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# Development and Validation of a RADEC-ESD-Based Disaster Resilience HOTS Instrument for Elementary School Teacher Candidates

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**ABSTRACT**

This research aims to develop and validate a Higher-Order Thinking Skills (HOTS) assessment instrument based on the RADEC-ESD (Read, Answer, Discuss, Explain, and Create - Education for Sustainable Development) learning model to measure the disaster resilience competencies of elementary school teacher candidates. Employing the Plomp development model, the study progressed through preliminary research, prototyping, and assessment phases. The instrument consists of 10 validated essay items evaluated by three expert judges (assessment, model, and education experts). Content validity was analyzed using Aiken's V formula, while empirical validity and reliability were tested through a trial involving student respondents. The results demonstrate that the developed instrument possesses high content validity (with Aiken's V values exceeding the critical threshold) and reliable psychometric properties, confirming its suitability for assessing complex cognitive levels and disaster resilience literacy. This instrument provides a robust evaluative framework for teacher education programs to prepare educators capable of fostering disaster-resilient students.

## INTRODUCTION

Indonesia is highly exposed to natural hazards, with West Java being one of the country's most populous and disaster-prone provinces. Data reported by Fauzan (2025) indicate that between January and March 2025, West Java experienced various hazards, including floods, extreme weather, and landslides, which caused damage to educational facilities and affected thousands of residents. These conditions highlight the importance of strengthening disaster resilience through education. The Comprehensive School Safety Framework 2022–2030 identifies educational institutions as a critical component of disaster risk reduction and resilience building, alongside safe school facilities and effective school management (GADRRRES, 2022). In this context, schools have an important role in preparing students and communities to anticipate, respond to, and recover from disasters. Consequently, teachers, including pre-service elementary teachers, need adequate competencies to integrate disaster risk reduction and resilience into elementary education.

Strengthening disaster resilience in education is closely connected to the goals of Education for Sustainable Development (ESD), which promotes education systems capable of developing knowledge, skills, values, and actions that support sustainable development. UNESCO (2021) emphasizes the importance of supportive policies, learning environments, and teacher competencies in achieving sustainable development goals. However, ESD implementation in Indonesia remains uneven and faces various challenges (Fatimah et al., 2025). Recent studies have also reported that teachers' ability to integrate ESD into learning remains suboptimal, particularly in biology and physics instruction (Anwar et al., 2025; Novita et al., 2025). These conditions indicate the need to

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strengthen teacher competencies so that sustainability and disaster resilience can be meaningfully integrated into classroom learning.

One pedagogical approach that may support this competency development is the RADEC learning model, which consists of Read, Answer, Discuss, Explain, and Create stages and was developed in accordance with the characteristics of Indonesian learners. The model provides opportunities for learners to engage with information, discuss ideas, communicate their understanding, and develop solutions or products. Previous studies have demonstrated that RADEC can enhance critical thinking, creative thinking, scientific literacy, and character development among elementary students, particularly in science learning, including topics related to the water cycle (Suryana et al., 2021; Nurnaningsih et al., 2023; Sukmawati et al., 2021; Burhanudin et al., 2024). These findings indicate the potential of RADEC to support the development of competencies relevant to sustainable and disaster-resilient learning.

Nevertheless, existing studies have predominantly examined the implementation of RADEC among elementary school students. Its application to develop disaster resilience competencies among pre-service elementary teachers remains limited. More specifically, research examining the use of RADEC to support ESD-oriented disaster resilience competencies among PGSD students has not yet been identified. This gap indicates the need for an approach that connects active learning, sustainable development, and disaster resilience within teacher education.

In addition to an appropriate learning approach, a valid and reliable assessment instrument is required to measure disaster resilience competencies accurately. Open-ended Higher-Order Thinking Skills (HOTS) instruments can assess complex learning outcomes when supported by adequate evidence of validity, reliability, discrimination power, and item difficulty (Miladanta et al., 2024). Therefore, an instrument that measures disaster resilience through higher-order thinking is needed to examine the extent to which pre-service teachers can analyze disaster-related problems and formulate appropriate responses.

Based on this research gap, this study aims to develop and validate an open-ended HOTS instrument based on the RADEC-ESD framework for measuring disaster resilience competence among PGSD pre-service teachers. Specifically, the study aims to establish evidence of the instrument's content validity, internal consistency reliability, item difficulty, and discriminating power. The resulting instrument is intended to provide an empirically evaluated assessment tool for examining disaster resilience competencies within teacher education.

