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Research Article

Construction of The Assessment Concept to Measure Students' High Order Thinking Skills

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Abstract

This study aims to develop a question instrument that able to measure students' high order thinking skills. The sample used in this study involved 3 expert validators, 2 user practitioners, 60 students in the limited test and 125 students in the field test. Data results were analyzed using the Quest program. The results of the study show that the characteristics of the assessment of high order thinking ability of students have validity with a "sufficient" minimum interpretation and have sufficient reliability. Validity with minimum interpretation is adequate, reliability is good, level of difficulty of questions with proportion of 1.6% is easy, 58.4% is moderate and 40% is difficult for multiple choice questions and 0% is easy, 50% is moderate and 50% is difficult for essay questions. The profile of the product score assessment to measure students' high order thinking skills is as follows: State High School B with a high order thinking skills scores reached 71.61, then continued with State High School D with a score of 66.03, State High School C with a score of 65.46, State High School E with a score of 63.69, and the last one is State High School A with a score of 60.26. Overall with the number of students 125 people have an average score of 65.41. So the high school that have a highest score is State High School B in profile assessment.

Keywords

higher order thinking skills, assessment, reproductive system, senior high school biology

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Introduction

21st century learning requires everyone to learn and think, focusing on developing intellectual abilities so they are able to adapt to changes and developments in the times. The outcome in 21st century learning is to have life and career skills, namely the ability to synthesize information, work as a team, to manage broadly and complexly, and be accountable to the community and environment (Leward & Hirata, 2011). Skills in technology, media and information (information, media, and technology skills) are the ability to recognize, discover and see all information with technology and media so that it can be meaningful. Whereas critical learning and innovation skills (critical learning and innovation skills) are the ability to clarify understanding of a problem so as to produce innovation and logical decisions. Various kinds of skills that have been obtained such as life skills and so on during the school are expected to improve learning outcomes (Juita, 2019; Julaila, 2019; Kusumah & Munandar, 2017)

Importance of study

Global competition in the digital age requires more than just mastery of science, but also mastery of various skills including critical thinking skills, problem solving, communicating, collaborating, creating, literacy, and awareness of global issues (Kay, 2009; Silva, 2009; Walsh & Sattes, 2011). The 21st century requires a generation of critical thinkers who are able to solve problems as well as actively participate in making decisions on local and global issues that are formed through thought processes (Silva, 2009). Critical thinking skills can be trained through learning that prioritizes thinking processes.

The process of thinking is an activity that involves the work of the brain, human feelings and desires that can be seen through learning that focuses on student activities, both visual, audio, kinesthetic, and verbal activities. In the process of thinking, individuals make connections between objects that become the subject matter with the parts of knowledge that they already have. Part of knowledge is everything that has been obtained in the form of understanding. According to Bloom's taxonomy (Anderson et al., 2001), the thinking process is divided into two, namely: Low Order Thinking Skills, namely the ability to think in the realm of C1-C3 and High Order Thinking Skills, namely the ability to think in realm of C4-C6. This thinking process is made in the form of taxonomy consisting of knowledge (C1), understanding (C2), application (C3), analysis (C4), evaluation (C5), and creating (C6).

The importance of high order thinking skills revealed by Peter (2012) in order to compete in the world of work and personal life, students must have the ability to solve problems and the ability to think critically. The High order thinking skill (critical) is the ability to analyze facts, organize ideas, defend opinions, make

comparisons, build conclusions, evaluate arguments, and solve problems (Wenno, 2008). Ability in high order thinking (critical) gives the right direction in thinking and helps in determining the relevance of something with others more accurately, therefore critical thinking skills are needed in solving problems or finding learning solutions.

Critical thinking ability can be improved by a scientific approach, namely the learning process designed in such a way that students actively construct concepts, laws or principles and are involved in the process of thinking (student centered). This is in line with Regulation of Ministry of Education & Culture No. 81 of 2013 concerning curriculum implementation, that future competency requirements needed by students are the ability to communicate, be creative, and think critically (Ministry of Education and Culture, 2011)

Reforming the learning process requires substance that supports it, in this case the school needs a learning model that can measure high order thinking skills (critical) and support the application of the 2013 Curriculum. These learning models, namely discovery, inquiry, project based learning and problem based learning. The characteristics of the learning model with this scientific approach are learning which consists of observing activities (to identify problems that want to be known), formulating questions (and formulating hypotheses), collecting data / information with various techniques, processing / analyzing data / information and drawing conclusions and communicating the results consist of conclusions to obtain knowledge, skills and attitudes. These steps can be continued with creating activities. With the application of these models in schools it is expected to be able to improve high order thinking skills according to what is mandated in the 2013 curriculum.

