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# Evaluation Criteria for Developing a Quality Management System for EdTech Tools

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***Abstract*— To support various changes in the education environment and teaching methods, a type of EdTech is emerging which utilizes new information technology and cloud computing-based platforms for education services and ensures more stable operation. As various types of EdTech tools are expected to become more widely adopted in school education in the future, there is a need for accurate information about these tools to be made available, as well as concrete strategies for expanding EdTech-based choice and effective utilization. This study aims to develop optimal evidence-based EdTech evaluation and certification indicators. The process involved five stages: 1) literature review, 2) gathering of expert opinions, 3) deriving improvements, 4) gathering opinions from school environments, and 5) finalizing a framework through analysis of school environment opinions and expert/researcher feedback. The proposed evidence-based EdTech evaluation and certification system includes five evaluation criteria in the technical domain (purpose, convenience, sustainability, integrity/stability, accessibility), with 13 evaluation items, and seven evaluation criteria in the usability domain (purpose, usability, functionality, compatibility, sustainability, integrity/security, ethics), with 20 evaluation items. The results of this study will enhance choice in school environments and contribute to the development of high-quality EdTech tools. The introduction of an evidence-based evaluation and certification system, based on objective data from EdTech stakeholders rather than relying on evaluation by a small group of experts, is expected to enhance trust in EdTech and improve its overall quality.**

***Keywords*— EdTech; e-learning; quality assurance; evaluation; educational S/W**

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## I. INTRODUCTION

The advent of the Fourth Industrial Revolution and the development of Information and Communications Technology (ICT) have ushered in a new era of education in the age of AI, bringing about various changes in multiple directions [1], [2]. The utilization of ICT in education contributes positively to the democratization and expansion of educational opportunities and enhances the efficiency and effectiveness of education [3]. However, software development projects sometimes fail to achieve the desired product quality, resulting in project failure or inability to meet user requirements- causing users to be unable to use the product after its release. Nevertheless, the quality of educational software (content, systems, services) is crucial because it ensures inclusive and equitable quality education, encourages lifelong learning opportunities for all, and has an overall positive impact on user satisfaction [4], [5], [6].

There has recently been a significant shift in patterns of education and learning processes, leading to increased interest in EdTech. The emergence of EdTech is replacing traditional methods that restricted learning to specific times and fixed locations with flexible and blended learning processes, bringing about a shift in the education market [7], [8]. Since the late 1990s, South Korea has been making consistent efforts to ensure the quality of educational software through educational information policy. KERIS (Korea Education & Research Information Service, a government agency under the Ministry of Education in South Korea) has operated the 'Educational Software Quality Certification' program since 1998 to distribute excellent educational software to schools. Subsequently, adapting to changes in the educational environment, KERIS developed an educational content quality certification system in 2006. It established an e-learning quality certification system in 2007, designating KERIS as the 'National E-Learning Quality Management

Center' to perform comprehensive, nationally recognized e-learning quality management. Moreover, in 2008, Korea standardized e-learning in content and service areas as Korean Standards (KS), and in 2009, the e-learning quality management certification system was implemented. In 2013, the "Act on the Promotion of the e-Learning Industry and the Facilitation of e-Learning Utilization" designated KERIS as an e-learning quality certification agency striving for e-learning quality management. However, these efforts have not been sustained due to changing interests among educational stakeholders, financial difficulties, changes in the education environment, and introducing new technological elements. Only the certification for remote education content quality in teacher training remains operational. [9], [10], [11].

The paradigm shift in education caused by the development of new ICT is increasing the influx of various EdTech tools into the school education environment. Schools demand an evaluation system that ensures accurate information and effective utilization of EdTech tools for education. Students require a system that recommends appropriate subjects and tools based on their preferences [12], [13], [14], [15].

Therefore, this study proposes evidence-based EdTech evaluation and certification indicators to respond to the introduction of new ICT in education and enhance the quality of education in school environments. The study analyzes similar domestic and international cases and extracts implications for achieving this goal. It suggests an optimal evidence-based EdTech evaluation and certification system by collecting opinions from educational stakeholders. This ensures the reliability, expertise, objectivity, and practicality of the evaluation and certification system, ultimately improving education quality through the development of the EdTech ecosystem.

This study conducts a literature analysis, case analysis, implication extraction, and EdTech evaluation indicator development. In the implication extraction, the study analyzes evaluation cases and operating methods of evaluation agencies, current conditions, and stakeholder opinions related to EdTech evaluation and certification. The study formulates evidence-based EdTech evaluation and certification criteria in developing the assessment and certification system. Furthermore, the study provides policy suggestions for the sustainable operation and establishment of the EdTech evaluation and certification system. This study utilizes literature analysis, focus group interviews (FGI) with experts, and KANO analysis to achieve the research objectives.

## II. Materials and Method

To develop EdTech evaluation and certification indicators, we analyzed evaluation and certification materials related to EdTech and other existing indicators. Our overseas analysis focused on Finland's Education Alliance Finland (EAF) and the UK's National Endowment for Science (NESTA) to grasp the scope of global trends. Additionally, to develop EdTech evaluation and certification indicators suitable for the Korean context, we analyzed EdTech-related quality assurance organizations in Korea (including that of KERIS). We analyzed EduTech Softlab, the Korea Digital Education Association, and private institutions such as AskEdTech among Korean public institutions. In addition, we referenced the content evaluation and institutional assessment of KERIS's Remote Education Training Institute, the National Institute for Lifelong Education's evaluation of remote credit banks, U-Learning Consortium's content quality certification, the National Technical Standards Institute's e-learning quality certification guidelines, and the National Competency Standards (NCS) for the e-learning sector. Through this process, we analyzed the evaluation systems of each institution, derived insights, and extracted evaluation criteria for evidence-based EdTech evaluation indicators.

