Landa-Blanco [85], who states that the implementation of AI in low- and middle-income countries requires adaptation to local characteristics rather than simply adopting technologies developed in developed nations. In the Indonesian context, the implementation of the Merdeka Curriculum and deep learning demands assessments that are more authentic, formative, and competency-oriented. Therefore, the development of AI-supported assessment systems must be designed in accordance with the characteristics of the national curriculum, teachers' capacities, and school conditions so that they can provide tangible benefits for teaching practices.

Theoretically, this study proposes a shift in perspective from technology-driven AI adoption toward teacher-centered and need-driven AI design. This shift indicates that the development of educational AI systems should not begin with available technological capabilities but rather with the identification of the assessment challenges faced by teachers. Consequently, AI features are developed in response to real pedagogical needs, thereby enhancing the relevance, acceptability, and sustainability of technology implementation in education. As a practical implication, the Teacher-Centered AI-Supported Assessment Framework presented in Fig. 5 can serve as a guide for educational technology developers, policymakers, and researchers in designing more context-specific AI-based assessment systems. This framework emphasizes that AI should be developed to help teachers provide faster feedback, interpret learning outcome data more comprehensively, monitor students' competency development, and support assessment as an integral part of the learning process (assessment for learning). Thus, the use of AI not only improves the efficiency of assessment but also enhances the quality of learning, particularly in the context of developing countries that are undergoing technology-based educational transformation.

5. Limitations

This study should be understood within the scope of its design and research context. First, the study was conducted among high school geography teachers in Surakarta who have implemented the Merdeka Curriculum and deep learning; thus, the findings reflect teachers' needs in the context of implementing these educational policies. Therefore, the transferability of the findings to different subjects, educational levels, or educational systems requires further empirical study. Second, this study focuses on identifying teachers' needs and developing a Teacher-Centered AI-Supported Assessment Framework based on the integration of quantitative and qualitative data; thus, it does not yet cover the stages of development, implementation, or evaluation of the effectiveness of the proposed AI system. Future research could validate this conceptual framework through system development, experimental studies, or cross-context implementation to test its validity and scalability.

6. Conclusions

This study shows that the development of AI-supported assessment systems must be grounded in an understanding of teachers' pedagogical needs, rather than solely in advancements in Artificial Intelligence (AI) technology. The findings indicate that the assessment challenges faced by teachers relate to providing meaningful feedback, utilizing assessment results to support learning, and the need for more comprehensive information in making pedagogical decisions. These conditions suggest that acceptance of AI is determined not only by technological readiness but also by the system's ability to address real-world assessment challenges in the classroom. Based on the integration of quantitative and qualitative findings, this study proposes the Teacher-Centered AI-Supported Assessment Framework as a conceptual contribution that places teachers' assessment challenges at the core of AI-based assessment system design. This framework broadens the perspective on AI adoption in education by shifting the focus from a technology-driven approach toward a teacher-centered and need-driven AI design, thereby directing AI development to strengthen pedagogical decision-making, improve the quality of formative assessment, and support learner-centered learning. In practical terms, this research provides a foundation for educational technology developers, schools, and policymakers to design AI-based assessment systems that are more contextual, adaptive, and aligned with teachers' needs. These findings also have broader implications for developing countries, suggesting that digital transformation in assessment requires not only infrastructure and technological readiness but also AI designs oriented toward pedagogical practices, so that their implementation can have a sustainable impact on improving the quality of learning.

Declarations

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Competing Interests

The authors declare that they have no competing interests.

Ethics Approval

This study was approved by the Health Research Ethics Committee, Kusuma Husada University of Surakarta, Indonesia (Ethical Approval No. 3469/UKH.L02/EC/V/2026). The ethical approval was granted on May 18, 2026, and is valid until May 18, 2027. All procedures involving human participants were conducted in accordance with the ethical standards of the institutional research ethics committee, the 2016 CIOMS Guidelines, and the principles of the Declaration of Helsinki.

Use of Artificial Intelligence

Generative artificial intelligence tools were used solely to improve the language, grammar, and readability of the manuscript. All scientific content, including the study design, data collection, data analysis, interpretation of findings, and conclusions, was developed, critically reviewed, and verified by the authors. The authors take full responsibility for the content of this manuscript.

