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Development of hots-based cognitive assessment instruments: ADDIE model

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ABSTRACT

Higher order thinking skills (HOTS) are an important element in facing the challenges of the 21 st-century. Difficulty in solving problems systematically, facing challenges in an organized manner, and being unable to design original solutions are due to the low HOTS that students have. HOTS ability can improve students who low-level thinking skills in several ways, for example, through learning integrated with media, practice, and assessment or HOTS-based cognitive assessment. The purpose of this study was to develop and implement a HOTS-based cognitive assessment to assess students' HOTS abilities. The device development model used is an adaptation of the analysis, design, development, implementation, and evaluation (ADDIE) model. The research sample consisted of 30 students in class 11 of the Governance and Office Automation Competency Program of Vocational High School 1 Kudus. The result is that 11 students have the HOTS ability with very good criteria, 17 well criteria, and 2 enough criteria. This study suggests that a test instrument for further research is to measure students' HOTS ability. The Experts conclude that HOTS-based cognitive assessment can be used as an approach to improve students' HOTS to actively think selectively and supported by logical argumentation.

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1. INTRODUCTION

Education policy is one way to ensure an optimal level of access to education to improve quality [1]. Developing critical thinking skills through the educational process is essential, as they play a pivotal role in determining an individual's success in life [2]. The essential facets of educational practice pertain to the contemporary learning framework of the 21 st-century, which entails the structuring of cooperative learning, the employment of information technology as a medium for knowledge production and collaboration, the cultivation of critical and imaginative thinking, and the resolution of genuine problems [3]. Modern 21st century education places increasing emphasis on developing and demonstrating higher order thinking skills (HOTS) in students [4]–[6].

The development of 21 st-century life requires the development of HOTS [7]. HOTS are an important element in facing the challenges of the 21 st-century [8]. HOTS is expected to be a skill needed now and, in the future [9]. HOTS are high cognitive activities or thinking skills [10]. The mastery of HOTS encompasses a cognitive process that centres on the various levels of HOTS, namely, the capacity to conceptualize, apply, synthesize, and/or evaluate information that is gleaned from observation, experience, reflection, thought, or communication. These skills serve as a crucial foundation for informed decision-making and action [11]. HOTS constitute a vital component of the updated Bloom's Taxonomy, characterized

by the presence of operational verbs such as analyze (C4), evaluate (C5), and create (C6). Many studies have established the HOTS assessment using the Bloom's taxonomy [12]. This taxonomy is commonly used because it is easy to implement. HOTS covers the analysis, evaluation, and create of cognitive processes in Bloom's taxonomy, and LOTS refers to knowledge, understanding, and application of cognitive processes [13], [14]. HOTS has been found to be highly correlated with academic performance. However, developing such skills is complex and difficult [15].

Research data shows that HOTS students in high school are low [16], [17]. Then, the teachers were still confused about the planning, implementation, and assessment of HOTS-based learning thus, they needed intensive guidance [18]. Guidance to develop HOTS for students requires changes or transformations in education through the design and implementation of educational curricula and policies [19]. One of the competencies in the independent curriculum that students must have been HOTS. So, problems related to HOTS students need to be handled so that they don't harm learning activities and child development. Through the HOTS-based learning process, students will get used to thinking critically, such as analysing, evaluating, and creating to find solutions to problems. Students who have high HOTS will actively think about answering questions with solutions that are solutions and supported by logical arguments [20]. HOTS was the ability to solve problems and create solutions [21]. Students' HOTS skills can be improved in several ways, including the use of specific teaching models, worksheets, problem-solving based assessments, and assessments [22]. The role of assessment is very important in any educational system as it guides teachers in choosing learning tasks and approaches to optimize the use of those tasks [23]. HOTS can be developed and improved through a HOTS-based assessment and practice questions. The teacher's ability to make assessments and rubrics as well as provide interesting and sustainable assessments can increase students' HOTS [24]. The cognitive capabilities of students can be ascertained through their ability to interrogate a problem, deliberate on it, evaluate it critically, articulate their views on it, and effectively utilize any recently acquired knowledge [25]–[27].

