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Development of an Assessment Instrument for Understanding Physics Concepts and Nationalism Attitudes of Learners on Newton's Laws Material

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Abstract: This study aimed to develop and validate an assessment instrument to measure students' understanding of Newton's laws and their nationalism attitudes. The instrument consisted of 15 essay questions on Newton's laws and a 30-item Likert-scale questionnaire on nationalism attitudes. Content validity was evaluated by eight experts (lecturers, teachers, and peers) using Aiken's V index, showing high validity. Empirical validation was conducted with 275 students from public senior high schools in Bima Regency, West Nusa Tenggara. Data were analyzed using Item Response Theory with the Partial Credit Model (PCM) via QUEST. Results indicated that all concept understanding items fit the PCM criteria, with acceptable reliability values ranging from 0.72 to 0.98. For the nationalism instrument, 29 items met the fit criteria, while one item was rejected. Overall, the developed instruments demonstrated strong validity and reliability, and are suitable for assessing both cognitive understanding of Newton's laws and students' nationalism attitudes.

Keywords: Assessment Instrument; Nationalism Attitudes; and Understanding Physics Concepts

Introduction

Physics education at the secondary level is fundamentally tasked with a dual mandate: fostering deep conceptual understanding of physical laws and developing students' essential cognitive skills, such as critical thinking and problem-solving (Permendiknas, 2006). Crucially, this technical focus must be integrated with the broader aims of national education, which explicitly calls for the holistic development of students encompassing cognitive, affective, and psychomotor domains (Law No. 20/2003). Therefore, effective physics instruction must inherently be designed to cultivate not just knowledge acquisition but also vital character attributes, specifically nationalism, as a cornerstone of responsible citizenship (President of the Republic of Indonesia, 2022). The recent shift in educational paradigms internationally, moving towards comprehensive frameworks like AlAfnan's taxonomy, further emphasizes the necessity of this integration for nurturing well-rounded learners (AlAfnan et al., 2024; Pratiwi et al., 2025).

Despite the clear educational objectives, the attainment of in-depth physics conceptual understanding remains a persistent global challenge. Studies frequently report that students struggle to move beyond superficial knowledge, often relying on rote memorization rather than constructing the relational meaning of concepts, severely limiting their capacity for application and complex reasoning (Puri et al., 2023; Zulrahayu, 2024). This problem is exacerbated by the prevailing use of traditional assessments that primarily

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test lower-order cognitive skills and fail to diagnose the root of conceptual difficulties or measure complex abilities like interpretation and extrapolation. For instance, diagnostic research shows that students' performance on higher-order cognitive tasks in specific physics topics is significantly below average, highlighting a systemic failure of current assessment tools to capture genuine comprehension (Lumbantobing, 2023; Resbiantoro et al., 2022).

The affective domain, particularly the development of nationalism attitude, faces concurrent pressures. In the era of globalization and rapid technological advancement, the unfiltered exposure to Western culture is widely reported to dilute nationalistic values, leading to issues such as increased consumerism and a preference for foreign cultural elements among youth (Winarsih et al., 2023). Phenomenologically, this manifests in educational settings through students' reduced engagement with national identity and local culture (Cholisin, 2017). Although the importance of the affective domain in learning is continually underscored in educational research, its integration and measurement in science subjects, especially physics, are often neglected in favor of the cognitive domain (Doyan et al., 2023; Limbu, 2024; Zulrahayu, 2024). Existing instruments for measuring nationalism tend to be generic and lack contextual integration with the specific learning process of physics (Utami et al., 2020).

The primary research gap stems from the methodological disconnect between assessing cognitive and affective outcomes. Previous efforts, even those that acknowledge the correlation between conceptual understanding and attitude Wirnasih et al. (2023), have largely focused on developing separate instruments. This fragmented assessment approach is inefficient, creates an administrative burden for teachers, and fails to provide a cohesive, real-time diagnostic profile of the student's development as required by the holistic education mandate (Lestari et al., 2025; Nurjanah et al., 2025). Furthermore, teachers' competency demands, outlined in Permendiknas No. 16 of 2007, necessitate effective tools for assessing both process and outcome. Therefore, there is an urgent methodological imperative to develop an integrated assessment instrument that can simultaneously and efficiently capture students' cognitive mastery and their affective stance within the context of the learning material (Nurhidayati, 2023; Sudirman et al., 2023).