## RESEARCH METHOD

This study employed a Research and Development (R&D) methodology by adapting the Educational Design Research framework proposed by Akker et al. (2023), which consists of three core phases: preliminary research, development/prototyping, and evaluation. The preliminary research phase focused on identifying the requirements and theoretical foundations for constructing the instrument, including disaster resilience competencies, disaster-related content, the RADEC learning model, ESD principles, and HOTS levels. The development/prototyping phase involved developing the test blueprint, constructing the initial items, and conducting expert validation. The evaluation phase consisted of empirical field testing and quantitative analysis to examine the psychometric characteristics of the developed instrument. This framework

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was selected because the study aimed not only to develop a HOTS instrument but also to establish evidence of its content validity, reliability, and empirical item characteristics for measuring disaster resilience competence among PGSD pre-service teachers.

Participants were selected using purposive sampling based on predefined inclusion criteria to ensure their relevance to the constructs and procedures evaluated in the study (Firmansyah & Dede, 2022). Two groups of participants were involved: expert validators and student respondents.

The expert validation panel consisted of three experts selected based on their academic or professional expertise relevant to the instrument. The inclusion criteria for expert validators were: (1) having academic or professional expertise directly related to at least one theoretical component assessed in the instrument; (2) having expertise in educational assessment and/or HOTS instrument development, the RADEC learning model, elementary education, or disaster-related education; and (3) being able to independently evaluate the relevance of the content, construct alignment, HOTS level, language clarity, and suitability of the items for measuring disaster resilience competence. The panel consisted of one assessment expert with expertise in educational assessment and HOTS instrument development, one RADEC learning model expert, and one education expert with expertise in elementary education and/or disaster-related educational content.

The empirical respondents comprised 47 fifth-semester PGSD students enrolled at a public university in West Java. The inclusion criteria were: (1) being officially enrolled as fifth-semester PGSD students at the time of data collection; (2) having completed a scientific literacy course; and (3) voluntarily agreeing to participate in the empirical testing. Students who had not completed the prerequisite scientific literacy course were excluded because the instrument required basic scientific reasoning and an understanding of disaster-related phenomena. These criteria ensured that the respondents had sufficient academic background to engage with the higher-order thinking demands of the instrument.

The instrument development process followed the three phases of the adapted Educational Design Research framework. During the preliminary research phase, a needs analysis was conducted to identify the target disaster resilience competencies, disaster-related concepts and mitigation content, as well as the relationship between the RADEC learning model and ESD principles. During the development/prototyping phase, the findings were used to construct a test blueprint and develop 10 open-ended essay items designed to assess C4 (analyzing), C5 (evaluating), and C6 (creating) abilities in the context of disaster resilience. The initial items were reviewed by the three experts through qualitative expert judgment and quantitative content validation using Aiken's V, following the interpretation criteria of (Utami et al., 2024). Items that required improvement based on the expert ratings and recommendations were revised before empirical testing.

The evaluation phase involved administering the revised instrument to 47 PGSD students under standardized testing conditions. Student responses were scored using predetermined scoring criteria and analyzed quantitatively to examine the instrument's internal consistency reliability, item difficulty, and discriminating power. The results of the empirical evaluation were subsequently used to determine the psychometric quality and feasibility of the developed instrument for measuring disaster resilience competence among PGSD pre-service teachers.

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The test blueprint was developed by integrating the RADEC syntax, disaster resilience indicators, ESD principles, and HOTS cognitive levels. Each RADEC stage was associated with a specific disaster resilience competency and corresponding ESD dimension, while the HOTS level was determined according to the cognitive demands of each indicator. As presented in Table 1, the Read and Answer stages were designed at the C4 level, Discuss and Explain at the C5 level, and Create at the C6 level. This mapping provided the conceptual basis for constructing the 10 open-ended essay items.