HOTS competencies can be developed through study, assessment, and practice [9]. A potential strategy to address students' HOTS problems is to give them ample opportunity to engage in practice questions designed at the C4, C5, and C6 cognitive levels, from the results of which can be determined the students' HOTS level [16]. This indicates that learning effectiveness is supported by media use strategies, methods, and assessment strategies. These factors have been proven to increase the effectiveness of her HOTS skills in students [9]. Teachers need training who develop student skills with an emphasis on open-ended, engaging questions that encourage students to take responsibility for their own development and explore their own qualities and abilities [28]. The teachers proposed various training contents to improve teaching ability [29], planning ability possibility to design questions and exercises for teaching and assessment. One of the things that teachers must pay attention to in making instruments is the teachers' question strategies and interactions that involve solving problems as well as questions that call for student HOTS [30] Based on the description above, this study aimed to design and determine the quality of HOTS-based cognitive assessment tools. The developed instrument can then be used to assess the quality of the students' HOTS and especially as an approach that can improve students' HOTS.

2. METHOD

This research makes use of research and development methods, so-called research and development (R&D). Educational research and development is a process used to develop and validate educational product [31]. The advancement plan utilized in this investigate is the analysis, design, development, implementation, and evaluation (ADDIE) advancement created by Dick and Carey [32], with five steps, namely i) analysis, ii) design, iii) develop, iv) implement, and v) evaluate. R&D can facilitate systematic research for the development of educational goals, strategies, materials, and learning processes [33]. This research was carried out at Vocational High School 1 Kudus and developed 10 essay questions on basic competence 3.6 Apply Effective Communication of Public Relations subjects of public relations and protocol governance automation. The populace of this think about was reviewing 30 students in class 11 of the Governance and Office Automation Competency Program of Vocational High School 1 Kudus. The HOTS-based cognitive assessment instrument development flow is displayed in Figure 1.

The first stage of development analysis to conduct needs analysis. Analysis was conducted by conducting interviews with questioners and a literature survey on indicators and methods for assessing HOTS in students. Second: Design or plan the development of test equipment, specifying the metrics to use. Thirdly, development includes several activities, such as creating item indicators from basic competencies 3.6 subjects of Automation Governance of Public Relations and Protocol, preparation of instrument questions such as making a question grid, question, and answer key. It involves developing evaluation guidelines and expert verification guidelines or developing a verifier questionnaire. Fourth, the implementation of a tool to

test the HOTS proficiency of Vocational High School 1 Kudus students. Fifth, assessments are conducted at each stage so that the developed tools can be used to assess the students' HOTS abilities. The evaluation can be done at each process or stage of development.

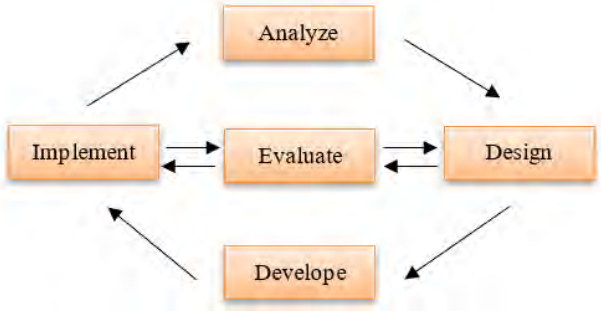

Figure 1. ADDIE model research flow

During the development phase, expert verification was carried out to determine the compatibility of elements and indicators, the use of materials, language, the correctness of the evaluation concept and to obtain suggestions for improving the instrument. The expert verifiers for this study are her three validators with experience in assessment and language. Table 1 shows eligibility scale to used validators to validate instrument.

Table 1. Interpretation of eligibility value

Eligibility scale (%)	Criteria
81 - 100	Very feasible
61 - 80	Feasible
41 - 60	Enough feasible
21 - 40	Unworthly
0 - 20	Very unworthly

Table 2 shows the criteria used to interpret the analytical data. The analytical data are difficulty level, power of difference, reliability, and validity. Instruments that pass expert validation are empirically verified to determine validity and reliability (test can be said to be reliable on the off chance that Cronbach's alpha esteem is more than 0.60 [34]), level of difficulty and discriminating power of items. Expert analysis of the validation data was performed qualitatively by reviewing the validators' proposals and quantitatively by calculating the average score given by the validators for each metric. During empirical validation, data analysis was performed quantitatively using Pearson's correlation and Cronbach's alpha test.