The results of research on education mapping through the fulfillment of eight National Education Standards (SNPs) in various State High Schools in Surakarta show that the achievement of process standards (standard 2) and assessment standards (standard 8) has a large gap between ideal scores and real score (Sajidan, Sugiharto, & Prasetyani, 2013). Fulfillment of process standards and assessment standards is the main task of professional teachers, thus the quality of learning and evaluation (Arikunto, 1997) carried out by teachers needs to be improved, so that professional teachers are able to carry out the tasks mandated by the Teacher and Lecturer Law No. 14 of 2005 that teachers are professional educators with the main task of educating, teaching, guiding, directing, training, evaluating, and evaluating students in the formal education pathway, as well as at the level of primary and secondary education, including early childhood education.

Educational Assessment Standards are criteria regarding mechanisms, procedures, and instruments for evaluating student learning outcomes. Educational assessment as a process of gathering and processing information to measure student learning outcomes includes: authentic assessment, self-assessment, portfolio-based assessment, repetition, daily tests, midterm tests, end of semester tests, competency

level exams, competency level quality exams, examinations national, and school / madrasah examinations in Regulation of Ministry of Education and Culture No.66, 2013 (Indonesia, 2013).

Literature Review

Research by Redhana & Liliasari (2008) explains that high order thinking skills learning programs are proven to be able to improve high-level thinking skills as a whole by using thinking training through three main elements namely 1) Giving open-ended problems, 2) Conceptual questions and 3) Socratic questions. The conceptual questions raised on open-ended problems make students use their thinking skills. Socratic questions are used, potentially encouraging students to empower high order thinking skills of students, because they include questions that ask for clarification, questions that investigate assumptions, questions that investigate reasons or evidence, questions that ask for opinions, questions that investigate implications or consequences and questions about questions. Thinking skills learning programs prove to be very effective for improving high order thinking skills of students who have moderate to less academic abilities. The research by Yang, Newby, & Bill, (2005) explains that high order thinking skill training can be pursued through giving socratic questions (clarification questions, questions investigating assumptions, and questions that investigate reason and evidence). This questions can facilitate students' high order thinking skills through exchanging ideas and perspectives, giving meaningful new content, exploring problems and giving real-life implications

Research Problem

On prior-research, observation has been conducted to see the data. The results carried out on five State High Schools in Surakarta City, showed that there were still weaknesses in meeting assessment standards in schools, as evidenced by the formative evaluation instruments that teachers used in schools only at the level of Low Order Thinking Skills (C1-C3).

Formative evaluation instruments in the form of questions are obtained by collecting all the questions related to the material in each evaluation, namely National Exams, School Final Exams, Semester Exams, Daily Examinations, and questions in the textbook used by the teacher, after which the questions are analyzed using Bloom's Taxonomy based on the dimensions of knowledge (factual, conceptual, procedural, metacognitive) and cognitive process dimensions (C1-C6). The results of the analysis showed that the fulfillment of the questions on the High Order Thinking (C4-C6) criteria in each Senior High School was less than 21%, whereas ideally the formative tests carried out by the teacher 80% included high order thinking skills (C4-C6) (National Accreditation Board Assessment Standards, 2012) Analysis is also seen from the type of knowledge, revealed that the type of knowledge

most found in the problem is factual knowledge and conceptual knowledge. Whereas procedural knowledge and metacognitive knowledge are relatively few.

The habit of teachers in conducting final evaluations of students who only measure low levels of ability alone results in weak skills of students in thinking, and only skilled in memorizing (Johnson & Harris, 2002) Results of school needs analysis can be concluded that teachers need assessment that is able to measure high order thinking skills' students.

Assessment is a general term that covers the entire procedure used to obtain information about student learning outcomes (observation, ranking, testing using paper and pencil) and make judgments about the learning process (Linn & Gronlund, 1995). The assessment process is very good and effective if the following principles are considered, namely: 1) Clearly determining what is accessed has priority in the assessment process. 2) Relevance to measured characteristics or performance. 3) Comprehensive in accordance with the procedure. 4) Requires an awareness of its limitations. 5) Is a last meaning, not a final meaning in itself (Linn & Gronlund, 1995).