### *A. Examples of EdTech Evaluation Certification*

Finland's EAF is based on global quality standards for learning solutions and provides evaluation, quality certification services, and information for helping schools (as buyers) choose trustworthy EdTech products. EAF's quality certification assessment criteria are based on educational psychology and attractive learning models. They developed the evaluation framework based on national curricula, 21st-century technology, and efficient learning definitions. EAF's quality assessment begins by defining the product's learning objectives. From the pedagogy perspective, they analyze educational accessibility, evaluating whether the product supports learning with various technologies. In terms of usability, they analyze learner engagement, considering elements that make the product exciting and engaging for learners, focusing on interaction and motivation. To support such quality certification, EAF secures a pool of trained teacher assessors on evaluation methods and software usage from the online learning platform CLANED (Claned Online Learning Platform). All assessments are led by EAF's evaluation administrators, who verify assessors' evaluations and provide feedback on their activities. Using assessment tools developed by EAF, four assessors (three external assessors and one internal assessor) evaluate each product according to the assessment criteria and provide the results in a report. The report's content is based on the three criteria mentioned earlier, and learner opinions are included. In particular, if there are issues related to privacy infringement or system usability, certification is denied until the problems are resolved. Based on such quality certification results, schools can make evidence-based purchasing decisions for EdTech products through a certified EdTech product catalog [16], [17].

Through a collaboration with NESTA, the UK Department for Education (DfE) operates an 'EdTech Innovation Testbed' and supports schools and universities in their participation. The EdTech Innovation Testbed aims to provide free trials of EdTech products suitable for practical requirements, verify their effectiveness with experts, and offer actionable insights for EdTech product providers. Additionally, it includes guidance on technologies required in practical settings (in schools and universities), their usefulness, and guidelines for the effective implementation and use of EdTech. The EdTech Testbed presents models like those in Table 1 [18].

The process of initiating the EdTech Innovation Testbed by the DfE consists of the following four stages: testbed enrollment; matching products with suitable technologies to meet requirements; expert evaluation through free real-world usage; and learning, sharing, and improvement with EdTech Testbed users. NESTA provides guidelines for the operation of the EdTech Innovation Testbed, including processes, qualification criteria, evaluations, product testing selection, and application procedures. In evaluation terms, NESTA emphasizes the design of specific assessments based on expert knowledge that aligns with institutional requirements. They require evaluation designs that can be most effectively implemented in schools and universities based on the existing empirical evidence, usage, and results of EdTech products [19].

TABLE I
EDTECH CONTEST JUDGING FOR EXCELLENCE- CATEGORIES & CONTENT

| Classification | Contents |
|---|---|
| Co-Design | It was developed as a model in which EdTech providers, researchers, teachers, and students collaborate to identify genuine educational needs and opportunities, integrating technology and educational expertise to address them. |
| Test and Learn | EdTech providers collaborate with schools to rapidly test and improve their products within a school environment. |
| Evidence Hub | It provides a space where schools and policymakers can collaborate with EdTech developers and researchers to make evidence-based decisions about the impact and effectiveness of actual products, guiding their adoption and expansion. |
| EdTech Network | It functions as a network of schools, researchers, and EdTech providers that facilitates communication for sharing various information and includes education and professional development related to EdTech products. |

In South Korea, the Ministry of Education, in collaboration with KERIS (Korea Education & Research Information Service), operates the EdTech Soft Lab, a multifaceted space aiming to create a circular ecosystem within the industry by connecting the education field with EdTech companies. The EdTech Soft Lab strengthens the effective adoption of EdTech in education by discovering excellent EdTech trial cases and examples of optimal usage in public education. The operation of EdTech Soft Lab is divided into three regions: the metropolitan area, the eastern region, and the western region. Among them, the metropolitan area's EdTech Soft Lab connects schools and businesses, promotes EdTech utilization education for teachers, and activates EdTech solution distribution. It provides opportunities for schools to access EdTech information and experience the latest technology while expanding their understanding of the education field and validating technological effects for companies. The metropolitan area's EdTech Soft Lab offers an EdTech solution trial process, as shown in Figure. 1, to discover excellent solutions, validate them, and improve them for field distribution based on the demand of school sites. The trial process focuses on technical completeness, educational suitability, and effectiveness, with actual classroom application involving students and teachers. Once the trial is completed, the solutions are made available on the metropolitan area's EdTech Soft Lab website [20], [21], [22], [23].