The novelty of this study is the development of a single, psychometrically rigorous instrument that merges the measurement of physics concept understanding and nationalism attitudes, uniquely contextualized within the local wisdom of rabi ro'o. This approach is not merely cultural embellishment; it constitutes a robust pedagogical strategy. International literature supports the notion that integrating local wisdom into science education significantly enhances students' engagement and scientific literacy by providing a relatable and culturally resonant learning context (Dini et al., 2025; Doyan et al., 2020; Verawati et al., 2024). The logical rationale is that by embedding physics principles within the tangible, culturally significant practices of rabi ro'o, the instrument will increase the assessment's ecological validity, fostering a deeper connection between abstract physics concepts and real-world national identity, thereby strengthening both cognitive application and affective internalization (Sari et al., 2020; Sudirman et al., 2023). This research is critically important as it pioneers an integrated, contextually relevant tool that directly addresses the dual-measurement challenge.

Based on several previous studies, each variable was developed separately, be it nationalism character or concept understanding. The same applies to the development of learning instruments that only improve character or concept understanding. Therefore, this research combines some of these previous studies to see their implementation in the physics learning process. So it is necessary to develop a learning instrument based on local wisdom rabi ro'o to improve understanding of physics concepts and nationalism attitudes of students.

Method

Research Method

This research uses development research methods adapted from Mardapi (2008) and Oriondo et al. (1998). The research method consists of four stages, namely: (1) the design of the test, which includes the determination of test objectives, the determination of competencies to be achieved, (2) preparation of tests, which includes the preparation of test's blueprint, writing test items, preparing scoring guidelines, item validation, as well as revision of validation results, (3) test trials, which include the determination of the trial subject, the implementation of the trial, and analysis of the results of the trial data, and (4) the preparation of valid instruments.

Research Subjects

The subjects of this study were students, experts, physics teachers and practitioners. There were 275 students of class X MIA from SMAN 1 Woha and SMAN 1 Belo, West Nusa Tenggara, who were involved in empirical validation. The number of samples is in accordance with the minimum sample size requirement that must be taken in the analysis of the SEM (Structural Equation Modeling) model, which is 100 to 200 (Hair et al., 2022). The sample was chosen in a random cluster with the consideration that the students had carried out physics learning that had been designed before by the researcher. While content validation involved two expert lecturers, three physics teachers, and four peers.

Data Analysis

The instruments developed were test and non-test instruments. The test instrument is used to measure the understanding of physics concepts consisting of 15 numbers in the form of essays. While the non-test instrument in the form of a questionnaire was used to measure nationalism consisting of 30 questions arranged in the form of a Likert scale.

Reliability testing is done using the QUEST program by reading the output summary of item estimates and summary of case estimates. Interpretation of instrument reliability values is done by comparing the results with the KR-20 model in accordance with Table 1.

Table 1. Interpretation of Reliability Values

Reliability Value	Interpretation
0.00 – 0.20	Low reliable
0.20 – 0.40	Less reliable
0.40 – 0.60	Sufficient
0.60 – 0.80	Reliable
0.80 – 1.00	Very reliable

The validity of the instrument was obtained through content and empirical validation. Content validation was done trought validation by expert consisting of lecturers, teachers and peer reviewers. The validators will be given a validation assessment instrument to conduct quantitative and qualitative assessments related to material, construction, and language. Quantitative assessment is obtained based on the score given by the validator, with assessment categories 1 to 4 for each item assessed by referring to the achievement score indicator. The result of the quantitative assessment given will be analyzed using the Aiken's V formula as seen in equation (1).

$$V = \frac{\Sum s}{[n(c-1)]} \quad (1)$$

Where n is the number of riter, c is the number of category, I is the lowest score in the scoring category, r is the score given bby rater. The value of s can be calculated using the equation (2) (Azwar, 2012).

$$s = r - I \quad (2)$$

The quantitative data obtained based on the experts' assessment is then converted into qualitative form to determine the quality of the instrument that has been developed. The qualitative assessment is based on Table 2.

