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The Development of Assessment Instruments with Problem Posing Methods to Measure Students Creative Thinking Ability in Acid Base Materials

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A B S T R A C T

Students creative thinking skills play an important role in achieving educational goals, especially in understanding chemical material. Education is currently focused on developing Higher Order Thinking Skills and creative thinking skills that are one of the highest level of thinking. The teacher as one of the creative drivers is an important factor to increase student creativity in school. This study aims to develop creative thinking assessment instruments with problem posing methods on acid-base material and conduct tests to determine the responses of educators and students. This research used the Research and Development method which refers to the Borg and Gall model. The sample in this study amounted to 60 class XI high school students in Rokan Hulu district. The results of the validation of the assessment instruments were in average of more than 0.78 (very good) and had a test reliability on the main field test of 0.88 which was classified as very high. The level of difficulty ranged from 0.29 - 0.56 with the category of difficult and moderate. The ability to differentiate the problem is good enough. And the results of student responses amounted to 50.4 on the questionability readiness questionnaire, 8.1 on the questionnaire for sufficient time. Whereas the result of the teacher's response was 57.3 on the question eligibility questionnaire.

1. Introduction

21st century education is being intensified in all parts of the world. This phenomenon occurs because the demands given to education have changed. The 21st century is marked as a century of openness or a century of globalization, meaning that human life in the 21st century underwent fundamental changes. It is

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said that the 21st century is a century that asks for quality in all human endeavors and work. The 21st century demands especially in the quality of human resources. These new demands are breakthroughs in thinking, drafting, and acting. In other words, a new paradigm is needed in dealing with new challenges (Daryanto et al., 2016). The best way to answer the challenges and demands of 21st century skills and the 2013 revised 2107 curriculum is through the education. The teacher is one component of the education unit. The teacher has a role to encourage and facilitate students to be able to optimize their thinking abilities. One of the required thinking skills is creative thinking. The ability to think creatively is the ability to find a new relationship, see various subjects from a new perspective and find new combinations of two or more existing concepts (Demir et.al., 2014).

Characteristics of 21st century community skills published by the Partnership of 21st Century Skill identify that learning in the 21st century must be able to develop the competitive skills needed in the 21st century that focus on developing Higher Order Thinking Skills, and creative thinking. These are one characteristics of high-level thinking, so to see the ability to think creatively is very important to be trained (Wardany, 2013). Practicing the ability to think creatively is very important to equip students to develop the ability they have to solve problems and explain the phenomena that exist in daily life (Maria et al., 2018).

The ability to think creatively is very useful in the learning process at school. One of the subjects studied at the high school level is chemistry. Chemistry is able to provide knowledge to students, chemistry subjects that are intended as a vehicle to grow thinking skills that are useful for solving problems in everyday life (Asmawati, 2018). High school level students in particular must not only have lower order thinking skills (LOTS), but must arrive at higher order thinking skills (HOTS). Based on an international study held by the International Association for the Evaluation of Educational Achievement (IEA) namely TIMSS (Trends in Mathematics and Science Study) in 2011 in the field of Chemistry, Indonesia scored 397 where this value is below the international average value of 500. From The results of TIMSS, it can be used to see the profile of students' thinking ability which can be said that the thinking ability of Indonesian students is still low. This is because Indonesian students in general are less trained in solving problems with characteristics such as TIMSS questions (Asmawati, 2018).

Students creative thinking skills have an important role in achieving goals in education, especially in understanding chemicals. A good understanding of the concept of chemistry tends to be obtained if students have good high-level thinking skills. In chemistry learning, someone who already has the ability to think critically, logically, and reason is also required to have the ability to think creatively in order to be developed and understood by others (Moma, 2015). Creative talent is owned by everyone, because everyone has a tendency or support to realize their potential. Therefore, it is very important for us to start learning to develop the ability to think creatively in ourselves. Needed to create a creative environment so that we can foster, develop, and improve the ability to think creatively. In Minister of Education Regulation No. 16 of 2007 concerning Academic Qualifications and Teacher Competency Standards stated that one of

the core competencies of teachers is to assess and evaluate the learning process and outcomes. Based on the demands of teacher competence in the Minister of National Education Regulation above, it can be seen that one of the competencies that must be possessed by teachers is to develop instruments for evaluation and evaluation of learning processes and outcomes. Assessment instruments are an integral part of an assessment process in learning. Assessment acts as a program of process assessment, learning progress, and student learning outcomes (Docktor et al., 2009). Assessment can provide constructive feedback for both teachers and students. Based on the results of the assessment, the teacher can make the right decision to determine the next steps to take. The teacher can also find out how far students have succeeded in learning chemistry and the accuracy of the teaching methods used.