Author Contributions

S: Conceptualization, Funding Acquisition, Project Administration, Supervision, Writing—Review & Editing. **RN:** Methodology, Validation, Supervision, Writing—Review & Editing. **IDP:** Formal Analysis, Validation, Writing—Review & Editing. **AEJKN:** Investigation, Data Curation, Formal Analysis, Visualization, Writing—Original Draft. **NPF:** Validation, Resources, Writing—Review & Editing. All authors read and approved the final manuscript.

Consent to Participate

Written informed consent was obtained from all participants prior to data collection. Participation was voluntary, and all participants were informed about the purpose of the study, the confidentiality of their responses, and their right to withdraw from the study at any time without any consequences.

Consent for Publication

All authors have reviewed and approved the final manuscript and have given their consent for its publication.

Data Availability

The datasets generated and analyzed during the current study are available from the corresponding author upon reasonable request.

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Figures

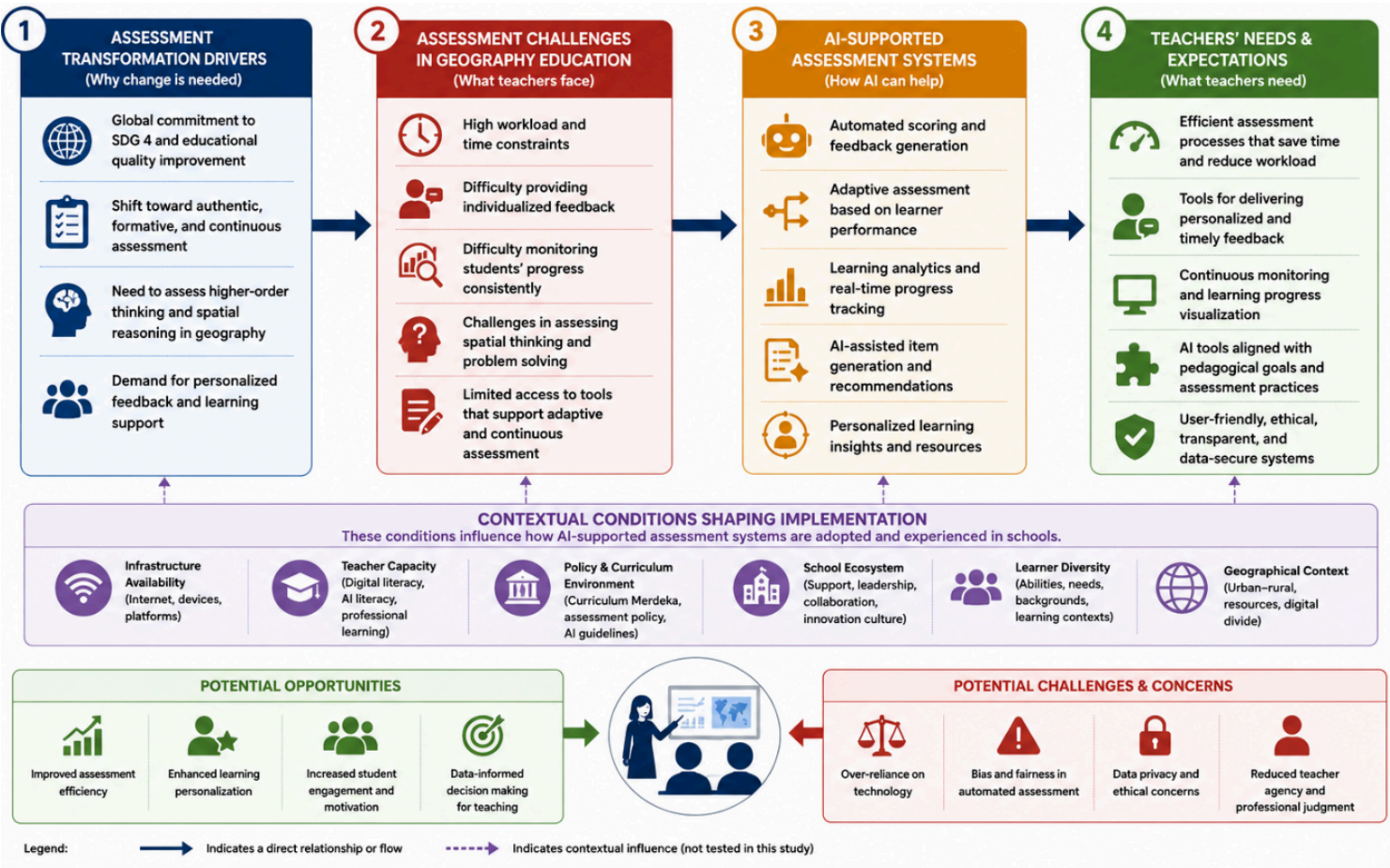


Figure 1

Conceptual Framework of AI-Supported Assessment in Geography Education

Source: Developed by the authors based on literature synthesis (2026).

