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Development of Intellectual Testing for Electric Motor Installation in Vocational Education

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ABSTRACT

This study aims to understand the functionality of computerized adaptive testing software based on a website application model for the competency of electric motor installation in vocational education. The research method in this research uses research and development and Waterfall model. The research subjects are teachers and students in the electric motor installation subject. Data collection is done using the Noeeriat software instrument. The results of this study are as follows: (1) This tool can function well. This is indicated by testing on the authority of teachers (86.22%) and students (87.50%). (2) The usability level of the tool is considered very feasible in terms of functionality, display, and usefulness. (3) This tool contributes to an improvement in student learning outcomes. This tool can be used to measure the level of students' competency achievement, as a basis for compiling progress reports on learning outcomes, and as a foundation for improving the learning process.

1. Introduction

The use of computer-assisted assessment has not yet been fully optimized in most Electrical Power Installation Engineering Skills Competencies, particularly in the Special Region of Yogyakarta (DIY). The current assessment processes predominantly employ a fixed test length approach, where the questions administered are not tailored to the level of students' abilities. Computer-based tests have not been able to present questions that align with the test takers' proficiency levels, which can affect the validity and reliability of the test results.

The current assessment practices in Electrical Power Installation Engineering Skills in the Special Region of Yogyakarta (DIY) reveal significant gaps, particularly in the optimization of computer-assisted assessments. Research indicates that multimedia-assisted learning can enhance concept mastery, yet the assessment methods remain traditional and inflexible, failing to adapt to individual student proficiency levels [21]. A needs analysis highlights the necessity for specific guidelines and industry involvement in project-based learning assessments, which could inform the development of more tailored evaluation models [39]. Furthermore, the integration of innovative teaching tools, such as IoT-based systems, can facilitate a more interactive learning environment, potentially improving assessment outcomes [21]. Additionally, the implementation of real-time fault location systems in training can provide practical insights, enhancing the relevance of assessments

[28]. Lastly, addressing occupational safety and health (OSH) in learning models is crucial, as it reflects the need for comprehensive assessment strategies that align with industry standards [40].

Assessment in education plays a crucial role in identifying students' learning needs and developmental achievements. It is a systematic and systemic effort carried out through the collection of valid and reliable data, which is then processed as a basis for decision-making in educational programs. Vocational education, specifically, plays an essential role in producing human resources with the skills and expertise in specialized fields, such as Electrical Power Installation Engineering. Assessment in education is vital for identifying students' learning needs and developmental achievements, particularly in vocational education, which aims to equip individuals with specialized skills, such as in Electrical Power Installation Engineering. Effective assessment involves a systematic collection of valid and reliable data, which informs decision-making in educational programs [26]. Various assessment techniques, including both objective and descriptive tests, are employed to monitor student progress and outcomes continuously [33]. Moreover, assessments influence the behavior of students and educators, guiding course selection and teaching methods, while also serving as a basis for accountability in educational systems [13]. In vocational settings, the integration of advanced assessment methods, such as data mining and artificial intelligence, can enhance instructional quality and improve the overall educational experience. Ultimately, a comprehensive assessment framework is essential for fostering skill development and ensuring that educational programs meet the evolving demands of the workforce [27].

However, the implementation of testing must also consider the anxiety and stress levels of the participants, as these factors can influence the interpretation of students' abilities, ultimately impacting the validity and reliability of test scores. High levels of anxiety can hinder test-takers' ability to comprehend and recall test material. One solution to address this issue is the development of Computerized Adaptive Testing (CAT), which has been proven to measure individual abilities more accurately, reduce test duration, and provide faster results compared to the traditional Paper and Pencil Test. The implementation of testing must indeed account for anxiety and stress levels, as these factors can significantly affect students' performance and the interpretation of their abilities. High test anxiety is associated with poorer academic performance, as it disrupts cognitive processes necessary for tasks like reading comprehension and fluid reasoning, leading to difficulties in recalling test material [4]. Research indicates that test anxiety coexists with depression and negatively correlates with academic performance, suggesting that psychological interventions can enhance outcomes [11]. Furthermore, interventions aimed at improving study habits and emotional regulation have shown promise in alleviating math anxiety, which similarly impacts performance [33]. The development of Computerized Adaptive Testing (CAT) offers a promising solution to enhance assessment experiences by tailoring evaluations to individual student abilities, thereby reducing test duration and anxiety. This adaptive approach utilizes algorithms to select questions based on real-time estimations of a learner's proficiency, which not only streamlines the testing process but also provides immediate feedback, fostering a less stressful environment for students [32] [19]. Research indicates that CAT can improve measurement accuracy and ensure test security, making it a preferred method over traditional assessments [8]. Furthermore, the integration of artificial intelligence in CAT enhances cognitive diagnoses, allowing for personalized support that addresses specific learning needs. By mitigating psychological barriers and enhancing the validity and reliability of test scores, CAT represents a significant advancement in educational assessment practices.

