



RESEARCH ARTICLE

Developing Sustainable Learning Effectiveness through Teacher Key Performance Indicators (KPI) Implementation in the Digital Era and Human-Centered Society 5.0

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ABSTRACT

Digital transformation and Human-Centered Society 5.0 require teachers to integrate technological competence, pedagogical expertise, and human-centered values. This study aimed to develop and evaluate a Teacher Key Performance Indicator (KPI) model to support sustainable learning effectiveness in the context of Society 5.0 education. A Research and Development (R&D) approach was employed using the ADDIE model: Analysis, Design, Development, Implementation, and Evaluation. Participants comprised 100 elementary school teachers selected through purposive sampling based on their involvement in technology-supported learning. Data were collected through questionnaires, interviews, classroom observations, and document analysis. Quantitative data were analysed using descriptive statistics, while qualitative data underwent thematic analysis. The developed KPI model comprised five dimensions: pedagogical competence, digital competence, human-centered teaching, instructional innovation, and professional development. The overall achievement score reached 86.4%, categorized as "Very Good." Digital competence recorded the highest score (92%), whereas instructional innovation scored lowest (82%), indicating an area for improvement. Qualitative findings suggested that the model encouraged professional reflection, digital adaptation, and learner-centered practices. The Teacher KPI model shows potential as a formative evaluation framework for supporting continuous professional development aligned with Society 5.0 principles. Further validation through comparative studies and diverse educational contexts is recommended.

INTRODUCTION

The rapid development of digital technology has transformed contemporary education and created new demands for teachers, schools, and educational institutions. The emergence of Human-Centered Society 5.0 represents a shift from technology-oriented development toward a society that integrates advanced technologies with human values, social well-being, and sustainable development. In education, this paradigm requires a transformation from traditional knowledge transmission toward learning environments that promote creativity, critical thinking, collaboration, digital literacy, and character development.

Society 5.0 emphasizes the integration of cyberspace and physical space through technologies such as artificial intelligence (AI), big data, and the Internet of Things (IoT), while maintaining

human needs as the central consideration. Therefore, educational transformation in this era is not solely determined by technological adoption but also by the ability of teachers to design meaningful, inclusive, and adaptive learning experiences. Teachers are expected to function not only as knowledge providers but also as learning designers, facilitators, and reflective professionals who can balance technological innovation with human-centered educational principles.

In this context, teacher competency measurement has become increasingly important. Teacher performance evaluation systems have traditionally emphasized administrative aspects, teaching workload, attendance, and student achievement outcomes. Although these indicators remain relevant, they do not fully represent the complex competencies required in contemporary education. Modern teacher performance assessment needs to incorporate broader dimensions, including pedagogical competence, digital competence, instructional innovation, professional growth, collaboration, and the ability to create learner-centered environments.

Key Performance Indicators (KPIs) provide a structured mechanism for measuring and monitoring professional performance. In educational contexts, teacher KPIs have evolved from simple outcome-based measurements toward multidimensional frameworks that evaluate both teaching processes and professional development. Previous studies have identified several important KPI dimensions, including student learning outcomes, classroom instructional quality, technology integration, professional development activities, and collaborative contributions within educational communities.

However, existing teacher KPI frameworks still present several limitations. First, many performance indicators remain focused primarily on measurable academic outcomes and administrative accountability rather than continuous professional improvement. Second, technology-related indicators are often separated from pedagogical and human-centered considerations. Third, some KPI systems are perceived by teachers as evaluation instruments for control rather than tools for reflection and professional growth. Therefore, there is a need for a teacher KPI framework that integrates technological competence, pedagogical quality, innovation capacity, and human-centered educational values.

Research Gap and Study Objective

Previous research has explored teacher performance indicators, digital pedagogy, and educational transformation in the digital era. Nevertheless, limited studies have attempted to develop a comprehensive KPI model specifically designed for elementary school teachers within the framework of Human-Centered Society 5.0. The originality of this study lies in developing a multidimensional Teacher KPI model that combines five interconnected domains: pedagogical competence, digital competence, human-centered teaching, instructional innovation, and professional development. Unlike conventional performance evaluation models that primarily emphasize outputs, the proposed framework positions KPI as a formative instrument to encourage teacher reflection, continuous improvement, and sustainable learning practices.