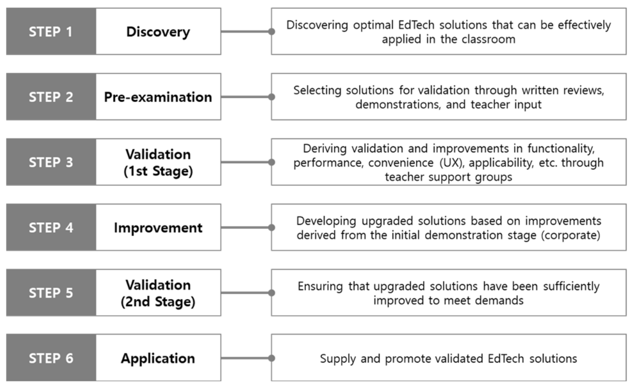


Fig. 1 Procedure for demonstrating EdTech solutions at Gyeonggi EduTech Softlab

The Eastern Region EduTech Softlab is pursuing various businesses related to validation and research, consultative body establishment, customized programs, and corporate support. Concerning validation support, they provide support for domestic EdTech companies through the EduTech Softlab Research Council-based validation research support, discovery of outstanding product content, experiential exhibitions, validation research, and testing. They have supported selected companies for outstanding projects derived according to the demands of school sites through public solicitations. The support conditions include completing content development that meets users' needs (schools) and validation applications through EduTech Softlab [24].

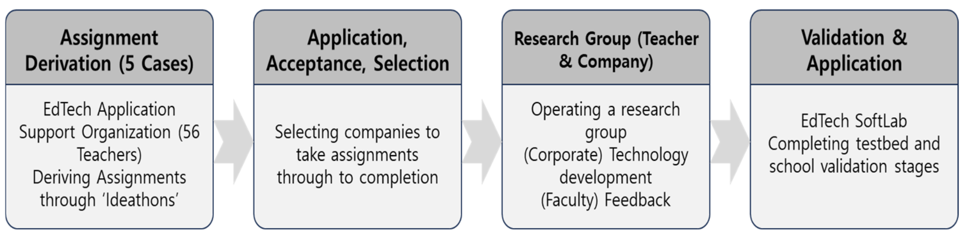


Fig. 2 Procedure for Task Execution at Daegu EduTech Softlab

The Ministry of Education is hosting the "EdTech Outstanding Company Contest" to strengthen support for enhancing the competitiveness of innovative and outstanding products from EdTech companies through discovery and nurturing. The submitted entries pertain to content/services and solutions that reflect global EdTech market trends. Support for exceptional submissions aims to boost competitiveness in EdTech companies. Evaluation is conducted through two stages: an initial document review and a final round evaluation. The details are outlined in Table 2 [25].

TABLE II
EVALUATION CATEGORIES AND CONTENTS FOR THE EDTECH OUTSTANDING COMPANY CONTEST

| Category | Contents |
|---|---|
| Contents/Service | ▪ Educational courseware content, learning software/apps, and teaching-learning materials produced using EdTech.<br>▪ In cases where companies submitting have produced or purchased their content and use media (internet, H/W tools, etc.) for service:<br>- eLearning content, educational apps, etc.<br>- Online educational services<br>- Provision of content and operating equipment (hardware) |
| Solution | ▪ Educational platforms or tools produced using EdTech.<br>▪Distribution and utilization of mainly user-provided content or information using developed solutions:<br>- LMS/LCMS, metaverse online content distribution platforms<br>- Online assessment, question banks, solutions<br>- Social media, real-time video lecture software, classroom tool software, and educational equipment (hardware). |

An example from a South Korean private EdTech company called AskEdTech (a subsidiary of LearningSpark) illustrates the development and validation of EdTech specialized evaluation criteria to aid in selecting and utilizing EdTech products in educational settings. This evaluation tool has been applied in the real-world assessment of AI education, teaching activities, and expert-teacher validation conducted by the Chungnam Provincial Office of Education [26]. The evaluation tool used in the EdTech Outstanding Company Contest applies a logical framework encompassing utility, usability, and affectability, which are general components of Human-Computer Interaction (HCI). The EdTech specialized evaluation criteria are divided into three analytical frameworks: educational utility, system usability, and affectability, comprising 17 evaluation elements and 42 questions. It is believed that multifaceted and reliable evidence can be obtained by comprehensively utilizing various methods, such as user evaluations and field research. Additionally, contextual factors such as the cost and maintenance policies of EdTech products can provide valuable information to enhance practicality in the field. They should be supplementary to the evaluation results [27].

From domestic and international cases, the following key points can be derived concerning evaluation criteria, certification processes, and operational approaches. First, there is a need to develop indicators for EdTech quality certification that can comprehensively evaluate educational and technical aspects without a strict separation. Additionally, it should be noted that AskEdTech and EAF include inferences of motivation and interaction in their evaluation criteria. NESTA considers aspects related to teacher tasks and administrative efficiency. Second, a procedural model suitable for the Korean context should be established regarding certification processes by combining the two processes presented by EduTech Softlab and NESTA. While both EduTech Softlab and NESTA present similar steps involving application, receipt, selection, research, validation, and utilization (product testing and evaluation), the processes offered by these two cases focus on the selection of testbed products. In particular, NESTA requires evidence based on usability and practicality in educational settings for EdTech product eligibility criteria, which is somewhat distant from quality certification. On the other hand, AskEdTech's focus is more on the evaluation criteria than the assessment process, and the EdTech Outstanding Company Contest may have a limitation in achieving practical quality certification with satisfaction evaluation alone. Third, regarding quality certification operational approaches, most cases involve experts, user evaluations, and field research from different fields. However, it is crucial to consider that EAF involves three teacher evaluators and one internal evaluator who assesses learning content, teaching and learning activities, and educational characteristics and provides a quality certification report.