The objectives of this research include:

1. develop a web-based Computerized Adaptive Testing (CAT) system for Electrical Power Installation Engineering assessments that can be accessed anytime and anywhere via the internet.
2. To improve the validity and reliability of assessments by tailoring test items to the abilities of individual students through the use of CAT.
3. To address the technical challenges faced in the current CAT models by creating a more scalable and flexible testing platform.

2. Method

The development of a Computerized Adaptive Testing Model for assessing cognitive abilities aligns with contemporary educational strategies that leverage technology to enhance learning outcomes. This model can significantly improve the accuracy and relevance of feedback provided to students, as evidenced by research showing that cognitive technology can personalize learning experiences and diagnose learning weaknesses effectively. Additionally, the integration of adaptive assessments can foster the development of essential cognitive skills among students, preparing them for the challenges of the 21st century. The influence of cognitive styles on research productivity further underscores the importance of tailoring assessments to individual learning preferences, which can optimize academic performance. Moreover, employing a Cognitive Knowledge Representation Model can facilitate the identification of students' reasoning levels, thereby enhancing the assessment process [34]. Ultimately, utilizing modern educational technologies can significantly contribute to the formation of students' cognitive competencies, ensuring a more effective educational experience [1].

The study conducted at Yogyakarta State University and SMK N 1 Pundong involved the development of a computerized cognitive assessment tool for students in the Electrical Power Installation Engineering Program, utilizing the Waterfall Model's five stages: communication, planning, modeling, construction, and deployment. This approach aligns with the growing trend of integrating digital technology in cognitive assessments, which enhances the evaluation process by providing personalized and timely feedback to students, thereby improving learning outcomes. The use of cognitive technology, which combines artificial intelligence and machine learning, has shown potential in accurately diagnosing learning weaknesses and adapting learning content based on assessment data. Furthermore, the increasing interest in digital cognitive assessment tools, particularly during the COVID-19 pandemic, highlights the relevance of such innovations in educational settings [23]. Overall, this study contributes to the ongoing exploration of effective cognitive assessment methodologies in the context of modern education [35].

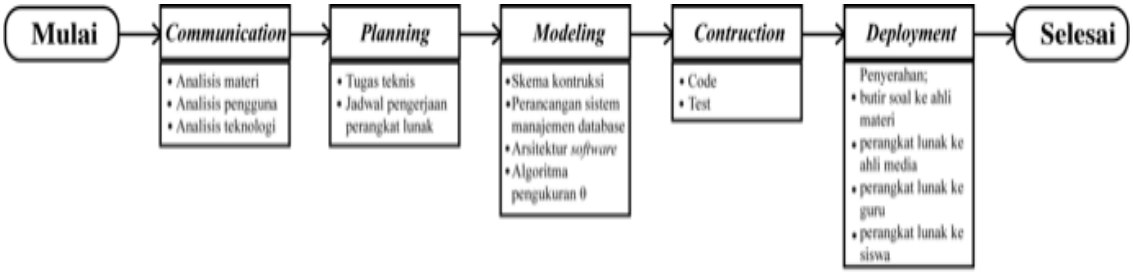

Fig. 1. Development Model Flowchart

The study's comprehensive data collection strategy effectively integrates interviews, observations, and questionnaires to gather relevant insights from knowledgeable individuals in the educational field. Semi-structured interviews with educators and experts allow for flexibility in exploring deeper insights into the adaptive assessment tool's functionality and usability, aligning with the mixed methods approach discussed by Ramos and Laskar, which emphasizes the importance of appropriate sampling techniques in qualitative research [24]. Non-participant observations provide contextual data on classroom interactions, reinforcing the need for real-world applicability in educational research as highlighted by Smith, who discusses the significance of observational methods in understanding educational dynamics [7]. Additionally, the use of questionnaires with a four-point Likert scale minimizes bias and encourages definitive responses, a strategy supported by Benozzo et al. who emphasize the importance of thoughtful sampling and data collection choices in qualitative research [5]. This multifaceted approach ensures a rich and comprehensive understanding of the assessment tool's effectiveness in educational settings.