**Table 1**. Test Blueprint for Disaster Resilience HOTS Instrument Based on RADEC-ESD Model

| RADEC Syntax | Disaster Resilience Indicator | ESD Principle | HOTS Level |
|---|---|---|---|
| **Read** | Identifying types, characteristics, and potential disaster risks in the local environment | Environmental dimension: Risk perception and ecosystem conditions | C4 |
| **Answer** | Formulating alternative mitigation actions based on gathered information | Social dimension: Collective responsibility of the school community | C4 |
| **Discuss** | Deliberating the feasibility of group-specific disaster preparedness plans | Social and Economic dimensions: Resource utilization | C5 |
| **Explain** | Presenting group findings regarding disaster-related phenomena | Environmental and Economic dimensions: Long-term sustainability | C5 |
| **Create** | Conducting investigations, problem-solving, or creating artifacts related to disaster resilience | Integrated multidimensional ESD (environmental, social, economic) | C6 |

## Data Analysis

Data analysis was conducted to obtain evidence of content validity, internal consistency reliability, item difficulty, and item discrimination. Since the instrument consisted of open-ended essay items with polytomous scoring, the analysis was conducted using statistical procedures appropriate for such data rather than dichotomous-item approaches. Content validity was examined through ratings from the three expert validators using Aiken's V, with interpretation criteria following (Utami et al., 2024). The results in Table 2 show that the Aiken's V values ranged from 0.93 to 0.96, with an overall average of 0.95, categorized as very high. The assessment expert obtained an average V of 0.93, indicating that the instrument was feasible in terms of the HOTS construct, language, time allocation, and layout. The RADEC model expert obtained a value of 0.96, indicating alignment with the RADEC syntax and learning outcome indicators, while the education expert also obtained 0.96, indicating accuracy and contextual appropriateness in relation to scientific facts and disaster mitigation concepts. Based on these results, the instrument demonstrated strong content validity and was considered suitable for empirical testing.

**Table 2**. Recapitulation of Content Validation Results for the Disaster Resilience HOTS Instrument

| Expert Validator | Number of Indicators | Average Aiken's V (V) | Validity Category | Conclusion & Recommendation |
|---|---|---|---|---|
| Assessment Expert | 10 | 0.93 | Very High | Feasible regarding HOTS construct, language, time allocation, & layout. |
| RADEC Model | 8 | 0.96 | Very High | Aligned with RADEC syntax and learning indicator outcomes. |

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| Expert Validator | Number of Indicators | Average Aiken's V (V) | Validity Category | Conclusion & Recommendation |
|---|---|---|---|---|
| Expert Education Expert | 8 | 0.96 | Very High | Accurate and contextual regarding scientific facts and mitigation concepts. |
| **Average** | **26** | **0.95** | **Very High** | **Theoretically and methodologically valid; ready for data collection.** |

Following content validation, the revised instrument was empirically tested with 47 PGSD students. Internal consistency reliability was assessed using Cronbach's Alpha, adopting a minimum threshold of 0.70 in accordance with (Setyaedhi, 2024). In addition, item difficulty and discriminating power were examined to determine the level of challenge presented by each item and its ability to differentiate student performance, referring to HOTS instrument development protocols from (Miladanta et al., 2024). The results of these analyses are summarized in Table 3.

**Table 3.** Summary of Item Analysis for Disaster Resilience HOTS Test Instrument

| Parameter | Value | Category | Conclusion |
|---|---|---|---|
| Reliability (Cronbach's Alpha) | 0.865 | Very High | Test instrument exhibits excellent internal consistency and reliability. |
| Item Difficulty | 0.74 – 0.90 | Easy | All test items fall into the easy category ($\bar{X}$ = 7.40 - 8.98). |
| Discriminating Power | 0.23 – 0.42 | Fair to Very Good | Items effectively differentiate between high- and low-performing students. |
| **Item Feasibility** | 100% | Accepted | All items are suitable for use without requiring total revision. |

As shown in Table 3, the instrument obtained a Cronbach's Alpha of 0.865, indicating very high internal consistency. The item difficulty indices ranged from 0.74 to 0.90, placing all items in the easy category. Although this indicates that the items could be answered by the respondents, the concentration of items in the easy category suggests that the instrument requires further refinement to achieve a more balanced distribution of difficulty. Meanwhile, the discrimination indices ranged from 0.23 to 0.42, indicating that the items had fair to very good capacity to distinguish differences in student performance. Overall, all items were considered feasible for use, while the distribution of item difficulty remains an aspect that should be addressed in subsequent instrument development.

## RESULTS AND DISCUSSION

### *Results*

The developed disaster resilience HOTS test instrument consisted of 10 open-ended essay items integrating the five stages of the RADEC model with the three dimensions of Education for Sustainable Development (ESD): environmental, social, and economic. The instrument was first subjected to expert judgment involving three validators representing assessment, RADEC learning, and education expertise. The content validation results are presented in Table 2, showing that the items achieved a very high level of content validity, with an overall average Aiken's V of 0.95. The results indicate that the instrument demonstrated adequate alignment with the intended constructs and was considered suitable for proceeding to empirical testing.