Furthermore, this study contributes practically by providing an evaluation framework that can be adapted by educational institutions seeking to develop teacher professional development systems aligned with digital transformation. The integration of digital-based monitoring and reflective evaluation provides opportunities for schools to make more informed decisions regarding teacher development programs while maintaining ethical and human-centered principles.

Based on this background, the study aims to develop and evaluate a teacher KPI model for supporting sustainable learning effectiveness in the digital era and Human-Centered Society 5.0.

The research questions are formulated as follows:

1. How is the Teacher KPI model developed using the ADDIE Research and Development framework for elementary school teachers in the context of digital education and Society 5.0?
2. What are the achievement levels of the developed Teacher KPI model across pedagogical competence, digital competence, human-centered teaching, instructional innovation, and professional development dimensions?
3. How do teachers perceive the implementation of the developed KPI model as a tool for professional reflection and sustainable learning improvement?

METHOD

Research Design

This study employed a Research and Development (R&D) approach using the ADDIE development model. The R&D approach was selected because the purpose of the study was not only to describe teacher performance but also to develop and evaluate a teacher KPI model suitable for digital education and Human-Centered Society 5.0.

The ADDIE model consists of five systematic stages:

1. Analysis
2. Design
3. Development
4. Implementation
5. Evaluation

The ADDIE framework was selected because it provides a structured process for developing educational models through systematic analysis, expert review, implementation, and evaluation.

Participants and Procedure

The participants consisted of 100 elementary school teachers involved in technology-supported learning practices. The research was conducted in elementary school contexts where digital learning implementation and teacher performance evaluation systems had been introduced.

Participants were selected using purposive sampling based on the following inclusion criteria:

1. Teachers actively teaching at the elementary school level.
2. Teachers who had experience implementing digital learning activities.
3. Teachers willing to participate in questionnaire completion, interviews, and classroom observation.
4. Teachers representing different levels of teaching experience.

Purposive sampling was used because the study focused on teachers with relevant experiences related to digital learning implementation rather than aiming for statistical generalization.

ADDIE Development Procedure

A. Analysis Stage

The analysis stage focused on identifying teacher competency requirements in the context of digital transformation and Society 5.0 education. Data were collected through:

- preliminary interviews with teachers and school practitioners,
- classroom observations,
- analysis of existing teacher performance evaluation documents.

The findings from this stage were used to identify essential KPI dimensions and indicators.

B. Design Stage

Based on the analysis results, the Teacher KPI framework was designed using five dimensions:

1. Pedagogical competence
2. Digital competence
3. Human-centered teaching
4. Instructional innovation
5. Professional development

Each dimension was translated into measurable indicators using a five-point Likert scale:

1 = Very Low

2 = Low

3 = Moderate

4 = High

5 = Very High

C. Development Stage

The development stage involved the preparation of the KPI instrument and evaluation framework. The instrument consisted of:

- KPI assessment questionnaire,
- teacher reflection form,
- observation checklist,
- interview guidelines.

The initial instrument was reviewed by educational experts and school practitioners to examine:

- relevance of indicators,
- clarity of statements,
- suitability for elementary school contexts,
- alignment with Society 5.0 principles.

D. Implementation Stage

The developed KPI model was implemented with participating teachers. Teachers completed the KPI assessment, reflected on their instructional practices, and provided feedback regarding the usability and relevance of the model. The implementation also involved classroom observation and document analysis to provide additional evidence regarding teacher practices.

E. Evaluation Stage

The evaluation stage examined:

1. Achievement levels of teacher KPI dimensions.
2. Practicality of the KPI framework.
3. Teacher perceptions regarding KPI usefulness as a reflective tool.

The evaluation results were used to determine the strengths and improvement areas of the developed model.

Teacher KPI Instrument Development and Validation

The Teacher KPI instrument was developed based on theoretical foundations related to teacher competence, digital pedagogy, and Human-Centered Society 5.0.

The instrument development process included:

1. Identification of theoretical indicators.
2. Construction of KPI items.
3. Expert review.
4. Revision based on expert feedback.
5. Implementation testing.

Content validity was examined through expert judgement involving experts in educational technology, educational evaluation, and school practitioners.

The validation process focused on four criteria:

1. relevance,
2. clarity,
3. comprehensiveness,
4. contextual suitability.