In implementing competency standards assessment must be developed that can measure the cognitive domain of students, especially high order thinking skills because assessment is an integral part of the learning process. Based on the background above, it is necessary to develop assessment research that is able to measure students' critical thinking skills. Assessment development is used to measure critical thinking skills from the indicators of learning that are carried out. The instrument for evaluating critical thinking from the results of development is expected to be able to improve the quality of assessments and enrich the treasures of biological questions in schools.

The purpose of assessment development research is to develop a question instrument that is able to measure students' high order thinking abilities.

The formulation of the problem in the development of evaluation instrument research is as follows: 1. what are the characteristics of assessment that can measure students' high order thinking skills? 2. How is the appropriateness of assessment capable of measuring high order thinking skills as a formative evaluation? 3. How to verify students' high order thinking skills scores

Method

The model of research and development (Research & Development) applied refers to the stages according to Borg & Gall (1983). Borg & Gall (1983) state that the research and development approach is research oriented to develop and validate the products used in research.

The steps in Research & Development (R & D) according to Borg & Gall (1983) are as follows: 1) Research and information collecting (research and data collection); 2) Planning (planning); 3) Develop preliminary form product (initial product

development); 4) Preliminary field test (initial field trial); 5) Main product revision (revision of product I); 6) Main field testing (main field trial); 7) Operational product revision (product revision II); 8) Operational field testing (operational field testing); 9) Final product revision (final revision); 10) Dissemination and implementation (deployment and implementation). In this study the steps taken are to arrive at the field test stage. The detailed steps at each stage of development will be elaborated in the development procedure.

This assessment development study was carried out in five State High Schools in Surakarta in Central Java Province. The sample used was the XI grade students of the even semester of 2014/2015 Academic Year. This assessment also conducted during the school period not a holiday same as Islami et.al., (2018; SAREGAR et al., (2019) in order to students still felt in a conducive academic atmosphere.

The techniques used in this study include analysis of test questions based on Rasch (1980) test related to the reproductive system available in the National Examination, formative and summative tests, and tests in the High School Biology Textbook in Surakarta. Then a draft test instrument was prepared consisting of three cases. The sample used in this research included 3 expert validators, 2 user practitioners, 60 students in the limited test and 125 students in the field test. The results of the trial data were analyzed using the Quest program.

Results and Discussion

Product Characteristics Assessment Instruments to Measure Students' High Order Thinking Abilities

High Order Thinking Skills are abilities that occur when someone takes new information and information that has been stored in his memory, then combined so that they are interconnected to achieve a goal or find answers in confusing situations (Kartimi & Liliasari, 2012; Lewis & Smith, 1993; Putra, Prayitno, & Maridi, 2018; Sutarto, Indrawati, Prihatin, & Dwi, 2018; Yusrizal, Suliyanah, & Basri, 2017). Successful application of high order thinking skills occurs when students successfully explain, decide, demonstrate, and produce problem solving in the context of knowledge and experience (Wenno, 2008). Higher-order thinking skills are based on cognitive domain concepts Bloom's Taxonomy (2001) on (Anderson et al., 2001), abilities involving analysis, evaluative and creating. (Anderson et al., 2001) state that indicators of high order thinking skills are important to be developed at school, this is because of the demand for mastering high order thinking skills with graduate competency standards. Students are expected to be able to develop and apply knowledge logically, creatively, critically and innovatively; this is indicated by decision making and demonstrating the ability to analyze and solve problems (Permendiknas No.23 of 2006).

Mastery of high order thinking skills requires a clear and valid assessment, but the development of the assessment has not been done by many education practitioners. Formative assessments found in schools only provide little opportunity for students to develop knowledge more deeply (Cullinane & Liston, 2011). Alternative assessments that are able to measure students' high order thinking skills are needed by teachers in schools. One way is to develop an assessment in the form of a high order thinking problem by loading the case on each issue.

Material experts are experts on the reproductive system. The purpose of validation is to guarantee that content validation is developed so that there is no conceptual error. The next validator is the expert of evaluation with the aim of validating the construct of the assessment instrument developed so that it can empower high order thinking skills. Educational practitioners are senior teachers who are in school, namely two teachers at IT Nur Hidayah High School. The results of the validator are revised before being applied to the school. Suggestions from the validator include improving the writing system, the truth of the concept. Suggestions from the validator were improved before the initial field trials were carried out.