Table 2. Criteria for interpreting empirical validation data

Difficulty level		Power of difference		Reliability		Validity	
Mark	Criteria	Mark	Criteria	Mark	Criteria	Mark	Criteria
0.00 - 0.19	Very difficult	Negative	It is not in accordance with	> 0.90	Very high	$r_{tab} = 0.374$	
0.20 - 0.39	Difficult	Less than 0.20	Poor	0.81 - 0.90	High	$r_{xy} > r_{tab}$	Valid
0.40 - 0.59	Sufficient	0.20 - 0.40	Fair	0.61 - 0.80	Enough	$r_{xy} < r_{tab}$	Invalid
0.60 - 0.79	Easy	0.40 - 0.70	Good	0.41 - 0.60	Low		
0.80 - 1.00	Very easy	0.70 - 1.00	Very Good	< 0.40	Very low		

Questions that pass expert and empirical validation tests can be used during the implementation phase to determine a students' HOTS skills. The subjects of this study were 30 students in class 11 of the Governance and Office Automation Competency Program of Vocational High School 1 Kudus. The data obtained is quantitative data in the form of student evaluations when the equipment is introduced. Data analysis of student performance was performed by calculating the ratio of student HOTS to each index for

each item of validity test, reliability test, determine difficulty level, dan power of difference. Then perform a qualitative interpretation of the students' response results by describing the students' HOTS abilities. Interpretation of the qualitative data was performed to determine the difficulty of the students in answering the questions.

3. RESULTS

3.1. Analysis phase

In the first stage, the researcher's analysis the needs of teachers and students, researchers' analysis the potential problems at Vocational High School 1 Kudus by using interviews and questionnaires. Based on research conducted at Vocational High School 1 Kudus it was found, that there is no HOTS-based cognitive assessment instrument that can easily understand students in working on questions so that students find it difficult to understand the stimuli of the questions given by the teacher and teachers provide more LOTS-based questions to students so that students' HOTS have not been honed optimally. Based on the comes about of interviews conducted by analysts with teachers of the automation subject of public relations and office management, the composition of the HOTS questions was less than the LOTS questions. The composition of the HOTS questions is 31% and the LOTS questions are 61%. It was found that the teacher experienced problems in selecting operational verbs and constructing HOTS-based question sentences. This has an impact on students who have difficulty understanding the questions (based on the comes about of the student survey).

3.2. Analysis design

This phase is executed after analysing the results of the first phase. Once the pain points are identified, we can start designing. This stage is known as making a design (blueprint), like a building, before it is built there must be a building design on paper first. Practice questions designed at the C4, C5, and C6 cognitive levels from revised Bloom's Taxonomy. In the design stage, the design of assessment instruments is carried out. The first thing to do is to determine the basic competencies in the subjects that will be used in making HOTS-based cognitive problems. Furthermore, compile lesson plans and learning objectives as a benchmark for assessment implementation. In designing assessment instruments, researchers compile assessment instruments which include a grid of questions, questions, and assessment rubrics. The grid is prepared based on the mapping of indicators and the achievement of learning objectives that have been formulated by the researcher. Grids as a reference in making questions and assessment rubrics, are displayed within the Tables 3 and 4 shows question distribution (revised Bloom's taxonomy).

3.3. Development

The third stage is development, researchers make improvements and revise HOTS-based cognitive assessment instrument products based on criticism and suggestions from the validator. Product feasibility analysis is obtained from the results of qualitative and quantitative data calculations. The qualitative test was obtained from validation by two expert validators, namely material, language, and evaluation validators. Perspectives of the HOTS appraisal instrument comprised of material, language, and evaluation aspects [35]. The comes about of the validator's evaluation are displayed within the Table 5.

Based on the expert verification results presented, all elements were found to meet the highly feasible criteria with an average of 93%, making it highly feasible. Empirical validation was performed using data from 30 test scores of classes 11 students of Vocational High School 1 Kudus in the Governance and Office Automation Competency Program using a tool revised following expert advice. Participants included students who already had knowledge of Core Competency 3.6 in the Public Relations and Protocol Governance Automation subjects. Several tests such as level of difficulty of the items, the differentiating power of the items, validity, and reliability.