Table 2 Validity Quality Categories

Validity results	Validity criteria
$0.8 < V \leq 1.0$	Excellent
$0.6 < V \leq 0.8$	Good
$0.4 < V \leq 0.6$	Moderate
$0.2 < V \leq 0.4$	Less

After going through the theoretical validation stage, the instrument was tested to obtain empirical validation data involving 275 students. The data obtained from the test results were then analyzed using the QUEST program with the PCM model (Adams et al., 1996). The data processed were polytomous because the instruments used were descriptions and questionnaires with four categories. The output of the QUEST program will show the analysis results in the form of (1) goodness of fit of the PCM model, with a good category if the INFIT MNSQ value is in the range of 0.77 - 1.30, (2) the level of difficulty of the question, with a good category if the value obtained is in the range of $-2 \leq b \leq +2$, and (3) reliability, with a good category if the value obtained is in the range of 0.6 - 1.0 (Subali & Pujiyanti, 2011).

Result and Discussion

Content Validity

Table 3. Theoretical Validation Analysis Results of Concept Understading Instrument

Question Item	Validity	Category
1	1.00	Excellent
2	1.00	Excellent
3	1.00	Excellent
4	1.00	Excellent
5	1.00	Excellent
6	1.00	Excellent
7	1.00	Excellent
8	1.00	Excellent
9	1.00	Excellent
10	1.00	Excellent
11	1.00	Excellent
12	1.00	Excellent
13	1.00	Excellent
14	1.00	Excellent
15	1.00	Excellent

The quality of the instrument can be seen from the level of validity and reliability. The test instruments developed consist of test and non-test instruments. The test instruments for concept understanding and nationalism have passed the theoretical validation process. This is so that the test instrument does measure what should be measured. The test instrument consists of 15 description items used to measure concept understanding. The non-test instrument in the form of a questionnaire measuring nationalism attitude includes

30 items arranged in the form of a Likert scale consisting of several answer options, namely strongly agree, agree, disagree, and strongly disagree for each statement item. Both instruments were developed to address the independent curriculum syllabus. Expert and practical lecturers reviewed each item. The results of the theoretical validation analysis of the concept understanding instrument are presented in Table 3.

Table 3 shows that the validity value for each item in the physics concept understanding test instrument that expert lecturers and practitioners have validated is 1.00. The reference in Table 1 shows that each item of understanding of physics concepts developed is excellent and valid for further use. The results of the validation analysis of the nationalism attitude measurement questionnaire are presented in Table 4.

Table 4. Theoretical Validations Analysis Results of Nationalism Attitude Questionnaire

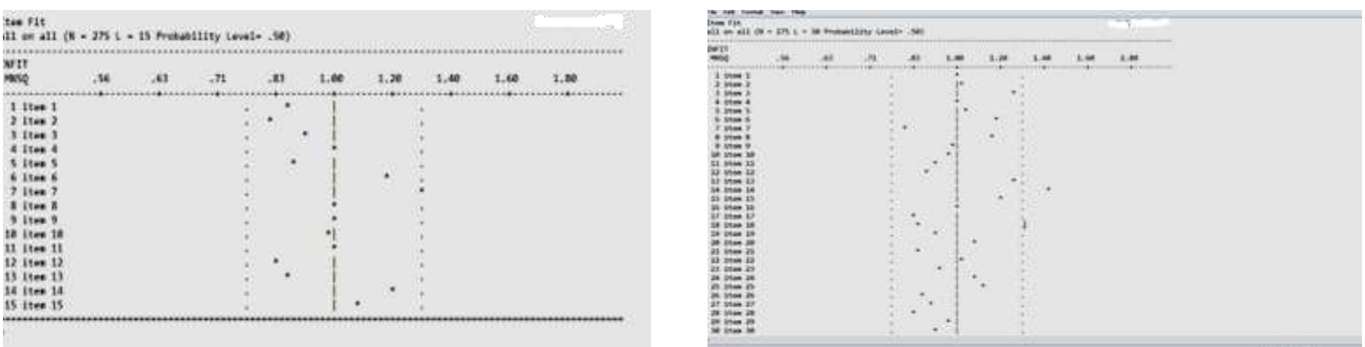
Numbers	Aspect	Indicator	Validity	Category
1.	Contents	The suitability of the question indicator with the competencies to be achieved	1.00	Excellent
		The suitability of question indicators with material related to Rabi Ro'o to achieve an understanding of concepts and nationalist attitudes	1.00	Excellent
		The suitability of the question items with the characteristics of students in the attitude of nationalism	1.00	Excellent
		Question item construction	1.00	Excellent
2.	Language	Correct use of language	1.00	Excellent
		The accuracy of the sentences used does not lead to interpretation	1.00	Excellent