Field trials were used to obtain revisions and further improvements were made. The field trial aims to obtain product assessment instruments that are good, valid, reliable and practical (Arikunto, 2006). The results of the field trials concluded that the assessment of high order thinking skills of students had good validity and reliability, had a questionable level of harmony with the proportion of 1.6% easy, 58.4% moderate and 40% difficult for MCQs and 0% easy, 50 Moderate% and 50% are difficult for essay questions, having a differentiating problem with a minimum enough interpretation and having good practicality about evaluation questions.

Assessment Instruments The ability of high order thinking students based on indicators from Anderson and Krathwohl, 2001, which has high order thinking skills, has sufficient validity and reliability, has a problem level with a proportion of 30% easy, 53% moderate and 17% difficult, has a distinguishing ability questions with minimal interpretation are sufficient and have practical test questions.

Products in the form of test questions can be used to empower high order thinking skills. The use of products is able to provide stimuli or stimuli from students and responses to stimuli is the response of students in answering by choosing the choices that have been provided.

Feasibility of Product Assessment Instruments to Measure Students' High Order Thinking Abilities

The product of the assessment instrument as a whole emphasizes the learning process up to testing the results of the learning process in the form of an evaluation tool about understanding the cases presented so that it is feasible if the product concept is applied (Assessment Reform Group, 2002) (Group, 2002). in Basic Competence Analyzing the relationship between the structure of the network making up the reproductive organs and their functions in the process of human

reproduction through literature studies, observations, experiments, and stimulation, aims to help teachers prepare questions that are able to empower higher-order thinking skills.

A good assessment instrument is to have validity, reliability and practicality. The validity of the assessment instrument to measure students' high order thinking skills is guaranteed through the validity of content and constructs that have been validated by evaluation experts, material and practitioners. Validation is also done by a user teacher or senior teacher. Content validity is done so that development products do not have conceptual errors. Construct validity is done to ensure that assessment instruments are able to empower students' high order thinking skills. Validation of the senior teacher or user teacher is done for the feasibility of the assessment instrument. Testing on the assessment instrument is carried out in stages to the senior teacher or user teacher.

The results of product evaluations by evaluation experts, material experts and practitioners obtained that the product development assessment instruments to measure students' high order thinking skills belong to the category of good and feasible to use. Details of the results of the assessment can be explained as follows: a) The product of the assessment instrument development was assessed by evaluation experts with a score of 93.11%. Based on the results of the assessment it can be concluded that the assessment instrument to measure students' high order thinking skills can be implemented in learning in a good category. b) Product development evaluation instruments are assessed by material experts with a score of 96.65%. Based on the results of the assessment it can be concluded that the assessment instrument to measure students' high order thinking skills can be implemented in learning in a class with very good categories. c) Product development assessment instruments were rated by practitioners 95.71%. Based on the results of the assessment it can be concluded that the assessment instrument to measure students' high order thinking skills can be implemented in learning in a good category. d) The stage of testing the problem in the field with 25 students in each high school in Surakarta. aims to test the validity, reliability, distinguishing power, level of difficulty of the questions developed. The results of the question analysis showed that the questions developed included good categories. Question items have validity with a minimum enough interpretation, good reliability, difficulty level of questions with proportion of 1.6% easy, 58.4% moderate and 40% difficult for multiple choice questions and 0% easy, 50% moderate and 50% difficult for questions essay. The differentiating problem with a minimum interpretation is sufficient, as well as the practicality of a good question. e) External validity can be seen from the problem of the type of higher order thinking skills that already exist then compared to the higher order thinking skills problem that is made overall the measurement level is good, and in terms of similarity almost the same. The basic difference is when analyzing the problem. Products made before validation are

analyzed in depth by looking at aspects of the knowledge dimension and aspects of the cognitive process dimension. Then the products made include the dimensions of factual, conceptual, procedural, and metacognitive knowledge, and include the dimensions of cognitive processes Higher Order Thinking Skills based on Bloom's Taxonomy, namely: analyzing, evaluating, and creating

Based on the results of the overall validation it can be concluded that the product development assessment instrument to measure students' high order thinking skills is feasible to be implemented in the field.