There are various assessments that can be made by the teacher to measure student achievement in learning. If the teacher wants to measure the cognitive domain of students, the teacher can use an assessment in the form of a test. Based on Permendikbud No. 53 2015, assessment of learning outcomes can be done through observation, self-assessment, assessment among students, tests, assignments, tests, practices, projects, and portfolios that are adjusted to the competency characteristics (Sunardi et al., 2017). Aa assessment using tests can be made in the form of written and non-written tests. These written test assessments are standardized and some are not. Standardized assessments mean that their validity and reliability have been measured and tested for use in student assessment activities. Meanwhile, assessments that have not been standardized need to be tested on students so that the level of validity and reliability of the assessment can be known. The situation in the field shows that many teachers have not made and used written test assessments that are truly appropriate in measuring indicators of student achievement and cognitive domain.

Based on a preliminary study conducted at two schools in Rokan Hulu Regency, that are the SMA Negeri 1 Ujungbatu high category and SMA Negeri 2 Ujungbatu, they have low category. These condition shows that the teachers at the two schools are still having difficulty in making an assessment that follows the higher order thinking ability students. The assessment instruments made are still merely measuring aspects of memorization and understanding. This proves that in making the assessment, the teachers did not understand the principles on how to do it. In addition, these teachers have also never made an assessment instrument to measure students creative thinking abilities, even though the school where they teach has implemented a 2013 curriculum that requires students to bring out their creativity in the learning process.

A study on the development of creative thinking assessment instruments conducted by Marwiyah (2015) shows the results of the validity of the research instruments in the form of essay tests showing the validity values stated in either category, and the assessment instruments developed can help teachers to identify the creative thinking skills of junior high school students on the atom , ions, and molecules. The difference with the research that will be conducted is the development of assessment instruments that will be carried out based on the

problem posing method. Problem posing is the formulation of questions from available information or situations, whether done before, when, or after the completion of a problem (Meutia, 2017; Mulyatiningsih, 2014). The development of this assessment instrument will be developed together with first degree of Chemistry University undergraduate students based on the problem posing method. In this paper, we will discuss research on the development of assessment instruments with problem posing methods to measure students' creative thinking abilities on acid-base material.

Research conducted by Pratiwi (2017) about tutoring using the problem solving learning model can have an impact on student learning outcomes. Likewise, research conducted by Ningsih (2017) that uses problem solving for the development of mathematics learning tools. In addition, the development of innovative teaching materials has been carried out as stated by Suarman et al. (2018). Therefore, researchers are interested in developing test assessment instruments. Moving on from the problems that have been described, more specifically the research conducted is developing an assessment instrument to measure students' creative thinking skills with the method of posing problems on acid-base materials.

2. Methodology

This study used research and development methods for R&D education (Research and Development Education) which was adapted from the Borg & Gall (1989) model. The development phase to be taken in the R&D development of the Borg and Gall model includes 10 stages. However, this research was only carried out at 7 stages because it was limited by time and research needs. A flow chart for developing creative thinking problems in acid-base materials with the Borg & Gall model can be seen in Figure 1.

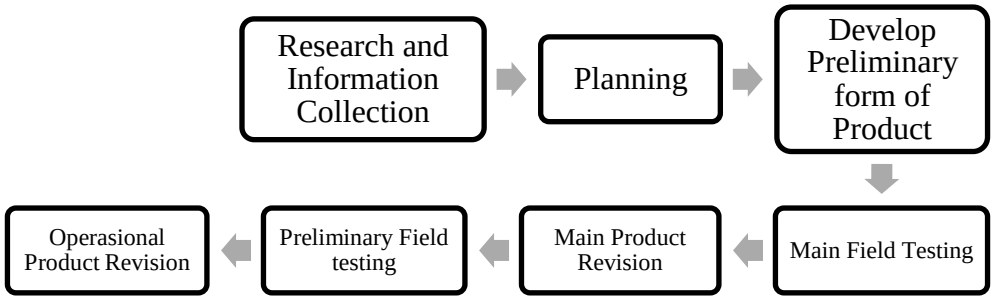


Figure 1. Development Flow of Creative Thinking Problems on Acid-Base Material with Borg & Gall Model

This development research was conducted at the Postgraduate of Study Program in Chemical Education FKIP Riau University, SMA Negeri 1 Ujungbatu, SMA Negeri 2 Ujungbatu, and SMA Negeri 1 Rambah. Data collected in the study were in the form of qualitative and quantitative data. Qualitative data were obtained from expert

validation instruments including content validation, constructs and language containing comments and suggestions for improvement of the instrument, the latest research journals, books and other related sources such as the national education system law, the Ministry of Education 2017 revised 2013 curriculum, Ministry of Education and Culture, articles, thesis and internet. While quantitative data were obtained from scores on the expert validation sheet, students' questionnaire responses regarding the readability and adequacy test, teacher's questionnaire responses to the time adequacy test and the feasibility of the creative thinking skills instrument and the data on the test results of the creative thinking ability description.