The data obtained shows that the question was asked a 50% sufficient level of difficulty and 50% difficult level of difficulty. The characteristics of the evaluation of the tall arrange considering capacity of students have 0% is easy, 50% is sufficient and 50% is difficult for essay questions [36]. This indicates that the developed question meets the criteria with sufficient difficulty for the category. Table 6 shows the results of calculating the difficulty level of the items.

The discriminatory power analysis was carried out to determine whether an item could distinguish between high–ability participants and low–ability participants [37]. In principle, the discrimination index is calculated by dividing the group into the upper group, namely the group of examinees with high scores, and the lower group, namely the group of examinees with low scores. A high score indicates high proficiency, and a low score indicates low proficiency. The results of the calculation of the differentiating power of items can be seen in Table 6.

Item validity was determined using Pearson product-moment correlation analysis (bivariate Pearson). The validation results obtained show that 10 questions were declared valid because $r_{xy} > r_{table}$. The r_{table} used for 30 samples is 0.374. Table 7 shows the r_{xy} calculation results for each item. In addition, instrumental reliability was also calculated using Cronbach's alpha with a significance value of 5%. Reliability calculations show a Cronbach alpha value of 0.863 with high reliability criteria for the HOTS-based cognitive assessment tool. This value shows that the equipment developed is very reliable to test the HOTS ability in class 11 of the Governance and Office Automation Competency Program of Vocational High School 1 Kudus

Table 3. Assessment instrument grid (public relations and protocol governance automation)

Basic competency	Material	Competency indicator	Question indicator	Cognitive level	No
3.6 Apply effective communication of public relations	Communication purposes	Identify communication goals	Given a stimulus related to communication, then students are asked to identify one of the goals of communication	C4	1
	Communication function	Identify communication functions	Given a stimulus related to the function of communication, then students are asked to identify the function of communication		2
	Communication element	Identify the elements of communication	Presented a case (problem) in communication, then students identify the elements that must exist in communication		3
	Public relations media	Identify public relations media	Presented media use data, then, students were asked to identify the reasons for using the media that is often used		8
	Types of public relations communication	Classify the types of public relations communication	Presented phenomena, students are asked to group according to the type of communication		4
	Communication barriers	Grouping barriers in communication	Phenomena that indicate there are barriers to communication are presented, then students are asked to classify these barriers		5
	Efforts to overcome communication barriers	Fixing deficiencies as an effort to overcome obstacles	Problems in communication are presented, then students are asked to find solutions to overcome these obstacles or problems		6
	Effective communication techniques	Consider effective communication techniques	A case is presented with 2 techniques as a choice to lead to effective communication. Then students are asked to consider appropriate techniques as suggestions for achieving effective communication.	C5	7
	Selection of public relations communication media	Designing to determine the right public relations communication media	Students are asked to design scenarios by choosing the right public relations communication media	C6	9
	Public relations communication media	Formulate effective and efficient public relations communication media	Students are asked to formulate effective and efficient public relations communication media by referring to the images presented in the questions		10

Table 4. Question distribution (revised Bloom's taxonomy)

No.	Aspect	Question number	Number of question items
1.	Analyze (C4)	1, 2, 3, 4, 5, 8	6
2.	Evaluate (C5)	6, 7	2
3.	Create (C6)	9, 10	2

Table 5. Validator assessment results

Validators	Validator assessment (%)	Interpretation criteria
Material validators	90	Very feasible
Language validators	100	Very feasible
Evaluation validators	90	Very feasible
Average	93	Very feasible

Table 6. The results of calculating the level of difficulty and differentiating power of items

No. Question	Difficulty level	Criteria	Power of difference	Criteria	Status
1	0.53	Sufficient	0.50	Good	Fixed
2	0.30	Difficult	0.53	Good	Fixed
3	0.40	Difficult	0.43	Good	Fixed
4	0.58	Sufficient	0.40	Fair	Fixed
5	0.52	Sufficient	0.20	Fair	Fixed
6	0.56	Sufficient	0.40	Fair	Fixed
7	0.39	Difficult	0.43	Good	Fixed
8	0.37	Difficult	0.30	Fair	Fixed
9	0.52	Sufficient	0.38	Fair	Fixed
10	0.39	Difficult	0.45	Good	Fixed