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Following expert validation and revision, the instrument was administered to 47 fifth-semester PGSD students. The results of the empirical item analysis are presented in Table 3, which summarizes the instrument's reliability, item difficulty, discriminating power, and overall feasibility. The findings indicate that the instrument demonstrated acceptable empirical characteristics for measuring disaster resilience through HOTS tasks. The distribution of item discriminating power is further illustrated in Figure 1, providing a visual representation of the variation in the ability of individual items to differentiate student performance.

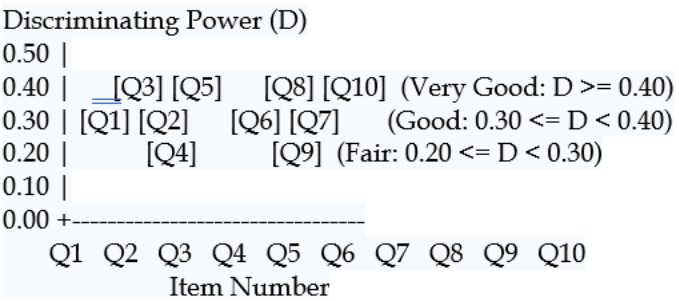


**Figure 1.** Distribution of Discriminating Power Values for the RADEC-ESD Based Disaster Resilience HOTS Instrument

The conceptual relationship between the RADEC syntax and the ESD dimensions underlying the developed instrument is presented in Figure 2. The figure illustrates how each RADEC stage is connected to disaster resilience indicators and relevant environmental, social, and economic dimensions of ESD.

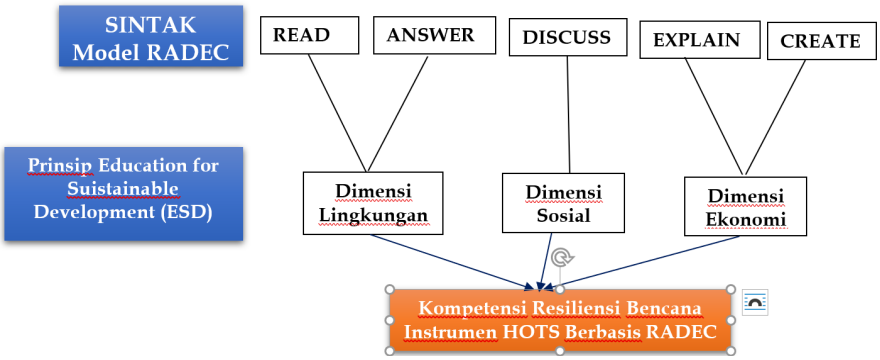


**Figure 2.** Integration of RADEC Model Syntax and ESD Principles

### *Discussion*

The findings indicate that the developed instrument possesses strong content alignment with the intended disaster resilience construct. The very high content validity obtained through expert judgment suggests that the items were appropriately formulated in relation to the HOTS construct, RADEC syntax, disaster resilience indicators, and ESD dimensions. This is consistent with Utami et al. (2024), who emphasize that high content validity provides evidence that an instrument adequately represents the construct being measured. The consistency of expert judgments also highlights the importance of involving validators with relevant domain-specific expertise when developing educational assessment instruments (Firmansyah & Dede, 2022).

The conceptual integration of RADEC and ESD is reflected in the structure of the instrument. The Read and Answer stages emphasize identifying and analyzing disaster-related information, while Discuss and Explain provide opportunities to consider

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collective perspectives and the broader implications of disaster mitigation. The **Create** stage extends these processes toward developing solutions or artifacts. Within this structure, ESD provides a sustainability-oriented context by connecting disaster resilience with environmental awareness, social responsibility, and responsible consideration of resources. Thus, the RADEC syntax functions as a progressive structure for engaging higher-order thinking, while the ESD dimensions provide the contextual orientation for assessing disaster resilience as a multidimensional competency.

The empirical findings further indicate that the instrument has adequate internal consistency. The reliability result suggests that the items function coherently in measuring the intended construct. This finding is consistent with Setyaedhi (2024), who notes that Cronbach's Alpha values above 0.70 indicate acceptable reliability for assessment instruments, including instruments using polytomous scoring. Thus, the developed instrument provides consistent measurement across its open-ended items.