Product Rating Score Profile to measure Students' High Order Thinking Skills

Formation of the truth of the facts from the data that has been analyzed using the quest program is then needed a profile so that the data that has been analyzed can be seen in different forms. Profile has the principle that each proportion presented has meaning if the proportion can be tested by observation. A more logical profile that is widely used in scientific work. High order analysis also refers to critical thinking analysis by Wiyoko (2019). The results of the profile to measure high order thinking skills can be seen in the table 1 below.

Table 1.

Results of Score Student's Analysis High Order Thinking Skills in Surakarta Senior High School

School	System Reproduction Material	
	Sum of Students	Score
Senior High School A	30	60,26
Senior High School B	26	71,61
Senior High School C	25	65,46
Senior High School D	25	66,03
Senior High School E	27	63,69
Total	**133**	**65,41**

Based on the table 1 above the results of the score analysis in each school in Surakarta with the number of students as many as 133 students in high school in sequence are Senior High School B with a high order thinking skills scores reaching 71.61, then continued with Senior High School D with a score of 66, 03, Senior High School C with a score of 65.46, Senior High School E with a score of 63.69, and the last one is Senior High School A with a score of 60.26. This means that overall the number of students 133 people have an average score of 65.41.

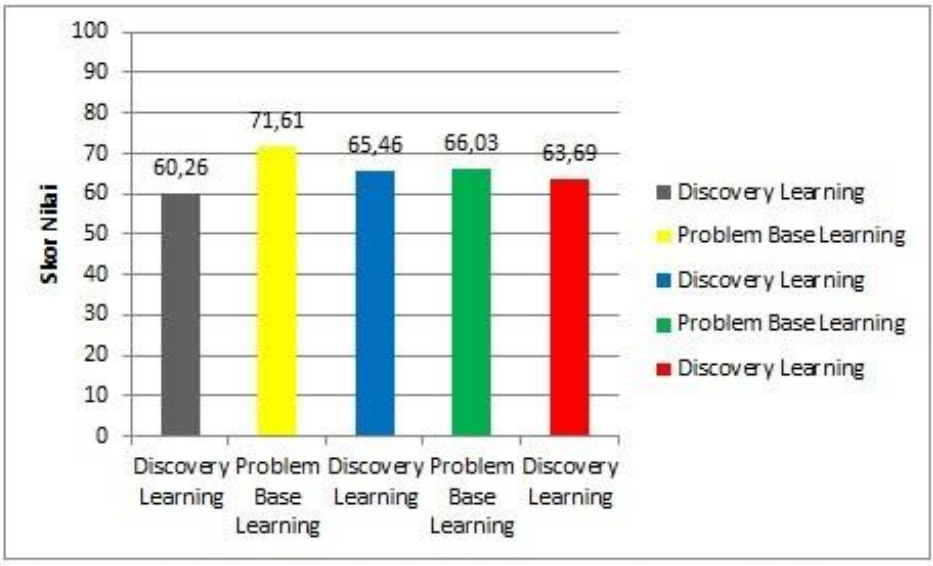
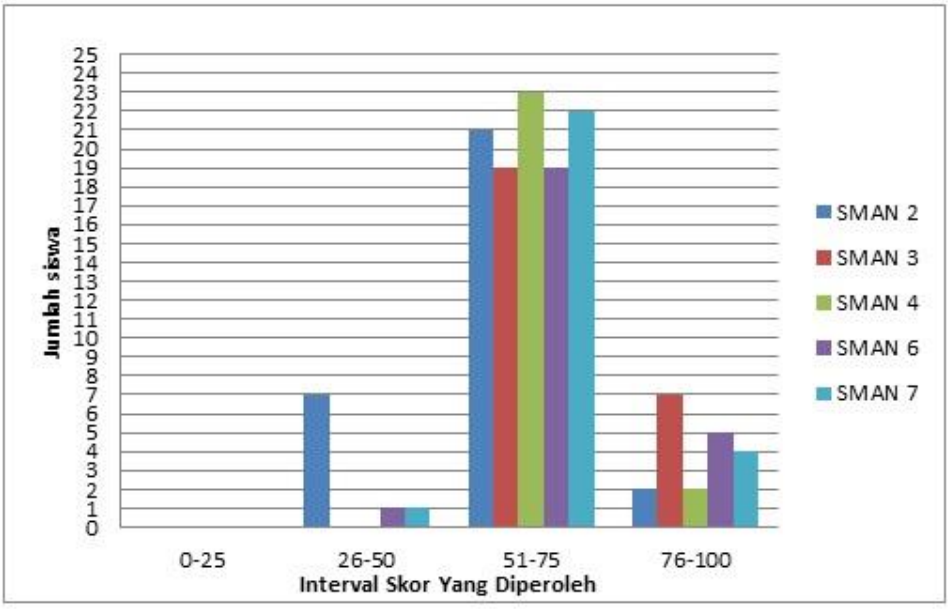