For quantitative validation, researchers may employ content validity indices such as Aiken's V or Content Validity Index (CVI). Instrument reliability can be examined using Cronbach's Alpha to determine internal consistency among questionnaire items.

Data Collection Techniques

Four data collection techniques were used:

Questionnaire

The questionnaire was used to measure teacher KPI achievement across five dimensions. Responses were collected using a five-point Likert scale.

Interviews

Semi-structured interviews were conducted to explore teachers' experiences, perceptions, and reflections regarding KPI implementation.

Interview topics included:

- usefulness of KPI for professional reflection,
- challenges in digital learning implementation,
- teacher adaptation toward human-centered learning.

Observation

Classroom observations were conducted to examine the alignment between reported competencies and actual instructional practices.

Documentation

Documentation analysis included lesson plans, digital learning materials, and teacher professional development records.

Data Analysis

This study employed a mixed-methods analysis approach.

Quantitative Analysis

Quantitative data from KPI questionnaires were analysed using descriptive statistics, including:

- mean scores,
- percentage conversion,
- performance category interpretation.

The achievement categories were determined based on percentage intervals:

Table 1. Percentage Intervals

Percentage	Category
86–100%	Very Good
71–85%	Good
56–70%	Moderate

Qualitative Analysis

Qualitative data from interviews and observations were analysed using thematic analysis consisting of:

1. Data reduction
2. Coding
3. Categorization
4. Theme development
5. Interpretation

The quantitative and qualitative findings were integrated during interpretation to provide a comprehensive understanding of Teacher KPI implementation.

RESULTS AND DISCUSSION

Development of the Teacher KPI Model

The development process resulted in a multidimensional Teacher Key Performance Indicator (KPI) model designed for elementary school teachers in the context of digital education and Human-Centered Society 5.0. The developed model integrates five major performance dimensions:

1. Pedagogical competence
2. Digital competence
3. Human-centered teaching
4. Instructional innovation
5. Professional development

Unlike conventional teacher evaluation systems that primarily emphasize administrative compliance and learning outcomes, the developed KPI model emphasizes a balanced assessment between instructional quality, technological adaptation, professional growth, and human-centered educational practices.

The implementation of the model was supported through a digital-based monitoring framework that enabled teachers to record achievement levels, conduct self-reflection, and identify areas requiring further professional development.

Quantitative Findings of Teacher KPI Achievement

The quantitative evaluation of the developed Teacher KPI model was conducted across the five core dimensions. Table 2 summarizes the mean scores, achievement percentages, and performance categories for each dimension, while Figure 1 visualizes the comparative results. Based on the percentage intervals established in Table 1, the findings reflect strong performance overall while highlighting specific competencies that require further professional development.

Table 2. Teacher KPI Achievement Results

KPI Dimension	Mean Score (1-5)	Achievement (%)	Category
Pedagogical Competence	4.3	86	Very Good
Digital Competence	4.6	92	Very Good
Human-centered Teaching	4.4	88	Very Good
Instructional Innovation	4.1	82	Good
Professional Development	4.2	84	Good
Overall Achievement	4.32	86.4	Very Good