### B. Evaluation Criteria Development Process

In this study, EdTech tools or products were defined through expert opinions and case analysis in the following way: "EdTech (tools or products) are IT technologies developed and applied to enhance educational outcomes in the educational field by providing support tailored to the characteristics of users, including learners, educators, and stakeholders". Based on this definition of EdTech, one can understand the perspective of the EdTech certification system as the evaluation of EdTech quality, tools, services, and more [28], [29]. Furthermore, the types of EdTech tools were classified as shown in Table 3 to conduct the research.

TABLE III
CLASSIFYING TYPES OF EDTECH TOOLS

| Term | Definition | Example |
|---|---|---|
| H-type | Tools that allow the download and execution of programming-based software. | Arduino, Micro:bit, Clover, etc. |
| HW + Contents-type | Tools for delivering educational content to devices like tablets | Providing services with their content along with HW, such as digital textbooks with devices |
| Contents-type | Tools that provide educational content through installed apps or web platforms. | These tools offer services based on their content, including Khan Academy, Question Bank, MATHia by Carnegie Mellon, Third Space Learning (UK), etc. |
| SW-type | Tools provided for educational support (teaching and learning, educational operations) through installed or platform-based approaches. | They provide an environment for users to create content themselves, such as Padlet, Mind Map, App Inventor, etc. |

Modular EdTech evaluation criteria were first developed to develop the evidence-based EdTech evaluation and certification system. Research into the EdTech certification system proceeded in five stages: 1. Literature analysis and establishing a certification system and assessment criteria (draft versions); 2. Gathering expert opinions; 3. Deriving improvements based on expert opinions; 4. Field suitability assessment; 5. Analysis of opinions from school settings and final confirmation occurred in five rounds of expert opinion gathering. Throughout the five stages, various stakeholders participated, including educational researchers, scholars, EdTech industry associations, educators, EdTech company representatives, the Korea Digital Education Society, and primary, middle, and high school teachers. Detailed information about each stage and the participants is provided in Table 4.

TABLE IV
EVALUATION CRITERIA DEVELOPMENT PROCESS (DETAILED)

| Stage | Contents | Reviewer |
|---|---|---|
| 1 | 1-1. Literature analysis<br>1-2. Authentication system and evaluation criteria (draft) | |
| 2 | Objective: Establishment of a plan for an EdTech certification system and collection of essential opinions for the development of an EdTech certification system and related criteria (draft) | |
| | 2-1. Written opinions (1st review)<br>2-2. Consultation meeting (2nd review)<br>2-3. Submitting written opinions (3rd review) | - 1st-2nd review stages: - 1st and 2nd reviews: 6 people total (1 education researcher, 1 scholar, 1 representative of an EdTech industry association, 1 EdTech entrepreneur, 1 representative of the Korea Digital Education Association)<br>- 3rd review: 6 people total (1 education researcher, 4 teachers, 1 EdTech entrepreneur) |
| 3 | 3-1. Deriving improvements based on expert input | |
| 4 | Objective: Review the proposed EdTech evaluation certification criteria developed based on feedback received. | |
| | 4-1. Content validity review (4th review)<br>4-2. Field suitability review (5th review) | - 4th review: 6 people total (1 education researcher, 2 scholars, 3 teachers)<br>- 5th review: 30 people total (16 elementary school teachers, 10 middle school teachers, 4 high school teachers) |
| 5 | 5-1. KANO analysis<br>5-2. Expert review and finalization | |

During the expert opinion-gathering process in phases 1 to 3 (of step 2), opinions were sought regarding the definition of EdTech, the categorization of EdTech types, and the differentiation between certification based on empirical evidence and evidence-based certification. The analysis of survey responses resulted in the following: Firstly, based on the definition and categorization of EdTech, it was determined that it would be possible to build an EdTech certification system. Opinions emphasized that an EdTech certification system based on evidence should focus on education rather than technology, covering aspects beyond just teaching and learning, such as enhancing students' academic abilities and improving the efficiency of teachers' administrative work. Secondly, regarding the certification system's perspective, discussions were held on how EdTech certification should proceed, either empirically or based on evidence. Ultimately, the evidence-based perspective was considered more suitable for educational argumentation activities. Further discussions took place concerning the time required for building the certification system, the education-oriented perspective of evaluators, and the possibility of industry policy regulations. Thirdly, it was recognized that classifying EdTech products based on the definition of EdTech, and their scope was an essential factor for companies considering EdTech product certification. Even if the same EdTech product is provided with additional services, choosing a new certification or re-certification direction may be necessary rather than maintaining the certification.