However, the distribution of item difficulty represents a limitation of the developed instrument. The majority of items were categorized as easy, indicating that the instrument did not yet provide a sufficiently balanced distribution of difficulty levels. This condition may be related to the characteristics of the respondents, as the participants were fifth-semester PGSD students who had previously developed scientific literacy and disaster-related knowledge through their academic experiences. Their educational background may have enabled them to respond effectively to the disaster resilience scenarios presented in the instrument. This interpretation is consistent with Eliza et al. (2023), who found a positive relationship between prospective teachers' resilience and their ability to solve HOTS-oriented tasks. Nevertheless, the predominance of easy items may reduce the instrument's capacity to differentiate students across a wider range of competency levels. Therefore, subsequent development should revise existing items and add more challenging items to achieve a more balanced difficulty distribution.

The item discrimination findings demonstrate that the instrument was capable of distinguishing differences in student performance. This characteristic is important for a HOTS instrument because students with different levels of higher-order thinking and disaster resilience competence should be able to demonstrate distinguishable performance. The finding is in line with Agustin et al. (2021), who reported that RADEC learning can support the development of higher-order thinking skills among undergraduate education students. Previous studies in elementary education have similarly demonstrated the contribution of RADEC to critical thinking, creativity, character development, and higher-order cognitive processes such as analysis, evaluation, and creation (Nurnaningsih et al., 2023; Sukmawati et al., 2021; Suryana et al., 2021; Burhanudin et al., 2024; Fiteriani et al., 2025).

The findings also have implications for strengthening ESD-oriented competencies in teacher education. Previous studies have identified challenges in teachers' ability to integrate ESD into learning, particularly in biology and physics contexts (Anwar et al., 2025; Novita et al., 2025). In this context, the present instrument offers an assessment mechanism for examining disaster resilience competencies through an ESD-oriented framework. Rather than functioning solely as a conventional disaster knowledge test, the instrument emphasizes analysis, evaluation, discussion, explanation, and creation of

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solutions. This orientation may support the preparation of prospective elementary teachers to address disaster resilience as part of sustainable education.

The development of such an instrument is also relevant to human-centered approaches to disaster education, which emphasize the importance of considering human needs, capacities, and participation in disaster risk reduction (Lin et al., 2024). By placing disaster resilience within the context of teacher preparation, the instrument may contribute to strengthening competencies that can subsequently be transferred into elementary school learning environments.

Despite these contributions, the study has limitations. The empirical testing involved a relatively small sample from a single public university in West Java, which limits the generalizability of the findings to PGSD students in other institutions and regions. Another important limitation is the uneven distribution of item difficulty, with most items falling into the easy category. This indicates that the current instrument requires further refinement to provide greater variation in cognitive demand and to improve its ability to differentiate respondents across competency levels. Future studies should therefore involve larger and more diverse samples, include students from multiple teacher education institutions, and develop or revise items across a wider range of difficulty levels to obtain stronger evidence of the instrument's psychometric quality and generalizability.

## CONCLUSION

This study successfully developed and validated a Higher Order Thinking Skills (HOTS) assessment instrument based on the Read-Answer-Discuss-Explain-Create (RADEC) model and Education for Sustainable Development (ESD) principles to measure disaster resilience competence among pre-service elementary school teachers. The instrument demonstrated very high content validity based on expert judgment (Aiken's V = 0.95) and excellent internal consistency based on empirical testing with fifth-semester PGSD students (Cronbach's Alpha = 0.865). Item analysis showed that all items had fair-to-very-good discriminating power, although the item difficulty distribution was predominantly in the easy category, indicating the need for further refinement of the item pool. These findings provide evidence that the instrument can be used to assess disaster resilience competence through higher-order thinking within an ESD-oriented framework. Practically, teacher education institutions can use the instrument to identify pre-service teachers' disaster resilience competencies and inform the strengthening of disaster-related and sustainability-oriented learning in teacher preparation programs. However, the findings should be interpreted with caution because the empirical testing involved a relatively small sample from a single public university in West Java, which limits the generalizability of the results. Future research should therefore involve larger and more diverse samples from multiple teacher education institutions and refine the item pool by incorporating a more balanced range of difficulty levels. Such studies can provide stronger evidence of the instrument's psychometric quality and support the broader development of assessment practices that integrate HOTS, disaster resilience, RADEC, and ESD in teacher education.

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