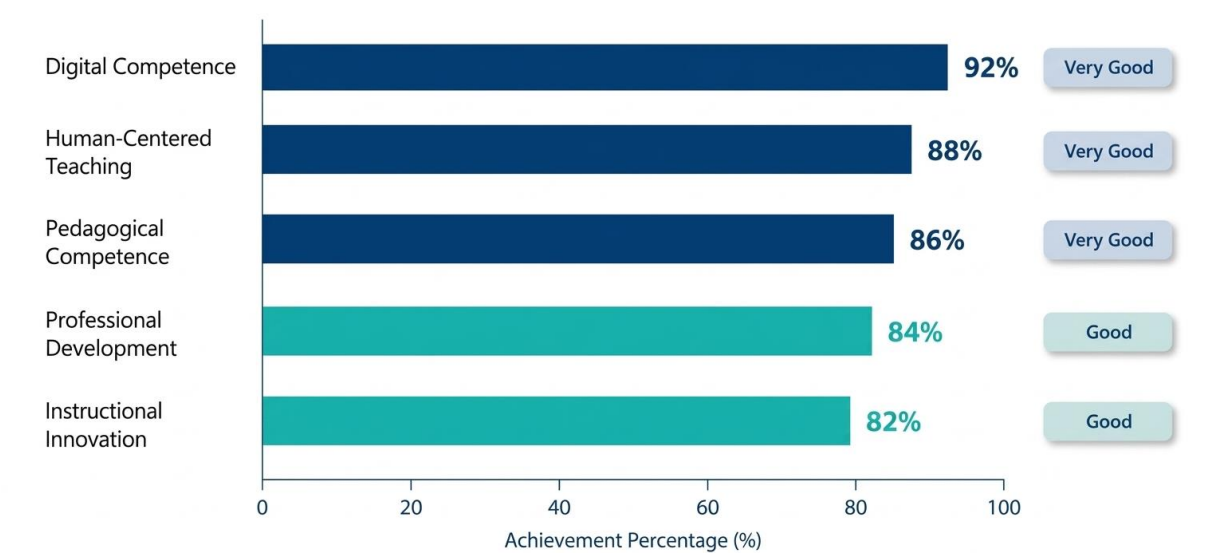


Figure 1. Teacher KPI Achievement Results

The overall KPI achievement score was 86.4%, indicating that teachers demonstrated a high level of performance across the assessed dimensions. Among the five dimensions, digital competence obtained the highest achievement score (92%). This finding suggests that teachers involved in the study had relatively strong abilities in utilizing digital platforms, instructional

technologies, and technology-supported learning resources. Human-centered teaching achieved 88%, indicating that teachers demonstrated awareness of learner needs, classroom inclusiveness, and the importance of maintaining meaningful teacher-student interactions in technology-supported learning environments. Pedagogical competence achieved 86%, showing that teachers were generally able to design and implement instructional practices aligned with contemporary learning demands. Professional development and instructional innovation obtained comparatively lower scores, with 84% and 82%, respectively. These findings indicate that although teachers demonstrated digital readiness, further support may be required to strengthen innovative instructional design and continuous professional learning practices.

Qualitative Findings: Teachers' Experiences and Reflections

The qualitative analysis from interviews and observations identified three major themes related to Teacher KPI implementation.

Theme 1: KPI as a Professional Reflection Instrument

Teachers perceived the KPI framework not only as an evaluation mechanism but also as a tool for reflecting on their instructional practices. The interview findings indicated that KPI encouraged teachers to identify personal strengths and areas requiring improvement, particularly in relation to lesson planning, technology integration, and classroom management. Teachers reported that structured indicators helped them understand professional expectations more clearly and provided direction for future development. This finding suggests that KPI implementation can support formative evaluation practices, where assessment functions as a mechanism for professional learning rather than merely performance judgement.

Theme 2: Digital Adaptation and Technology Integration

The second theme concerned teachers' adaptation to digital learning environments. Teachers indicated that digital competency indicators encouraged them to explore various digital learning resources, learning management systems, and interactive learning media. However, several teachers also identified challenges related to designing innovative digital learning activities rather than simply using technology as a replacement for conventional teaching materials. This finding explains why digital competence obtained the highest score, while instructional innovation remained the lowest-performing dimension. The results suggest that technological availability does not automatically lead to pedagogical innovation. Teachers require continuous support in transforming digital tools into meaningful learning experiences.

Theme 3: Maintaining Human Values in Digital Learning

The third theme highlighted the importance of maintaining human-centered principles in technology-supported education. Teachers emphasized that technology should support, rather than replace, teacher-student relationships. Classroom observations indicated that teachers continued to prioritize interaction, emotional support, and student engagement despite increased digital integration. This finding aligns with the principles of Society 5.0, which emphasize that technological advancement must remain connected with human needs and social values.

Integration of Quantitative and Qualitative Findings

The quantitative results demonstrated that teachers achieved a high level of KPI performance, particularly in digital competence and human-centered teaching. Meanwhile, qualitative findings explained how teachers interpreted KPI as a reflective framework that supported professional awareness.

The mixed-methods findings indicate that the value of the KPI model extends beyond numerical measurement. The model provides a structured approach for teachers and schools to identify competency strengths, recognize development needs, and establish continuous improvement strategies.

However, the findings should be interpreted as evidence of achievement levels and teacher perceptions rather than evidence of causal improvement because the study did not employ an experimental or longitudinal design.