Based on Table 3, it is known that the validity of the nationalism attitude questionnaire that has been validated by expert lecturers and practitioners shows a value of 1.00 for each aspect measured. Based on the reference in Table 4, this shows that each item of the nationalism attitude statement developed is in the very good category and valid for further use.

Goodness of Fit

After the questions were validated by lecturers and practitioners, they were tested on students who had received Newton's law material about motion. The instrument trial involved 275 randomly selected students to obtain data on the results of empirical validation. The data obtained were analyzed using IRT analysis of the PCM model using the QUEST program. The results of the goodness of fit analysis of the instrument are shown in Figure 1.

The results of item fit with PCM are seen based on the INFIT MNSQ value. Items are said to fit the PCM model if the INFIT MNSQ value is in the range of 0.7 to 1.30 (Adams et al., 1996). Based on the results of the IRT analysis shown in Figure 1, it can be seen that all questions measuring understanding of physics concepts are in the INFIT MNSQ range, namely 0.77 - 1.33, in line with Novitasari et al. (2021). Whereas in the instrument of nationalism attitude questions, it can be seen that there is one question that is misfit, namely at number 14, so that this question is automatically rejected and not used for measurement. In both instruments there are also several items whose INFIT MNSQ values are close to 1.00 where the best range of godness of fit is a value of 1. This means that all items used in the measurement of understanding the concept of fit or fit the PCM model (Rasch Model) and the attitude of nationalism there is one misfit item or does not fit the PCM model (Rasch Model).



(a) (b)

Figure 1. Results of Item Fit Analysis of the Instrument. (a) Concept understanding test; (b) Concept understanding test

Reliability

The reliability test shows the consistency of the scores produced in the measurement. The value that expresses reliability is called the reliability coefficient. The higher the reliability coefficient of an instrument, the smaller the error pattern in the measurement.

Alternatively, the question will have high reliability when the value is close to 1. The reliability test was conducted using the QUEST program by reading the output of the summary of item estimates and the summary of case estimates. Interpretation of instrument reliability value is done by comparing. Interpretation of instrument reliability values is done by comparing the results with the KR-20 model in Table 5.

Table 5. Interpretation of Reliability Value

Reliability Value	Interpretation
0.00 – 0.20	Very unreliable
> 0.00 – 0.40	Not Reliable
> 0.40 – 0.60	Moderately Reliable
> 0.60 – 0.80	Reliable
> 0.80 – 1.00	Very Reliable

The results of the physics concept understanding test and nationalism attitude questionnaire show the summary of item and case estimates as presented in Table 5. Based on Table 6, it can be seen that both the physics concept understanding test and the nationalism attitude questionnaire have item reliability values that are in the range of 0.60 - 0.80, while the case reliability value is in the range of 0.06 - 0.80. So, it can be concluded that both instruments are in the reliable category regarding item reliability and case reliability.

