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VALIDATION OF INSTRUMENTS FOR THE DEVELOPMENT OF VIRTUAL REALITY–INTEGRATED E-MODULES USING THE CONTENT VALIDITY RATIO AND CONTENT VALIDITY INDEX

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Abstract. *Valid instruments are a fundamental prerequisite in Educational Design Research because they determine the accuracy of the evaluation of the developed learning products. In the context of 21st-century learning, which emphasizes critical, creative, collaborative, and communicative (4C) skills, e-module– and Virtual Reality (VR)–based learning media must be measured using scientifically validated instruments. This study aimed to validate a set of instruments used in the development of VR-integrated e-modules through the Content Validity Ratio (CVR) and Content Validity Index (CVI) approaches. Five experts, consisting of professors and doctoral scholars in education, learning technology, and digital media, were involved as panelists. The analysis results showed that all instruments achieved CVR = 1.00 and CVI = 1.00, indicating that all indicators were judged to be essential and relevant. These findings demonstrate that the instruments possess very high content validity and are appropriate for evaluating the effectiveness, usability, and contribution of VR-based e-modules to students' higher-order thinking skills.*

Keywords: *Content Validity Index (CVI); Content Validity Ratio (CVR); Educational Design Research; E-Module; Virtual Reality.*

1. INTRODUCTION.

The transformation of education in the 21st century requires a paradigm shift from mere knowledge transmission toward the development of higher-order thinking skills (HOTS), particularly critical and creative thinking. This shift is driven by the complexity of global challenges, rapid advances in digital technology, and labor market demands that require individuals to analyze, evaluate, and generate innovative solutions in dynamic contexts (Chaname-Chira et al., 2024; Ennis, 2011; Facione, 1990; WEF, 2023). Contemporary educational systems therefore emphasize learning environments that support inquiry, problem solving, and creativity rather than rote memorization.

Critical and creative thinking are widely recognized as foundational for problem solving, decision making, and innovation across disciplines. Ennis (2011) defined critical thinking as reasoned and reflective thinking focused on deciding what to believe or do, while creative thinking enables the generation of novel ideas and alternative solutions. Empirical evidence from secondary and higher education contexts confirms that strengthening HOTS significantly improves students' ability to deal with complex academic and real-world problems (Hu & Bi, 2025; Lan & Zhou, 2025; Landa-Blanco & Cortés-Ramos, 2021; O'Reilly et al., 2022).

In mathematics and science education, HOTS can be effectively developed through active learning models such as problem-based learning, project-based learning, flipped learning, and STEAM-oriented approaches. These models require learners to analyze authentic situations, design solutions, and reflect on outcomes, which aligns closely with the nature of higher-order thinking (Asri et al., 2024; Basri et al., 2019; I. W. Santyasa et al., 2021; W. Santyasa et al., 2018; Tegeh et al., 2022). Research also indicates that these pedagogical models enhance scientific

creativity and problem-solving ability when integrated with collaborative and inquiry-based learning strategies (Anggoro et al., 2024; Warpala et al., 2025).

Alongside advances in learning technologies, e-modules, interactive multimedia, and Virtual Reality (VR) are increasingly used to create immersive, engaging, and contextualized learning environments. Studies have demonstrated that digital learning platforms, multimedia content, and VR-based simulations significantly enhance student engagement, conceptual understanding, and higher-order thinking (Agustini et al., 2022; Darmawan et al., 2024; Net et al., 2024; Rong et al., 2022; Sari et al., 2024; Suartama et al., 2023; Wang, 2020). However, the educational effectiveness of these innovations can only be scientifically verified when assessed using valid and reliable instruments. Without rigorously validated instruments, evaluations of e-module quality and their impact on 4C skills are prone to bias and may lead to misleading conclusions (Abbasi-Sosfadi et al., 2025; Arnyana et al., 2017; Harjo et al., 2019; Zohoorian et al., 2023).

2. LITERATURE REVIEW

2.1 Instruments in 21st-Century Education

Twenty-first-century education emphasizes the development of the 4C skills—critical thinking, creativity, communication, and collaboration—as core competencies that learners are expected to acquire (Nurhayati et al., 2024; Partono et al., 2021; Supena et al., 2021). These skills not only reflect cognitive abilities but also involve metacognitive and socio-emotional dimensions that are essential in modern learning environments.