Discussion

The findings demonstrate that a multidimensional Teacher KPI model can provide a relevant framework for evaluating teacher competencies in the context of digital transformation and Human-Centered Society 5.0. The highest achievement in digital competence (92%) reflects the increasing importance of technological capability in contemporary education. This finding supports previous research emphasizing that digital transformation requires teachers to develop competencies beyond basic technology use, including the ability to integrate digital resources into meaningful pedagogical practices.

However, the difference between digital competence and instructional innovation findings provides an important insight. Although teachers demonstrated strong technological readiness, innovation in instructional design remained comparatively lower. This suggests that technology adoption and pedagogical transformation represent different competency areas. Teachers may be capable of operating digital tools but still require support in designing creative, student-centered learning experiences. This finding is consistent with previous studies emphasizing that digital transformation requires not only infrastructure but also pedagogical redesign and continuous professional development.

The achievement of human-centered teaching (88%) indicates that teachers maintained attention to learner needs despite increasing technology integration. This finding supports the central principle of Society 5.0 education, where technological advancement should enhance human capability rather than reduce educational interaction into automated processes.

The results also support the argument that teacher KPI systems should move beyond traditional accountability models. Instead of functioning only as instruments for evaluation, KPIs can become formative tools that encourage reflection, professional dialogue, and continuous improvement.

Nevertheless, implementing KPI systems requires careful consideration. Excessive emphasis on numerical indicators may create unintended consequences, such as reducing complex teaching practices into simplified scores. Therefore, KPI implementation should be accompanied by professional judgement, contextual interpretation, and ethical data management.

CONCLUSION

This study developed and evaluated a Teacher Key Performance Indicator (KPI) model designed to support sustainable learning practices in the digital era and Human-Centered Society 5.0. Using the ADDIE Research and Development framework, the study produced a multidimensional KPI model consisting of pedagogical competence, digital competence, human-centered teaching, instructional innovation, and professional development dimensions.

The implementation results showed an overall achievement score of 86.4%, categorized as Very Good. Digital competence represented the strongest dimension, while instructional innovation emerged as an area requiring further strengthening. The qualitative findings indicated

that teachers perceived KPI as a useful reflective instrument that supported professional awareness, digital adaptation, and learner-centered instructional practices. These findings suggest that Teacher KPI models can function not only as evaluation mechanisms but also as tools for continuous professional development.

However, KPI implementation should avoid reducing teacher performance into numerical indicators alone. A human-centered approach requires combining quantitative measurement with professional interpretation, ethical data practices, and continuous dialogue among teachers and educational stakeholders. Future studies should investigate the model using broader samples, longitudinal approaches, and comparative research designs to examine its effectiveness across different educational contexts.

DECLARATIONS

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Author Contributions

The authors contributed collaboratively to the development, implementation, analysis, and writing of this research. E.N.S: Conceptualization, research design, data collection, development of the Teacher KPI model, analysis of findings, manuscript preparation, and revision. A.S: Theoretical framework development, methodological guidance, validation of research design, critical review, and manuscript refinement. R.S: Contribution to educational technology perspectives, manuscript review, interpretation of findings, and academic editing. All authors reviewed and approved the final version of the manuscript before submission.

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Conflict of Interest

The authors declare no conflict of interest.

Data Availability Statement

The datasets generated and/or analysed during the current study are not publicly available due to confidentiality considerations related to participant information and institutional research ethics. However, relevant aggregated data supporting the findings of this study may be made available from the corresponding author upon reasonable request.

Ethics Approval and Informed Consent

This study involved human participants, namely elementary school teachers participating in the development and evaluation of the Teacher Key Performance Indicator (KPI) model. The research procedures followed ethical principles for educational research, including voluntary participation, informed consent, confidentiality protection, and responsible management of participant information. Before data collection, participants were informed about the objectives, procedures, potential benefits, and confidentiality practices of the study. Participation was

voluntary, and participants were informed that they could withdraw from the study at any stage without negative consequences.

AI Use Disclosure

The authors declare that artificial intelligence (AI)-based tools were used only to support language refinement, proofreading, and improvement of academic expression during manuscript preparation. AI tools were not used for generating research data, conducting data analysis, interpreting empirical findings, or making scientific conclusions. The authors remain fully responsible for the originality, accuracy, integrity, and validity of all content presented in this manuscript.

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