Table 7. The results of the analysis of the validity and reliability of the hots based cognitive assessment

No. question	r_{xy}	Interpretation	Reliability	Interpretation
1	0.759	Valid	0.863	High reliability
2	0.714	Valid		
3	0.753	Valid		
4	0.597	Valid		
5	0.447	Valid		
6	0.720	Valid		
7	0.758	Valid		
8	0.633	Valid		
9	0.655	Valid		
10	0.759	Valid		

3.4. Implementation

Once the HOTS based cognitive assessment instrument was revised and completed, the implementation phase of the research study began. Implementation carried out of 30 students' class 11 at Vocational High School 1 Kudus of the governance and office automation expertise program. The purpose of this study was to profile students' HOTS abilities using Bloom's Revised classification model conducted on class 11 students of the Vocational High School 1 Kudus Governance and Office Automation Competency Program. Well-structured HOTS test device available of 10 questions with 3 taxonomy bloom stages, including i) analysis, ii) evaluate, and iii) create. The students' answers consisted of 10 questions from 10 materials, with a total score of 100 points for each item, with a maximum score of 10 points for each question. Once all student responses have been revised and graded, the next step is to process the total score achieved. Students divide by the maximum score of 100 and multiply by 100. The students' HOTS abilities results are shown in the chart below. The results achieved by the student fall into the categories of the students' HOTS abilities as shown in Figure 2 and Table 8.

Based on the empirical evidence derived from the responses provided by students, the table presented below displays the outcomes of students' HOTS abilities. The results of Figure 2 and Table 8 were obtained from 10 HOTS-based questions done by students. The result was that 11 students had HOTS with excellent criteria, 17 students had HOTS with good criteria, and 2 students had HOTS with enough criteria.

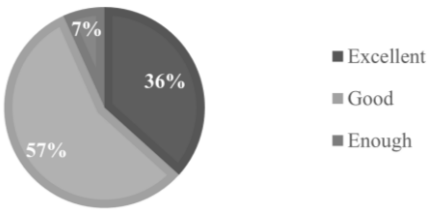

Figure 2. Results of Students' HOTS

Table 8. Results of Students' HOTS Abilities

Many students	Interpretation of student scores	Interpretation criteria
11	81 - 100	Excellent
17	61 - 80	Good
2	41 - 60	Enough
0	21 - 40	Fail
0	< 20	Poor

3.5. Evaluate

Evaluation is an ongoing process and may occur at any time during course development and delivery. A process to check whether the developed HOTS-based cognitive assessment was successful. Revision of validators as evaluations that must be improved so that the HOTS-based cognitive assessments that were developed are appropriate when testing certain qualifications. In this regard, this review focuses on identifying HOTS-based cognitive assessments that has been developed with good difficulty level, differentiating power, good validity, and high-reliability coefficients before testing their efficiency in of public relations and protocol governance automation learning. We also tested the reliability of a HOTS-based cognitive assessment tool with improved content. Thereby, the students' critical thinking in applying effective communication and public relations media was taught.

4. DISCUSSION

Students, the nation's generation, must have HOTS [38]. The era of disruption necessitates the acquisition and deployment of both HOTS and critical thinking skills [39]. The integration of HOTS has become increasingly imperative in the education, particularly in the 21 st-century, advances in knowledge and technology require humans to adapt and develop according to the times, with the application of an effective HOTS learning model, can increase a high mindset so that students can keep up with developments in knowledge and technology in this era now. The concept of HOTS has emerged as a notable and significant subject in the realm of educational research, capturing the scholarly interest of many researchers [40]. HOTS includes thinking processes that require students to do more than just memorize and convey information [41]. HOTS indicators for the typical category of complex thinking, include comparing, classifying, making inductions, making deductions, examining errors, constructing support, abstracting, and assessing perspectives [42]. The highest indicator in improving HOTS is abstraction ability, which is being able to identify several solutions (rich solutions) to the context-based challenges offered [43].