Determining the appropriate sample size for questionnaire-based research is crucial for ensuring the reliability of the findings. A sample size of 30-50 knowledgeable respondents, such as material experts, media experts, teachers, and students, can provide valid conclusions due to their relevant expertise [10]. The calculation of sample size should consider factors such as the desired confidence level and precision, which typically require a larger sample for increased reliability [12].

Additionally, statistical methods and software like G*Power can assist researchers in estimating the necessary sample size based on the study's goals and hypotheses [16]. However, if only one questionnaire response is obtained, it is essential to reconsider the methodology or employ additional data collection methods to avoid skewed results, as a single data point may not represent the population accurately [30] [3]. Thus, careful planning and execution in sample size determination are vital for robust decision-making in research.

Questionnaire is a data collection technique that involves respondents. Respondents were given a series of written questions to assess the product that had been developed. There are four respondents in this study, namely material experts, media experts, teachers, and students. The preparation of the questionnaire in this data collection technique uses a Likert scale with four answer choices. This scale was chosen in order to obtain maximum data from the respondents' assessments, because scoring the five-choice Likert scale instrument often has a tendency for respondents to choose answers in category three. The four-choice Likert scale will confirm the respondents' answers in the assessment of the questionnaire. The instrument used by the researcher is a closed questionnaire with alternative answers. The scoring of the answer choices consists of; (1) strongly agree, (2) agree, (3) disagree, and (4) strongly disagree.

Table 1. Statement Score

No	Answer Category	Scor
1	Strongly agree	4
2	Agree	3
3	Disagree	2
4	Strongly disagree	1

Data analysis used in this study is descriptive statistical analysis. Descriptive statistics describe the data that has been collected as it is, without general conclusions being drawn. The product feasibility data in this study were obtained from the results of the scattered questionnaires. The questionnaire uses a four-choice Likert Scale perception. The data obtained is in the form of qualitative, then converted to quantitative data with an assessment of four gradations. After the quantitative data is obtained, then look at the weight of each response and the average score using the formula for the $\bar{x}$ equation.

$$\bar{x} = \frac{\sum x}{n}$$

Where: $\bar{x}$ = Average score

n = number of appraisers

$\sum x$ = total score of each appraisers

After the average score is obtained, then converting quantitative data to qualitative data based on the Feasibility Classification table. The Feasibility Classification Table has intervals between classes where the determination can be obtained by the interval space equation. The percentage of eligibility can be obtained by converting the average score using the eligibility percentage equation (%).

$$interval\ space = \frac{highest\ score - lowest\ score}{number\ of\ class\ intervals}$$

$$ligibility\ percentage(\%) = \frac{observed\ scores}{maximum\ score} x100\%$$

Table 2. Eligibility Category

No	Average Score	Percentage	Eligibility Category
1	>3,26 – 4,00	81,50% - 100%	Very Worth it
2	>2,51 – 3,25	62,75% - 81,25%	Worthy
3	>1,76 – 2,50	44,00% - 62,75%	Unworthy
4	1,00 – 1,75	25,00% - 43,75%	Very Unworthy

3. Results and Discussion

3.1. Results

The Noerriat software, designed for online exam administration, underwent rigorous functionality testing to ensure its effectiveness for both educators and participants. This process included expert validation, where material experts rated the software's content and usability, achieving high scores indicative of its quality, similar to findings in other studies that emphasize the importance of expert assessments in educational tools [2] [20]. User trials, including alpha and beta testing phases, were crucial in gathering feedback on the software's performance and user experience, paralleling the methodologies used in evaluating e-learning programs for primary education [36]. Additionally, the iterative testing approach allowed for continuous improvement, aligning with the outcomes-based assessment strategies highlighted in the literature, which advocate for data-informed enhancements in educational software [17]. Overall, the comprehensive evaluation process ensured that Noerriat meets the needs of its users effectively.