Figure 1.
Profile of Average Students High Order Thinking Skill Score on Reproduction System Material

Based on the profile on figure 1, the average score of students' high order thinking skills in each school is different, this is because the learning model, learning method and the level of thinking ability of the problem analysis for each student are different. Of the five schools that exist, the approach in the learning process all uses a scientific approach (sciencetific approach) but the learning models and methods of the five schools are different, this can be seen from the Learning Lesson Plan made by teachers in schools. Senior High School A uses Discovery Learning Learning Model and high school lecture method B uses Problem Base Learning learning model and discussion and question and answer method. High School C uses Discovery Learning learning models and lecture methods, literature studies and frequently asked questions. Senior High School D uses Problem Base Learning learning models and methods of discussion, lectures, question and answer, and literature studies. Whereas in Senior High School E uses the Discovery Learning learning model and the learning method of discussion and question and answer. thus the approach, model and learning method are very influential on the results of the students' high order thinking ability scores. The better the application of models, methods and approaches in the learning process will have a good impact on the scores obtained by students.

Another matter that makes the scores of high order thinking skills of students in each school is different is the intensity of the application of evaluation test exercises to hone students' thinking skills. Representation of students' thinking skills can be seen from the results of the needs analysis and the difference in average scores in Figure 2. In addition to the factors described above, another thing that causes

differences in the scores of students' high order thinking skills is the time the execution of questions is carried out after a long vacation and the unpreparedness of students working on the problem, meaning that many students are forced to recall material studied, even though the content of the question content prioritized the analysis of a case displayed in the question.



Gambar 4.7 Profil Hasil Uji Coba Kemampuan Berpikir Tingkat Tinggi Siswa Pada Materi Sistem Reproduksi

Figure 2.

Profile of Testing Result Students High Order Thinking Skill Score on Reproduction System Material

Based on the picture above it is known from the value of the results of field trials to measure high order thinking skills in five Surakarta State High Schools, scores with interval values 0-25 no students get that value in each high school. At 26-50 interval values, there are 9 students who get this value, each consisting of 7 high school students 2, 1 high school student 6 and 1 high school student 7. At intervals of 51-75 there are 104 students, consisting of 21 students Senior High School A, 19 high school B students, 23 high school students C, 19 high school D students, and 22 high school students E. At intervals of 76-100 there are 20 students consisting of 2 high school students 2, 7 high school students 3, 2 high school students 4 , 5 high school students 6, and 4 high school students 7. Overall the scores obtained by students at most are in intervals 51-75.

Conclusion

Based on the results of data analysis and discussion that has been done, can be concluded: a) Characteristics of the results of the development of assessment

instruments to measure students' high order thinking skills based on HOT indicators from Anderson et al. (2001) have validity with a minimum "sufficient" interpretation and sufficient reliability. b) The feasibility of the results of the development of assessments to measure students' high order thinking skills has been through content and construct validity carried out by the validation of evaluation experts, material experts. Validity with minimum interpretation is sufficient, reliability is good, difficulty level of questions with proportion of 1.6% is easy, 58.4% is moderate and 40% is difficult for multiple choice questions and 0% is easy, 50% is moderate and 50% is difficult for essay questions. The differentiating problem with a minimum interpretation is sufficient, as well as the practicality of a good question. c) Profile of product assessment scores to measure students' high order thinking skills are as follows: High School B with a high order thinking ability score reached 71.61, then continued with Senior High School D with a score of 66.03, Senior High School C with a score of 65.46, E High School with a score of 63.69, and the last one is Senior High School A with a score of 60.26. Overall with the number of students 125 people have an average score of 65.41.

The finding of the problem that occurred in this study is that there is no instrument that can measure the high order of students' thinking skills in biological material. Therefore, this study aims to develop instruments that can measure high order thinking skills of students. The instrument was tested by experts and through a validation process. So that the score is obtained as explained in the discussion section. So that there is a valid and reliable instrument that can measure high order student thinking skills in biological material

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