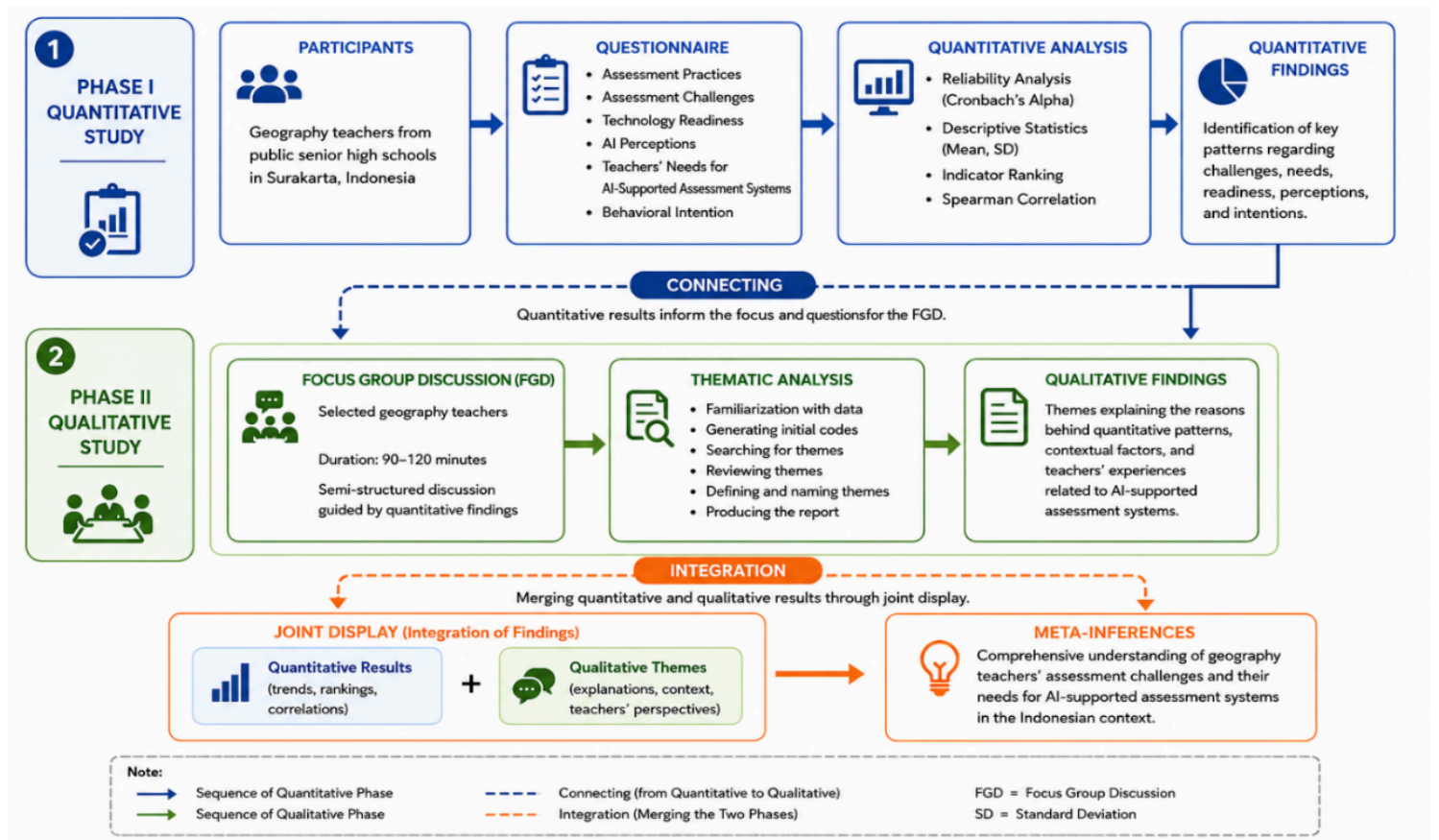


Figure 2

Research Design

Source: Developed by the authors (2026)