TABLE V
LEVELS AND OPERATIONAL DEFINITIONS OF EVALUATION CERTIFICATION CRITERIA

| Level | Operational Definition | Classification (in this study) |
|---|---|---|
| Domain | This signifies a perspective on essential concepts or classifications necessary for EdTech certification. In other words, it represents the largest unit or category when categorizing related distinctions or similar kinds. | · Technical Certification (TA)<br>· Usability Certification (UA) |
| Indicators | These are meaningful expressions representing the minimum units for judging the attributes of questions. They serve as scales for expressing and instructing attributes, values, effects, and more that can be explicitly measured. | · Purpose<br>· Convenience<br>· Sustainability<br>· Integrity/Stability/Security<br>· Accessibility<br>· Applicability<br>Functionality (from a design perspective)<br>· Compatibility<br>· Ethics |
| Items | Unlike questions that seek correct answers, items refer to data contents treated as a single unit for judgment. | · 'Technical Certification (TA)': 13 Items<br>· 'Usability Certification (UA)': 20 Items |

The evaluation criteria for EdTech product certification, derived from the literature analysis and expert opinion gathering, were divided into three levels: evaluation domains, indicators, and items. Evaluation domains represent the basic concepts or perspectives required for EdTech certification. They categorize the most extensive fields or categories when classifying related distinctions. In this research, they were divided into "Technical Certification (TA)" and "Usability Certification (UA)". Evaluation indicators: These are the minimum units to assess the attributes of an item being measured. They express and instruct the attributes, values, effects, etc., that can be explicitly measured. In the case of technical certification, five indicators were established, while usability certification had seven. 'Evaluation items' refer to data contents treated as one unit for judgment, unlike problems where the goal is to find the correct answer. In this research, 13 evaluation items were established for technical certification and 20 for usability certification. The specific operational definitions of the three levels are detailed in Table 5. For the EdTech product certification evaluation criteria, the need for different items was assessed using a 5-point Likert rating scale before the field suitability review. During the validity review, opinions were gathered regarding the composition of evaluation indicators, items, EdTech types corresponding to evaluation items, and other views.

The validity review results showed that among the 13 evaluation items related to indicators of Technical Certification (TA) (i.e., purpose, usability, sustainability, integrity/stability, and accessibility), 12 scored an average of 4 points or higher. For one item, specifically related to response speed in network-based services under the integrity/stability indicator of Technical Certification, the average score was 3.7 points. This lower score was interpreted as a result of potential subjectivity from evaluators in assessing response speed. Regarding the usability certification, out of the 20 items related to indicators (i.e., purpose, usability, functionality, compatibility, sustainability, integrity/stability, and ethics), 19 items scored an average of 4 points or higher. The average point score for the compatibility indicator: "Is it possible to use without installing separate programs" was 3.8. Analysis of other opinions suggested that the installation of EdTech programs may vary depending on embedded-based programs or system operating environments supported by the product. It was also suggested that the content provided in the evaluation criteria for the compatibility indicator may inadvertently favor products that require separate programs.

TABLE VI
EVALUATION CRITERIA COMPOSITION (DRAFT) FOR EDTECH TOOLS

| Evaluation Domain | Evaluation Indicators |
|---|---|
| Technical Certification (TA) | Purpose |
| | Convenience |
| | Sustainability |
| | Integrity/Security |
| | Accessibility |
| Usability Certification (UA) | Purpose |
| | Applicability |
| | Functionality (from a design perspective) |
| | Compatibility |
| | Sustainability |
| | Integrity/Security |
| | Ethics |

Subsequently, for the field suitability review, a review was conducted (using the KANO model) for the certification criteria (draft) that included 13 items for the 'Technical Certification (TA)' area and 20 items for the 'Usability Certification (UA)' area. Items for which judgment needed to be deferred based on expert opinions from the validity review were assessed for their final suitability based on the field suitability review results. The structure of the evaluation criteria for EdTech tools is presented in Table 6.

## C. Data Analysis Method

Data collected through expert opinions was analyzed using the KANO analysis method. The KANO analysis is a suitable model for extracting helpful or practical factors when developing new services targeted at stakeholders, and the analytical technique (using the KANO model) overcomes the limitations of conventional one-sided perception models in the composition of survey questions. For example, it can ask for perceptions regarding including or excluding features like: "Providing a detailed manual for EdTech products". Thus, this analysis aims to propose a certification tool to enhance the necessary functions of EdTech products and their applicability in school settings concerning four types of EdTech: hardware-based, hardware and content-based, content-based, and software-based. Moreover, it also utilizes the KANO analysis model to extract criteria that aid in planning and developing new features and designs for products, considering user satisfaction from a user's perspective [30], [31].

For analysis using the KANO model, each question was structured with a 5-point rating scale ("Like"- preference for preference, "Agree"- anticipation, "No feeling or Indifferent"- neutral, "Unavoidable"- tolerance, "Dislike" - dissatisfaction). The results for each item were then presented in terms of fulfillment and non-fulfillment aspects, as shown in Figure 3. [32], [33], [34].

| | | | Unsatisfactory | | | | |
|---|---|---|---|---|---|---|---|
| | | | Preference | Anticipation | Neutral | Tolerance | Dissatisfaction |
| | | | 1 | 2 | 3 | 4 | 5 |
| Satisfactory | Preference | 1 | Q | E | E | E | L |
| | Anticipation | 2 | R | I | I | I | M |
| | Neutral | 3 | R | I | I | I | M |
| | Tolerance | 4 | R | I | I | I | M |
| | Dissatisfaction | 5 | R | R | R | R | Q |

M : Mandatory (A given), L : Linear (One-dimensional), E : Attractive, R : Reverse, Q : Questionable, I :Indifferent

Fig. 3 The KANO Analysis Method

In the KANO model, each item is analyzed in the form of combinations: Mandatory (M, A given), Linear (L, One-dimensional), Attractive (E), Reverse (R), Questionable (Q), and Indifferent (I). For example, if the response is "preference" in the positive section and "neutral" in the negative section, it can be interpreted as "attractive." Therefore, the item can be considered as measuring attractive factors when evaluating EdTech products.