Therefore, instruments used to assess 21st-century skills must adequately represent cognitive, metacognitive, and affective dimensions in a balanced manner. Puger et al. (2024) and Ramsden (2020) emphasize that assessments focusing solely on cognitive outcomes without considering thinking processes and self-regulation fail to provide a comprehensive picture of learning quality.

A number of recent studies have developed validated HOTS instruments, such as CTARS-ELT for academic reading (Abbasi-Sosfadi et al., 2025), the Higher-Order Thinking Scale for pre-service teachers (Zhou et al., 2023), the Adaptive Thinking Scale for language teachers (Zohoorian et al., 2023), and the Scientific Critical Thinking Model in science education (Hu & Bi, 2025). These instruments are designed to capture the complexity of higher-order thinking processes across different learning contexts.

A common feature of all these studies is their emphasis on content validity as the foundation of instrument development. Without strong content validity, indicators may fail to accurately represent the intended constructs, thereby reducing the credibility of research findings. Consequently, instrument validation is a critical stage in studies aiming to measure HOTS in a scientifically sound manner.

2.2 Content Validity Ratio (CVR)

The Content Validity Ratio (CVR) was developed by Lawshe (1975) as a quantitative method based on expert judgment to determine whether an instrument item is essential. This approach evaluates the degree of agreement among experts regarding whether a particular indicator is truly necessary for measuring a given construct. CVR enables researchers to eliminate irrelevant items at an early stage of instrument development.

The main advantage of CVR lies in its ability to transform qualitative expert judgments into an objective numerical index. As a result, decisions to retain or discard an item are not based merely on intuition but on the level of consensus among experts. This makes CVR a highly robust method in educational and social science research.

In recent years, CVR has been widely applied across disciplines, including education, psychology, and health sciences. Romero-Jeldres et al. (2023) demonstrated that Lawshe's

method remains relevant and robust in contemporary social research. Other studies have employed CVR in the development of self-management instruments (Hutting et al., 2025), self-regulation scales (Kermani et al., 2024), and travel behavior questionnaires (Rezaei et al., 2023).

For a panel of five experts, Lawshe (1975) established that the minimum acceptable CVR value is 0.99. This means that nearly all panelists must judge an item as essential for it to be retained. Such a stringent criterion makes CVR particularly suitable for instrument development studies that require a very high level of content validity.

2.3 Content Validity Index (CVI)

The Content Validity Index (CVI) is a measure used to assess the overall validity of an instrument by calculating the average CVR across all items. Polit and Beck explained that CVI provides a comprehensive representation of the extent to which an instrument adequately covers the intended construct domain.

CVI is particularly important because even if individual items are valid, the instrument as a whole may not proportionally represent all aspects of the construct. Therefore, CVI ensures that the overall structure of the instrument meets acceptable standards of content validity.

In educational research, a CVI of 0.90 or higher is generally considered to indicate very high content validity. Many studies on the development of critical thinking and self-regulation instruments adopt this criterion as a benchmark for instrument adequacy (Harjo et al., 2019; Kermani et al., 2024). A high CVI ensures that the instrument not only contains relevant items but also maintains a balanced representation of indicators.

By combining CVR and CVI, researchers can obtain a comprehensive assessment of instrument quality. CVR ensures the validity of each individual item, while CVI confirms the validity of the instrument as a whole. This dual approach strengthens the validation process and enhances the credibility of research findings, particularly in the context of developing e-modules and Virtual Reality–based learning for 21st-century education.

3. RESEARCH METHODS.

This study is part of an Educational Design Research (EDR) approach aimed at producing learning products that are valid, practical, and effective through systematic processes of design, validation, and evaluation (Plomp & Nieveen, 2013; Suharta & Sudiarta, 2022). In the context of developing a Virtual Reality (VR)–integrated e-module, the instrument validation stage is a critical phase because it determines the accuracy of measuring product quality, learning processes, and students' higher-order thinking outcomes.