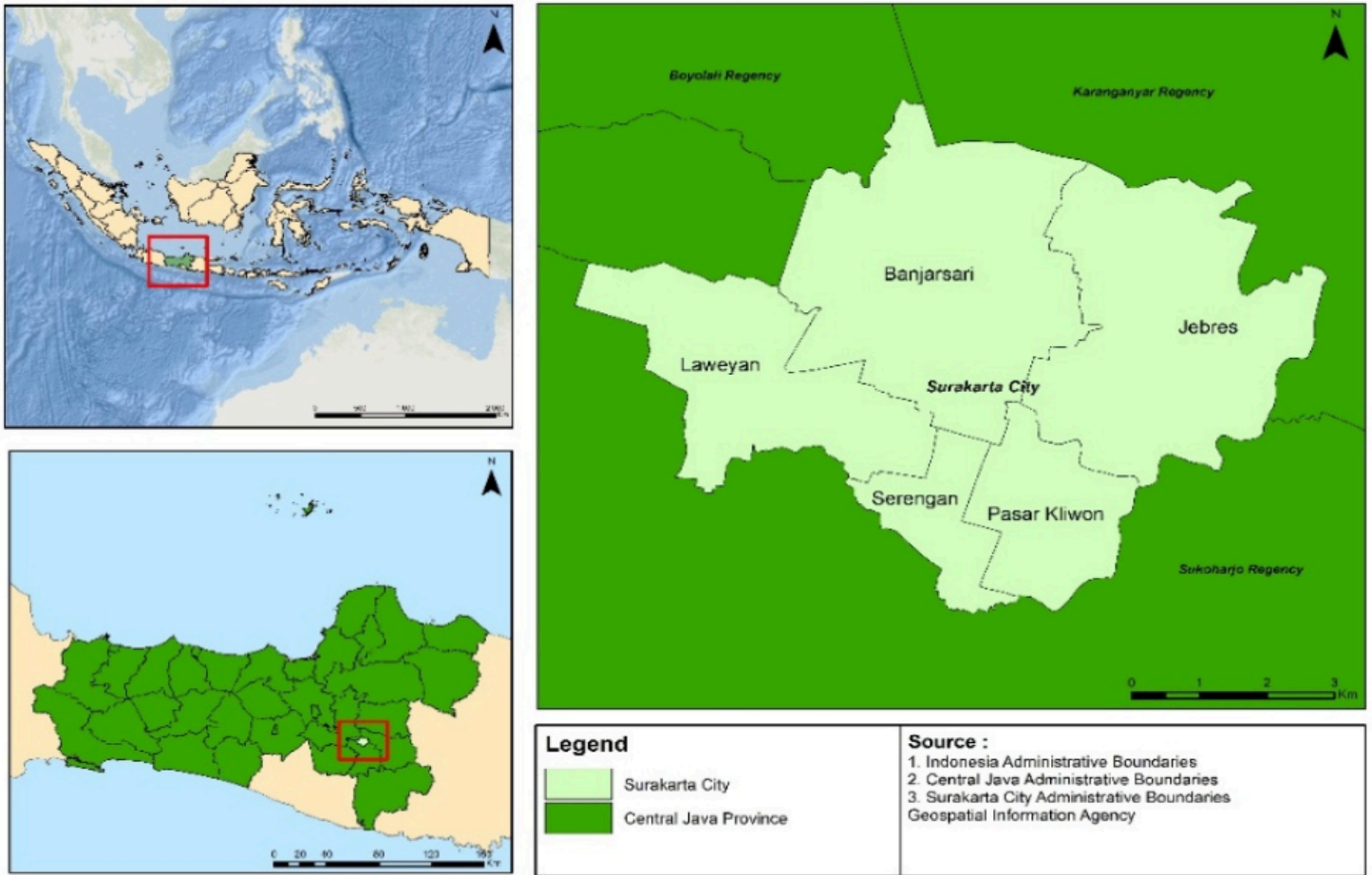


Figure 3

Research Location Map

Spearman Correlation Heatmap (8 × 8) Among Research Dimensions

($n = 40$; all correlations are significant at $p < 0.01$, two-tailed)