The results of the KANO analysis are used in the final decision-making process through satisfaction and dissatisfaction coefficients. The satisfaction coefficient implies that the function or service for the item results in high satisfaction when included. The dissatisfaction coefficient suggests that the function or service for the item results in high dissatisfaction when not included. Therefore, a high dissatisfaction coefficient suggests that negative perceptions about the EdTech product can be vital when that function or content is not included. Both coefficients are interpreted from an absolute value perspective. If the satisfaction coefficient is 0.5 or higher, it is considered satisfactory, while a dissatisfaction coefficient of -0.5 or lower is considered dissatisfactory. In other words, items with a dissatisfaction coefficient of -0.5 or lower are considered important. Therefore, if the satisfaction coefficient is 0.5 or higher and the dissatisfaction coefficient is -0.5 or lower, the item is classified and interpreted as highly important.

## III. Results and Discussion

This study was analyzed using the KANO model to establish criteria for evaluating EdTech products and tools, and the final evaluation indicators were presented by collecting expert opinions. Analysis results of the technical certification evaluation domain are the technical certification evaluation area, which consists of five indicators: purpose, convenience, sustainability, integrity/stability, and accessibility. In interpreting the KANO analysis results for the technical evaluation area: ‘purpose' (labeled as 'TA_a') showed a satisfaction coefficient of 0.64 and a dissatisfaction coefficient of -0.75, which were greater in absolute value than 0.5. The 'purpose' evaluation indicator 'TA_b' also had a satisfaction coefficient of 0.7 and a dissatisfaction coefficient of -0.77, indicating that it is a crucial evaluation indicator for EdTech product certification purposes.

'Integrity/stability' (labeled as 'TA_h') showed the highest importance, with a satisfaction coefficient of 0.73 and a dissatisfaction coefficient of -0.90. In other words, the item 'TA_h' (“Does the included feature in the product work without errors?”) is a question that can evaluate essential aspects when assessing EdTech products. If the features included in the product are error-prone, it could lead to high dissatisfaction with the EdTech product.

'Convenience' (labeled as 'TA_d') had the lowest dissatisfaction coefficient, -0.41, compared to other items. Additionally, 'Integrity/stability' (labeled as 'TA_i') had a relatively lower value, with a satisfaction coefficient of 0.37. This means that even if the EdTech product being evaluated complies with standards or technical regulations, it does not necessarily result in higher satisfaction. However, for 'Integrity/stability' (with a dissatisfaction coefficient of -0.5) it is implied that if these regulations are not adhered to, user dissatisfaction could increase. In other words, although the importance of satisfaction is relatively low, dissatisfaction could increase if this content is absent. Therefore, this item is interpreted as highly important as an evaluation criterion.

TABLE VII
KANO ANALYSIS RESULTS OF THE TECHNICAL EVALUATION DOMAIN

| Evaluation Indicator | Classification | Evaluation Item | Dissatisfaction Coefficient | Satisfaction Coefficient |
|---|---|---|---|---|
| Purpose | TA_a | Was the product developed for educational purposes? | 0.64 | -0.75 |
| | TA_b | Does the technology used in the product contribute to achieving educational goals? | 0.70 | -0.77 |
| Convenience | TA_c | Is the user interface (UI) designed for convenience, considering user characteristics? | 0.77 | -0.83 |
| | TA_d | Does it provide a personalized UI for individuals? | 0.48 | -0.41 |
| | TA_e | Are supporting materials available for using the product's features, such as help, manuals, tutorials, etc.? | 0.70 | -0.73 |
| Sustainability | TA_f | Does the product have an adequate maintenance (A/S) system in place? | 0.70 | -0.83 |
| | TA_g | Does it have an appropriate upgrade/update system for product use (including operational software)? | 0.73 | -0.83 |
| Integrity/Security | TA_h | Do the product's features work without errors? | 0.73 | -0.90 |
| | TA_i | Is the product compliant with standards or technical regulations? | 0.37 | -0.50 |
| | TA_j | If it is a network-based service, is the response speed appropriate? | 0.67 | -0.80 |
| Accessibility | TA_k | Does it meet accessibility guidelines (e.g., local accessibility legislation and/or W3C WCAG 2.0 standards, Korean web content accessibility guidelines, e-government compatibility compliance guidelines, etc.)? | 0.53 | -0.60 |
| | TA_l | Are there no installation or usage difficulties with the product? | 0.57 | -0.80 |
| | TA_m | Is the cost reasonable for schools or individuals to purchase? | 0.67 | -0.73 |

The usability evaluation domain consists of seven criteria: purpose, applicability, functionality (from a design perspective), compatibility, sustainability, integrity/security, and ethics. The 'UA_x' criterion for ethics was analyzed with a satisfaction coefficient of 0.77 and a dissatisfaction coefficient of -1.0. For cases indicating ethical issues, it was possible to interpret that dissatisfaction with the content increased overall (with a dissatisfaction coefficient of -1.0): this indicated a high level of importance. The 'UA_y' criterion of ethics also showed a high level of importance, with a satisfaction coefficient of 0.87 and a dissatisfaction coefficient of -0.93. The criteria 'UA_q' and 'UA_r' for integrity/security also had dissatisfaction coefficients of -0.93 respectively, indicating that if these aspects were lacking, dissatisfaction increased accordingly.