Noerriat software developer procedures include communication, planning, modeling, construction, and Deployment. After the website application-based software has been developed, then perform software function tests and product trials. Function test is used to see the performance of the software that has been developed, while product testing is used to see the feasibility level of the software from the point of view of experts and users.

The function test of the Noerriat software features on the authority of the teacher and the test takers was carried out three times. There are four tests of the teacher's authority function, namely testing on; (1) start page URL, (2) navigation panel, (3) exam navigation, and (4) question navigation. The first test on test navigation gets a proportion of 38.46%, the second test gets a proportion of 84.62%, and the third test gets a proportion of 100%. The first test on navigation questions gets a proportion of 66.67%, the second test gets a proportion of 100%, and the second test gets a proportion of 100%. Overall, the teacher's authority function test obtained a proportion of 86.22%.

The participant's authority function test is focused on three parts of the test, namely; (1) start page URL, (2) panel navigation, and (3) exam navigation. The first test on exam navigation gets a percentage of 50.00%, the second test gets a percentage of 87.50%, and the third test gets a percentage of 100%. There are four components that are not functioning in the first test, namely; (1) test entry button, (2) item option selection, (3) question answer button, and (4) view result button. In the second test, one component was not functioning, namely the view results button. Overall, the test participant's authority function test obtained a percentage of 87.5%.

Product trials were carried out in four stages, namely material expert trials, media expert trials, limited trials, and expanded trials. The first trial was conducted to see the feasibility of the item in the question bank from the point of view of the subject matter expert. This item is used to see the basic abilities of the test takers. Noerriat's software feasibility criteria consist of four categories, namely very feasible, feasible, sufficiently feasible, and not feasible. The level of feasibility of the items is seen based on the three stages of the assessment aspect. The third aspect of the assessment is; (1) writing, (2) construction, and (3) relevance. Regarding the calculation of the average and proportion of each aspect, it can be seen in the data from the material expert's assessment, while the illustration can be seen in the proportion chart from the material expert's assessment.

Table 3. Data from Material Expert Assessment Results

No	Assessment Aspects	Average	Percentage	Eligibility Category
1	Writing	3,38	84,38	Very Worth it
2	Construction	3,45	86,25	Very Worth it
3	Relevance	3,50	87,50	Very Worth it
4	Totality	3,44	86,04	Very Worth it

Testing by material experts to see the content in the question bank is part of the external testing process. Material validation is carried out to see suitability of the questions in the question bank. This item is used to see test taker's basic abilities. Noerriat's software eligibility criteria consist of four categories, namely very decent, decent, quite decent, and not worth it. The level of suitability of the questions seen based on three stages of aspect assessment. These three aspects of assessment that is; (1) writing, (2) construction, and (3) relevance. After obtaining data from material expert's point of view, then carry out data processing. Data processing is carried out to see the results of the reliability of the instrument and the level of suitability of the question items. Regarding the first aspect, there are three assessment indicators in the writing aspect. The three assessment indicators are; (1) sentence structure, (2) grammar, and (3) readability. Based on the assessment results, results were obtained which stated that the product was feasible and could be used in further research processes.

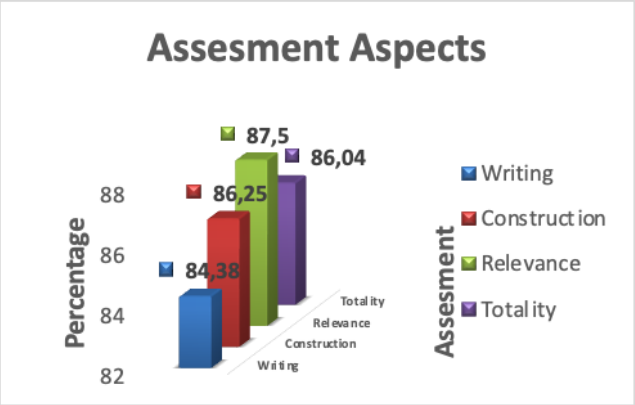

Fig. 2. Material Expert Percentage Rating Chart

The second trial was carried out to see the feasibility of Noerriat's software performance from the perspective of media experts. Noerriat software testing consists of three parts, namely admin, instructor, and students. The feasibility level of Noerriat's software is seen based on five aspects of the assessment. The five aspects of the assessment are; (1) operating system functionality, (2) user authorization, (3) display, (4) computerized adaptive testing, and (5) assessment. Regarding the calculation of the average and the proportion of each aspect can be seen in the media expert's assessment data.