Figure 4

Heatmap Correlation (8 × 8)

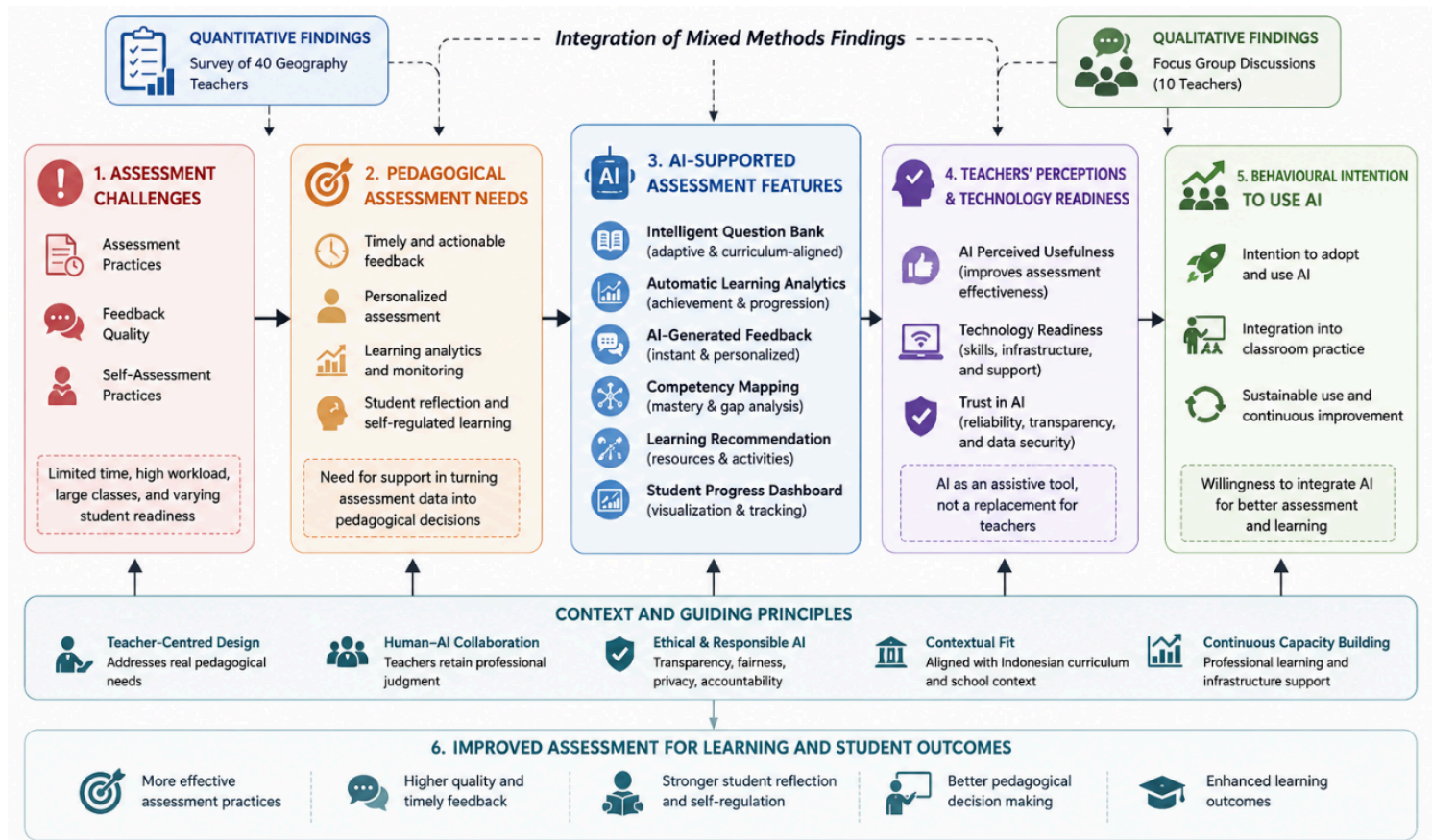


Figure 5

Teacher-Centred AI-Supported Assessment Framework Derived from the Integration of Quantitative and Qualitative Findings.

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