Teachers and educational practitioners carry a crucial responsibility and must demonstrate awareness of the significance of teaching HOTS to equip youth with the necessary tools for thriving in the current century [44]–[46]. Implementing innovative pedagogical methods constitutes one of the considerable endeavours' educators faces in enhancing academic performance and promoting comprehension among students [47]. The 21 st-century education system places significant emphasis on HOTS. The subject of HOTS cannot be considered a standalone domain. The inclusion of HOTS in the classroom is imperative for educators to nurture their students' abilities. Therefore, it is imperative that all educators attain proficiency in HOTS for the purpose of fostering talent development [48].

The ability of HOTS students can be improved through several things, one of which is through learning methods. Learning methods can improve HOTS [43]. Therefore, teachers must innovate learning by selecting the appropriate learning methods and focusing on student interests [49]. However, questions have a higher influence on increasing student HOTS than learning methods. Improving students' HOTS abilities with weak effects is dominated by using learning methods and HOTS abilities with the medium effect are dominated by assessment strategy [9]. It is necessary to present a more attractive assessment to be able to facilitate HOTS in students [50]. An approach based on HOTS in measuring the assessment of questions on certain subjects can be a solution for an educator to increase student HOTS [24].

This research endeavours have generated a cognitive evaluation instrument undergirded by HOTS, in the assessment of educational outcomes in the subject of automation of public relations governance and protocol in basic competencies 3.6 apply effective communication of public relations. The process of developing HOTS-based cognitive assessment instruments was carried out of the research sample were 30 students in class 11 of the Governance and Office Automation Competency Program of Vocational High School 1 Kudus, 10 questions were declared valid and reliable so that researchers could use 10 questions as cognitive assessment instruments. The process of developing HOTS instruments that perform qualitative tests by expert validators to determine the feasibility of questions and quantitative tests of item analysis to revise and retrieve the best questions because the optimal assessment tools are those that have undergone rigorous validation testing [35].

The present study's findings indicate that the validity of the assessment tool utilized for measuring HOTS has been tested and analysis, in the subject of public relations and protocol are viewed from a material perspective, namely with a value of 90% and it is said to have very decent criteria. While the validator's assessment in terms of language is 100% and is classified as a very decent criterion, as well as the evaluation validator with very decent criteria with a percentage of 90%. Based on these data the validator in terms of material is very strong, which means that the HOTS assessment instrument has quality material. Overall, the HOTS-based cognitive assessment instrument has an average presentation value of 93% and is categorized as very feasible. The results of this study show that the use of HOTS-based cognitive assessment tools is very feasible in the context of the Automation Governance of Public Relations and Protocol courses for students in

class 11 of the Governance and Office Automation Competency Program of Vocational High School 1 Kudus. While the acquisition of students' HOTS levels was obtained after students finished working on the questions. The average degree of HOTS among students is "Good" criteria.

5. CONCLUSION

The results of this study reveal two theoretical and practical implications. The theoretical implication is that a quality assessment instrument in terms of language, material, and evaluation which has fulfilled several aspects of the test questions, can add to students' high-level reasoning competencies. As for the practical implications, namely, the output of this research can be a suggestion to educators to increase innovation in the preparation of the stimulus questions, progress the quality of the questions.

This study has several limitations, namely, the HOTS assessment instrument was only developed in the automation governance of public relations and protocol subject with the selection of material on basic competency 3.6 apply effective communication of public relations in the form of compiling 10 essay questions in which all questions were declared valid and reliable. This assessment instrument is only aimed in class 11 of the Governance and Office Automation Competency Program of Vocational High School 1 Kudus with a total of 30 students, besides that the development model applied uses the ADDIE model.

Based on the description above, the suggestions given by the researcher to the next researcher are, i) the preparation of the assessment instrument is developed broadly, namely more than 1 basic competency, ii) can test the feasibility of the instrument broadly to obtain better quality questions, and iii) can integrate with ICT in applying HOTS-based cognitive assessment instruments as learning innovations. Overall, it is hoped that instilling HOTS is part of a lifelong competence for proficiency and mindset skills to prepare professional human resources. It is trusted that this research will become a reference for stakeholders in schools in making policies to create the development of HOTS-based questions on other materials and subjects.

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