Items with satisfaction coefficients of 0.8 or higher include 'UA_j' for functionality (design perspective), 'UA_l' for compatibility, and 'UA_o' for sustainability. These are considered highly important criteria, and user satisfaction could rise if these aspects are in evidence. Items with dissatisfaction coefficients that have absolute values exceeding 0.8 included 'UA_g' for applicability, 'UA_l' for compatibility, and 'UA_n' for sustainability. This means that if these aspects do not function properly, they can be interpreted as factors that increase user dissatisfaction.

The 'UA_i' criterion for functionality has a satisfaction coefficient of 0.63, making it an important criterion for increasing user satisfaction. However, with a dissatisfaction coefficient of -0.40 (higher than -0.5), it can be interpreted that user dissatisfaction does not increase significantly even if EdTech tools or products do not alleviate classroom or tool-related constraints.

TABLE VIII
KANO ANALYSIS RESULTS OF THE USABILITY EVALUATION DOMAIN

| *Evaluation Indicator* | **Classification** | **Evaluation Item** | **Dissatisfaction Coefficient** | **Satisfaction Coefficient** |
|---|---|---|---|---|
| *Purpose* | UA_a | Is the product usable for educational purposes? | 0.67 | -0.73 |
| | UA_b | In the case of content provided for learning, does it align with elementary and secondary education content? | 0.63 | -0.67 |
| | UA_c | Does it help in motivating and engaging users? | 0.63 | -0.50 |
| *Applicability* | UA_d | Does it align with the intended use purposes presented by the product? | 0.70 | -0.73 |
| | UA_e | Does it align with the teaching and learning methods presented by the product? | 0.67 | -0.53 |
| | UA_f | As content provided for learning, does it take into consideration learner levels and difficulty? | 0.60 | -0.63 |
| | UA_g | Is the content presented objectively and accurately, without errors in representing concepts, theories, etc.? | 0.70 | -0.80 |
| *Functionality (from a design perspective)* | UA_h | Was it designed considering individual customization reflecting user levels and requirements? | 0.67 | -0.63 |
| | UA_i | Does it help alleviate environmental and tool-related constraints in teaching? | 0.63 | -0.40 |
| | UA_j | Does it provide roadmaps or similar tools for users to engage in self-directed learning? | 0.80 | -0.57 |
| | UA_k | Can it provide users with periodic feedback during and after the teaching and learning process? | 0.73 | -0.77 |
| *Compatibility* | UA_l | Is it usable on various devices, web browsers, and operating systems? | 0.80 | -0.83 |
| | UA_m | Can it be used without the need for separate program installation? | 0.67 | -0.53 |
| *Sustainability* | UA_n | Can users easily receive support for maintenance requirements? | 0.73 | -0.80 |
| | UA_o | Does it facilitate continuous linkage of educational activities through data storage and management? | 0.83 | -0.73 |
| | UA_p | Can users store or export activity data when needed? | 0.63 | -0.57 |
| *Integrity/Security* | UA_q | Are the personal details required for product use appropriate? | 0.66 | -0.93 |
| | UA_r | Are privacy policies and the like provided? | 0.77 | -0.93 |
| *Ethics* | UA_x | Are there no copyright, portrait rights, or similar issues with the provided content? | 0.77 | -1.00 |
| | UA_y | Does the provided content adhere to ethical standards? | 0.87 | -0.93 |

This study analyzed using the KANO model to establish criteria for evaluating EdTech products and tools. Following this, an expert review was conducted on decision-making regarding areas of disagreement and the opinions from the field suitability review. The following decisions were made:

First, the expert opinion review examined certain items requiring exclusion. For example, in the technical evaluation domain, there was a suggestion to expand the scope of the item: "Was the product developed for educational purposes?" in the "Purpose" criterion. After considering the final review meeting and the results of the field suitability review, this item was included in the requirements. In the usability evaluation domain, an expert opinion suggested removing the item: "Is it possible to use it without installing a separate program?" under the "Compatibility" criterion. However, since the satisfaction and dissatisfaction coefficients showed high values in the field suitability review, indicating its high importance, this item was included in the evaluation criteria. For the integrity/stability criterion in the technical evaluation domain, there was a suggestion that the item: "Appropriateness of response speed in the case of network-based services" could depend on the evaluator's network. However, it was considered a valid opinion, and it was decided to consider conducting evaluations in a state not dependent on the evaluator's network during the evaluation process and include this item in the evaluation criteria.

Second, the field suitability review results, including items with low importance, were reviewed. For example, in the technical evaluation domain, the item: "Does it provide a personalized UI?" under the "Convenience" criterion showed similar satisfaction (0.48) and dissatisfaction (-0.41) coefficients. Although its importance appeared lower in comparison with other items, it was included in the evaluation criteria based on the opinions of experts who participated in the final review, who considered UI design to be a significant factor in supporting the learning of students using content or software and included this item in three of the four types (excluding hardware). For the integrity/stability criterion in the technical evaluation domain, regarding the item: "Is it applicable with standards or technical regulations?", there was a difference in opinions between teachers participating in the field suitability review and technical experts. When reflecting this item in the evaluation criteria, it was considered that the evaluators would need education on technical standards.

Under the functionality (design perspective) criterion in the usability evaluation domain, there was a high dissatisfaction coefficient for the item: "Does the use of EdTech tools or products help alleviate environmental and tool-related constraints in classroom settings?". However, this item was included in the evaluation criteria based on expert consensus.