Table 4. Data from Media Expert Assessment Results

No	Assessment Aspects	Average	Percentage	Eligibility Category
1	Operating system functionality	3,63	90,63	Very Worth it
2	User authority	3,63	90,83	Very Worth it
3	Appearance	3,42	85,42	Very Worth it

No	Assessment Aspects	Average	Percentage	Eligibility Category
4	Computerized adaptive testing	3,60	89,93	Very Worth it
5	Scoring	3,50	87,50	Very Worth it
6	Totality	3,55	88,86	Very Worth it

The very feasible category is stated based on the value of the average of all aspects. The average score of 3.63 for the aspect of operating system functionality is obtained from two assessment indicators. Two assessment indicators from the aspect of operating system functionality are the smartphone operating system and the computer operating system. The average score of 3.63 for the aspect of user authority is obtained from two assessment indicators. Two assessment indicators from the aspect of user authority are software functionality and access rights.

Assessment for the display aspect obtained an average score of 3.42. The average score is obtained from two assessment indicators. The two indicators in question are display comfort and display legibility. The mean score of 3.60 for the computerized adaptive testing aspect was obtained from three assessment indicators. Three assessment indicators from the aspect of computerized adaptive testing are the starting point for testing, Selection of subsequent test items, and stopping the test. The average score of 3.50 for the scoring aspect is obtained from two assessment indicators. Two assessment indicators from the scoring aspect are ability estimation and assessment. Illustrations of the results of the assessment on each aspect can be seen in the percentage chart of media experts.

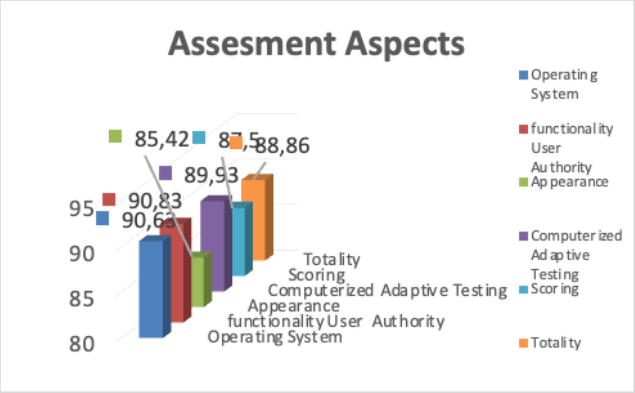

Fig. 3. Media Expert Percentage Rating Chart

The third trial was carried out to see the performance feasibility of the Noerriat software from a limited group of users. This limited-scale user group involves TITL teachers and class XII students of the TITL Expertise Program. Trials that involve teachers are called alpha testing, while trials that involve students are called beta testing.

Alpha testing was carried out to see the performance of the Noerriat software from the teacher's perspective. The feasibility level of Noerriat's software is seen based on four stages of aspect assessment. The four aspects of the assessment are; (1) functionality, (2) appearance, (3) relevance of the material, and (4) usefulness. Regarding the calculation of the feasibility level, the average and the percentage of the teacher's assessment of each aspect can be seen in the alpha test results data table.

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Table 5. Alpha test result data

No	Assessment Aspects	Average	Percentage	Eligibility Category
1	Functionality	3,71	92,71	Very Worth it
2	Appearance	3,42	85,42	Very Worth it
3	Material relevance	3,50	87,50	Very Worth it
4	Usefulness	3,88	96,88	Very Worth it
5	Totality	3,63	90,63	Very Worth it

The very feasible category is obtained after the teacher evaluates the Noeeriat software. The average score of 3.71 for the functionality aspect is obtained from the three assessment indicators. The three indicators in question are the operating system, access rights, and instructions for use. The average score of 3.42 for the display aspect is obtained from the three assessment indicators. Three assessment indicators from the display aspect, namely; (1) display color, (2) readability of writing and descriptions, and (3) grammar.