Table 6. Instrument Reliability Estimation

Reliability		Instrument
	Concept Understanding Ability	Nationalism Questionnaire
Summary of case estimate	0.73	0.83
Summary of item estimate	0.77	0.71

Item Difficulty Level

Quality question items and the level of difficulty of the item must also be considered. The item is considered good if it has a difficulty level b between -2 and +2 (Hambleton et al., 1985). QUEST output also shows the level of item difficulty. Figure 2 shows that the index of difficulty b of concept understanding questions is in the range of -1.00 to +0.8. So, the physics concept understanding assessment instrument consists of easy, medium, and complex items. This shows that all items are in a suitable category because the item difficulty index ranges from -2 to +2. Parameter estimation of item difficulty level follows the PCM model.

This study aims to produce a concept understanding assessment instrument and nationalism integrated with local wisdom on Newton's Law material using the development stage, which refers to the 4D model: Define, Design, Develop, and Disseminate. Experts have validated the assessment instrument in this study. The V Aiken validation analysis results showed that the research instruments prepared had met the valid criteria. In addition, the developed device has undergone many trials, both feasibility tests, practicality tests, and field trials.

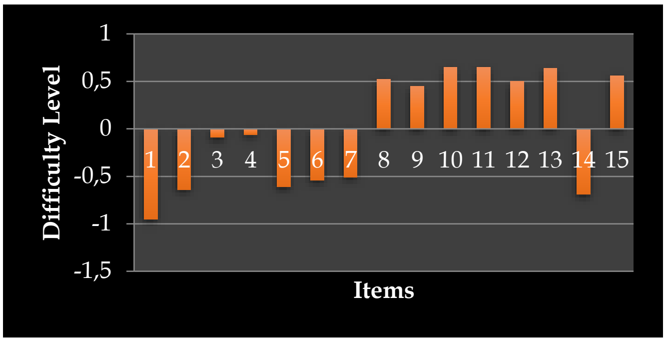


Figure 2. Item difficulty level of concept understanding questions

Concept understanding and nationalism are measured using test and non-test instruments. In addition to developing physics learning tools, this research also developed the concept of understanding test instruments in the form of 15 essay questions and nationalism non-test instruments in the form of a questionnaire consisting of 30 statements. Assessment of test and non-test instruments was carried out by two lecturers, three physics teachers, and four peers. The results of the assessment of the test instruments developed are included in the "High" category. Thus, it can be concluded that the test and non-test instruments developed are suitable for use (Wijaya et al., 2021).

Experts, physics teachers, and peers first validated the developed test instruments. After revision based on validator suggestions, the test, and non-test instruments were tested on 275 high school students for empirical testing. Assessment of test and non-test instruments to obtain valid and reliable results was carried out by QUEST analysis. The analysis results stated that the test instrument on the question of understanding the concept that was prepared was valid and reliable in contrast to the non-test on the nationalism questionnaire, which was prepared reliably, and 1 item was not valid, namely numbers 14 and 29 valid items were reliable. Therefore, the learning tools developed are feasible to be tested on students. The first trial conducted on students was limited. This trial was conducted to determine students' responses to the learning devices developed. Based on the results of the analysis, students responded positively to the developed physics learning tools. Therefore, it can be said that the device that has been developed meets the practicality properties, in line with the research of Novitasari et al. (2021) and Astuti et al. (2022) that valid and reliable concept-understanding assessment instruments make it easy to read and analyze questions (Low et al., 2023; Naqiyah et al., 2020).

Conclusion

The study concludes that the instrument development procedure follows the stages of test design, preparation, testing, and valid test assembly; the developed instrument is valid based on qualitative and quantitative assessments and is suitable for testing; it aligns with the Partial Credit Model (PCM), with items ranging from 0.77 to 1.33—except for one invalid nationalism item; it demonstrates good reliability with values between 0.72 and 0.83; the difficulty level of the physics concept understanding items falls within the acceptable range of -1.20 to 0.80; and both test and non-test instruments have passed empirical testing, meeting validity and reliability criteria.

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Conceptualization, methodology, validation, formal analysis, investigation, resources, data curation, writing—original draft preparation, writing—review and editing, visualization, E., N.M.D., I.L.M., and R.A.F. All authors have read and approved the published version of the manuscript.

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