In EdTech-based online education programs, various activities and assignments must be designed to enable an interactive and active learning environment. When tools needed for physical learning environments and online learning environments are packaged, interactive educational content is provided. This ultimately increases student participation and, in turn, enhances student learning continuity [35]. The basic details for evaluating EdTech products and tools in the technical and usability domains are shown in Figure 4, which includes stages such as expert opinion collection, field suitability review, and final expert review.

**<Technical Certification: TC>**

Evaluation Criteria: 5 (Purpose, Convenience, Sustainability, Integrity/Security, Accessibility)

Evaluation Items:13

**<Usability Certification: UC >**

Evaluation Criteria: 7 (Purpose, Applicability, Functionality, Compatibility, Sustainability, Integrity/Security, Ethics)

Evaluation Items: 20

| EdTech Evaluation Items (by Type) | | |
|---|---|---|
| EdTech Type | Technical Certification Evaluation Items | Usability Certification Evaluation Items |
| HW-type | 11 Items | 7 Items |
| HW + Contents-type | 13 Items | 20 Items |
| Contents-type | 13 Items | 20 Items |
| SW-type | 13 Items | 16 Items |

Fig. 4 EdTech Product - Tool Evaluation Criteria (Basic Details)

The technical and usability domains have three overlapping evaluation criteria: purpose, sustainability, and integrity/stability/security. This index was generated considering these characteristics. Each item was placed in a way that allows evaluation for four different types of EdTech (hardware, hardware+ content, other content, and software). In other words, not all items evaluate all four types of EdTech.

## IV. Conclusion

The future adoption of new information and communication technologies is expected to expand, given the opportunity to realize ideals of efficiency, effectiveness, and equal opportunities through the utilization of information and communication technology in education. In the early stages of educational informatics, limited information and communication technologies such as computers and the Internet were utilized. However, various other information and communication technologies, including artificial intelligence, big data, blockchain, and virtual reality, are currently being applied in place of those above. The term "EdTech" originates from an anticipation that using such new technologies will bring forth new possibilities in the field of education.

EdTech-based physical devices and software are available in various forms within educational settings. However, this diversity can create concerns about whether appropriate EdTech tools can be selected in school settings [35], [36], [37]. It follows that the EdTech evaluation certification system should strengthen decision-making power in these educational settings and guide the development of high-quality EdTech tools from an industry perspective. Additionally, introducing an evidence-based evaluation and certification system, which relies on objective data from EdTech stakeholders (rather than simplistic evaluations by assessors), will increase trust in EdTech products.

Based on the research results presented in this study, the following recommendations are provided for introducing and operating a sustainable evidence-based evaluation and certification system.

First, continual government support and consistent policy implementation are necessary. While the need for e-learning quality management was highlighted during the early stages of educational informatics, research and execution plans for a national-level quality certification system were established. However, only content quality certification for remote education institutions remains, and its legacy is barely being maintained. Moreover, the importance of quality management has gradually weakened due to the removal of quality management items from related laws in 2015. It is now the time for the government to establish and maintain consistent policies to benefit educators and students in educational settings. Providing incentives to EdTech certification companies at the national level could be one possible approach.

Second, the EdTech quality certification system should be perceived as nurturing and promoting the EdTech field, rather than regulating it. Quality certification should not hinder the creativity and diversity of products. However, if organizations developing EdTech tools perceive quality certification as regulation, it may create difficulties for the EdTech quality certification system. Therefore, when operating the EdTech quality certification system, engaging in sufficient dialogue and sharing perceptions with the EdTech industry is essential to activate the system. This may involve forming a consultative body with representatives from the EdTech industry or encouraging participation from EdTech associations and companies in advisory committees.

Third, funding sources for operating the EdTech quality certification system must be identified. In the past, the government initially funded quality certification for educational software and e-learning. However, current practices apply the principle of beneficiary cost-sharing, with the evaluated parties bearing the financial burden. For evidence-based EdTech quality certification (considering the increased burden on parties being assessed due to evaluation periods), the system may need to begin with government funding and gradually transition to a cost-sharing model between the government and parties being assessed during the stabilization phase. The lack of specific incentives for companies that undergo EdTech quality certification should also be considered when designing the budget and funding model.

Fourth, specific strategies for capacity development and quality control of certification bodies are required. The qualifications of experts within certification bodies who conduct quality certification affect the accuracy, objectivity, and qualitative level of EdTech quality certification, as confirmed during the expert opinion collection process. To ensure the qualitative excellence of quality certification, various approaches, such as team-based operation (rather than arbitrary assignment of assessors) need to be harmoniously integrated. In particular, there is a need for the specific development of expert expertise affiliated with quality certification bodies, as well as the establishment of a detailed evaluation system to determine how evaluations will be conducted.

Finally, consideration should be given to expanding EdTech products for special education purposes, multicultural education, and other specific target groups. This study presented quality certification criteria for EdTech tools targeting general schools. However, EdTech tools are not only relevant to general schools but are also essential for the learning of students in special education schools and those in need of multicultural education. Currently, EdTech tools used in special education schools are mostly foreign products, often due to reasons such as cost-effectiveness and a lack of sufficient EdTech tools. Therefore, it is necessary to consider expanding the quality certification of EdTech tools for use in special education.

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