Assessment for the aspect of material relevance obtains an average score of 3.50. The average score is obtained from two assessment indicators. The two indicators in question are item items and level of difficulty. The average score of 3.88 for the usability aspect is obtained from two assessment indicators. Two indicators of assessment from the aspect of expediency, namely the implementation of tests and assessments. Illustration of the results of the assessment on each aspect can be seen in the alpha test percentage chart.

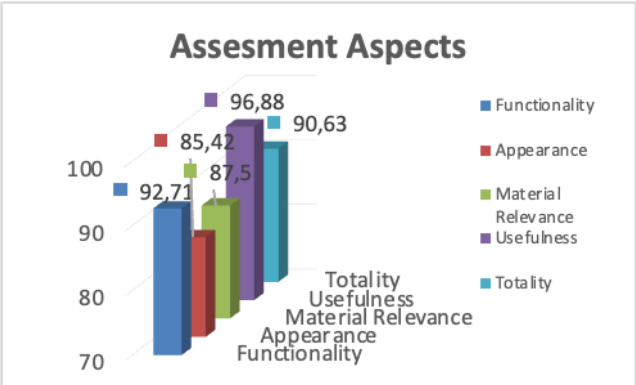

Figure 4. Alpha testing percentage chart

Beta testing was carried out to see the performance of the Noerriat software from the perspective of some students. Seventeen students involved in beta testing. The feasibility level can be known after going through three aspects of the assessment. The three aspects in question are; (1) functionality, (2) appearance, and (3) usability. The following are the results of student assessments of the Noerriat software.

Table 6. Beta Test Result Data

No	Assessment Aspects	Average	Percentage	Eligibility Category
1	Functionality	3,25	81,20	Feasible
2	Appearance	3,23	80,70	Feasible
3	Usefulness	3,21	80,15	Feasible
4	Totality	3,23	80,68	Feasible

Eligible categories are obtained after some students evaluate the Noerriat software. Students give proper categories on the aspects of functionality, appearance, and usability. The average score of 3.29 for the functionality aspect is obtained from the four assessment indicators. Four assessment indicators from the aspect of functionality, namely; (1) operating system, (2) access rights, (3) user manual and (4) artificial intelligence. The average score of 3.26 for the display aspect is obtained from the three assessment indicators. Three assessment indicators from the display aspect, namely; (1) display color, (2) readability of writing and descriptions, and (3) grammar. The average score of 3.21 for the expediency aspect is obtained from the three assessment indicators. Two indicators of the assessment of the expediency aspect are assessment/scoring and safety. Illustration of the results of the assessment on each aspect can be seen in the beta testing percentage chart.

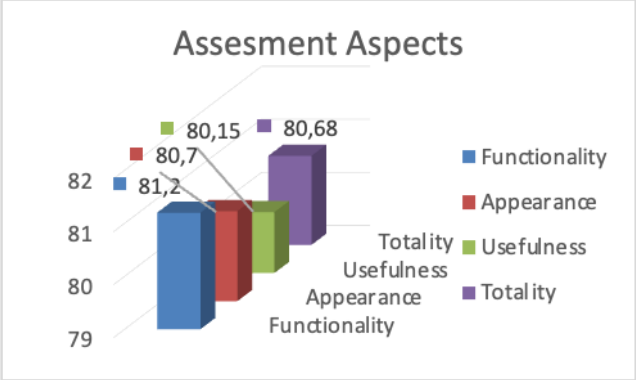

Figure 5. Beta Testing Percentage Chart

After getting the results from alpha testing and beta testing, then make improvements based on suggestions on limited testing. When the software has been repaired, it is then used in an expanded trial process. The expanded trial aims to see the performance of the product being developed when used on a larger scale. Fifty students involved in the expanded trial. The feasibility level can be known after going through three aspects of the assessment. The three aspects in question are; functionality, appearance, and usability. The following are the results of student assessments of the Noerriat software.