The focus of this study is to conduct content validity testing on a set of instruments used to evaluate the VR-based e-module in mathematics learning. The validated instruments cover aspects of content quality, instructional design, media, learning implementation, and user responses (lecturers and students). Validation was conducted prior to the implementation phase to ensure that the conclusions drawn from the data are based on sound and credible measurement (Abbasi-Sosfadi et al., 2025; Harjo et al., 2019).

The validation techniques employed were the Content Validity Ratio (CVR) and the Content Validity Index (CVI) developed by Lawshe (1975). These methods were selected because they represent international standards in educational and psychometric instrument development and have been widely used in studies on critical thinking, higher-order thinking skills, and 21st-century competencies (Hu & Bi, 2025; Zhou et al., 2023; Zohoorian et al., 2023). CVR was used to assess the validity of individual items, while CVI was used to determine the overall validity of the instrument.

Five panelists were involved, consisting of three professors and two doctoral-level experts in learning technology, mathematics education, and digital media. The selection of panelists followed the principle that content validity should be evaluated by experts who understand both

the theoretical constructs and the practical context of instrument application (Romero Jeldres et al., 2023). Each panelist was asked to rate every instrument item using three categories: "essential," "useful but not essential," or "not essential."

4. RESULTS AND DISCUSSION

4.1 Results

The results of the Content Validity Ratio (CVR) analysis indicate that all instrument items obtained a CVR value of 1.00. This means that all panelists judged every item as essential. With five panelists, the minimum acceptable CVR value according to Lawshe (1975) is 0.99. Therefore, all items in this study met the criteria for content validity, and no items needed to be eliminated.

The Content Validity Index (CVI), calculated as the average CVR value across all items in each instrument, also yielded a value of 1.00. This result applied to all validated instruments, including expert validation instruments for content, design, and media, as well as the observation sheet, lecturer interview, student interview, and the USE Questionnaire. A CVI of 1.00 indicates an extremely high level of content validity and reflects full agreement among the experts (Hutting et al., 2025). For the content aspect instruments, all panelists agreed that indicators related to content relevance, conceptual accuracy, curriculum alignment, and language clarity appropriately represented the intended measurement domain. Likewise, for the design and media instruments, all indicators were judged to be relevant for assessing visual quality, interactivity, navigation, and the integration of Virtual Reality within the e-module, in line with principles of message design and multimedia learning theory (Sudarma et al., 2015; Sudatha et al., 2021).

The observation instruments, lecturer interviews, student interviews, and the USE Questionnaire also achieved maximum CVR and CVI values. This indicates that the indicators used to measure learning implementation, user perceptions, and the usability of the e-module comprehensively covered all essential aspects required to evaluate a technology-based learning product (Suartama et al., 2023; Wayan Marti et al., 2023).

CONCLUSION.

Based on the validation results using the Content Validity Ratio (CVR) and Content Validity Index (CVI) approaches, it can be concluded that all instruments developed in this study possess a very high level of content validity. All items across the expert validation instruments for content, design, and media, as well as the observation sheets, lecturer interviews, student interviews, and the USE Questionnaire, achieved CVR = 1.00 and CVI = 1.00, exceeding the minimum threshold established by Lawshe (1975). This indicates complete agreement among the experts that all indicators are essential and relevant for measuring the quality of the Virtual Reality–integrated e-module.

These findings indicate that the research instruments comprehensively represent all intended constructs, including content quality, instructional design, media quality and technological integration, learning implementation, as well as user experience and perceptions. Therefore, the instruments are not only methodologically sound but also theoretically grounded for evaluating the effectiveness of VR-based e-modules as innovative learning media.

In the context of 21st-century learning, particularly the development of critical and creative thinking skills, instrument validity is crucial because it determines the accuracy of evaluating the impact of technology-enhanced learning. The very high validation results in this study ensure that the data collected during the implementation stage can be used to draw valid conclusions regarding the contribution of VR-based e-modules to students' higher-order thinking skills.

Overall, this study makes a significant methodological contribution to the development of evaluation instruments for technology-based learning, particularly Virtual Reality–integrated e-modules. The validated instruments can serve as credible measurement tools for future

research, both in the context of learning product development and in studies examining the effectiveness of digital learning environments.

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