Table 7. Expanded Trial Result Data

No	Assessment Aspects	Average	Percentage	Eligibility Category
1	Functionality	3,33	83,36	Very Worth it
2	Appearance	3,27	81,63	Very Worth it
3	Usefulness	3,32	83,00	Very Worth it
4	Totality	3,31	82,66	Very Worth it

Referring to the expanded trial data table, Noerriat's software is declared very feasible. Students give very decent categories on the aspects of functionality, appearance, and usability. The average score of 3.33 for the functionality aspect is obtained from the four assessment indicators. Four assessment indicators from the aspect of functionality, namely; (1) operating system, (2) access rights, (3) user manual and (4) artificial intelligence. The average score of 3.27 for the display aspect is obtained from the three assessment indicators. Three assessment indicators from the display aspect are display color, text readability, caption legibility, and grammar. The average score of 3.22 for the expediency aspect is obtained from the three assessment indicators. Two indicators of the assessment of the expediency aspect are assessment and security. Illustrations of the results of the assessment on each aspect can be seen in the expanded trial percentage chart.

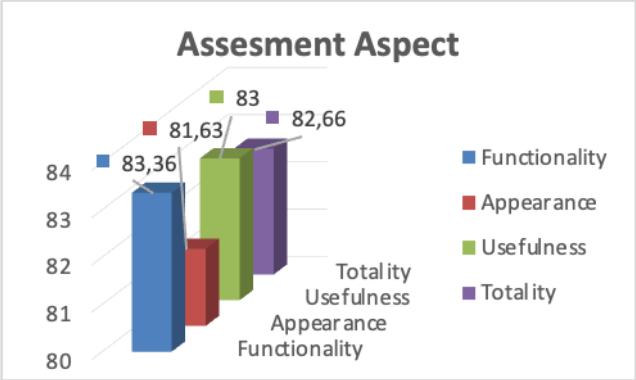

Figure 6. Expanded Trial Percentage Chart

Regarding the results of the expanded trial, the effectiveness test of Noerriat's software was obtained from a comparison of the scores between the pretest and posttest. The level of effectiveness can be known through paired t-test. The first stage of the paired t-test, there are two hypotheses in this test. The first hypothesis (H0) is that there is no difference in student learning outcomes after using the tool, and the second hypothesis (Ha) is that there is a difference in student

3.2. Discussion

The testing of the Noerriat software highlights the critical role of teacher authority in enhancing both the stability and effectiveness of educational technology. The authority function of teachers was assessed across four key areas, including navigation and problem-solving, with notable improvements observed after multiple tests. For instance, the success rate in problem navigation reached 100% by the third test, demonstrating a significant enhancement following initial problem identification [25]. This aligns with findings that emphasize the importance of pedagogical authority in facilitating effective learning environments, where teachers' assertiveness can positively influence student engagement and performance [42] [15]. Furthermore, participant functioning in exam navigation improved dramatically from 50% to 100% over the course of the tests, underscoring the necessity of teacher support and authority in guiding students through complex learning tasks [14] [29]. Overall, these results suggest that effective teacher authority is essential for maximizing the potential of educational technologies.

4. Conclusion

Significant Improvements in User Authority Features: The development of the Noerriat software demonstrated consistent improvements in both teacher and student authority features through an iterative testing process. Teacher authority functionality saw substantial increases in success rates, reaching 100% in exam navigation and question management by the final testing round. Similarly, student authority success rates improved from 50% to 100%, indicating robust functionality for both user groups.

High Validation Scores from Experts: Subject matter and media experts provided strong positive feedback, with overall suitability scores of 86.04% and 88.86%, respectively. The software was

deemed "Highly Suitable" for its ability to meet educational goals, technical performance, adaptive testing, and scoring mechanisms.

Strong User Acceptance in Alpha and Beta Testing: Teachers responded favorably to the software, with an overall acceptance rate of 90.63%, particularly regarding usability (96.88%) and functionality (92.71%). Although initial beta testing among students yielded a slightly lower acceptance rate (80.68%), expansion testing showed significant improvements, with all categories rated "Highly Suitable" and an average of 82.66%.

Ready for Implementation in Educational Environments: Noerriat software has proven reliable, effective, and well-suited for supporting online assessments, particularly in vocational training for electrical engineering competencies.

Declarations

Author contribution: DLBT directed the research objectives and methodology. NREN drafted the manuscript. The final draft was collectively reviewed by DLBT and approved by both DLBT and NREN.
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Conflict of interest. no conflict of interest.
Additional information. No additional information is available for this paper.

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