Data collection techniques used validation sheets, teacher and student response questionnaires, and assessment sheet data about creative thinking skills. Validation sheets are a measurement tool for assessing the validity of assessment instruments for creative thinking abilities. Questionnaire is as a tool to measure the adequacy of time, readability of questions, and the appropriateness of assessment instruments for the ability to think creatively.

The validity of the content is determined using the Aiken formula by 3 experts namely 3 chemistry lecturers with the following formula (Azwar, 2012).

$$V=S / [n*(c-1)], \quad \text{where} \quad S = \sum ni\ (r-lo)$$

and:
V = Validity index of Aiken. V values range from 0 - 1
ni = Number of experts who chose Criteria i
r = Criteria i
n = Number of all experts
c = Number of ratings / criteria

To interpret the value of content validation obtained from the above formula, then classifying validity was used as shown in Table 1 (Arikunto, 2010)

Table 1. Categories of Validation

The amount r_{xy}	Interpretasi
$0,80 < r_{xy} \leq 1,00$	Very high
$0,60 < r_{xy} \leq 0,80$	High
$0,40 < r_{xy} \leq 0,60$	Enough
$0,20 < r_{xy} \leq 0,40$	Low
$0,00 < r_{xy} \leq 0,20$	Very low

Questionnaire responses of teachers and students in the form of a readability questionnaire, sufficient time, and the appropriateness of assessment instruments for the ability to think creatively with acid-base material were based on the Likert scale as shown in Table 2

Table 2. Rating Categories of Likert Scale

Scoring scale	Information
4	Strongly disagree
3	Disagree
2	Agree
1	Strongly agree

One of the construct validity tests was done based on the product moment correlation formula (Widoyoko, 2012):

$$r_{xy} = \frac{N\sum xy - (\sum x)(\sum y)}{\sqrt{(N\sum x^2 - (\sum x)^2)(N\sum y^2 - (\sum y)^2)}}$$

Where:
r_xy = The correlation coefficient between variable x and variable y
x = Student score on each item
y = Total score of each respondent (students)
N = number of test takers

3. Results and Discussion

This research and development produced the form of a matter of creative thinking ability on acid-base material that has been tested for validity. This development procedure is carried out with the Borg and Gall Model with the following detailed steps:

Preliminary Research and Information Collection Stage

This stage is a needs analysis consisting of literature and empirical studies. Literature study was done by analyzing the syllabus. The syllabus review is to find core competencies and basic competencies that will be used in compiling indicators, collecting reference data and literature relating to research development of assessment instruments with problem posing methods to measure students creative thinking abilities through various book sources. The latest is to search journals on the development of creative thinking skills assessment instruments, articles and internet media that are relevant to research.

Empirical studies conducted by conducting pre-research directly at SMA Negeri 1 Ujungbatu and SMA Negeri 2 Ujungbatu using interview and questionnaire methods. Interviews were conducted with teachers and questionnaires were distributed to students in the two schools. The questions asked during the interview relate to the assessment used by the school and the knowledge of the creative thinking abilities assessment. Meanwhile, the questions that were asked in the student questionnaire were about the assessment given by the teacher in learning as well as students' responses to the assessment.

Planning Phase

The planning stages are (1) compiling indicators of cognitive assessment instruments for creative thinking abilities, lattice questions, test questions for creative thinking skills, scoring rubrics and assessments, (2) determining instrument validity with the help of chemist tests to validate instruments that have been made, (3) planning the instrument revision in accordance with the validator's advice, (4) planning a limited trial in the form of test readability and sufficient time, (5) first revision plan (6) wide-scale trial planning and determining the construct validity, construct reliability, distinguishing power , and the level of difficulty of the items, (7) product revision plan based on analysis of trial results, (8) trial plan in a wide area under the actual conditions, (9) final product revision plan.

Design Development Stage

a. Determine the purpose of the assessment instrument, the purpose of developing the assessment instrument with the problem posing method is to measure the students' creative thinking abilities at SMA Negeri 1 Ujungbatu, SMA Negeri 2 Ujungbatu, and SMA Negeri 1 Rambah.

b. Forming an assessment instrument. The assessment instrument that was developed was in the form of a grid about the ability to think creatively in the form of a matter of description that was supplemented by guidelines for assessment. These grading and assessment guidelines are prepared based on basic competency indicators and indicators of creative thinking. Basic competency indicators are developed in accordance with basic competencies (KD) for high school acid base materials according to the 2013 revised 2017 curriculum. The material chosen is acid and base solutions with basic competencies understanding the concepts of acids and bases as well as their strength and equilibrium ionization in solution. The basic competencies are translated into 7 indicators of achievement. Furthermore, the indicators of questions to be formulated will be adjusted to the indicators of creative thinking, namely fluency, flexibility, and elaboration.

c. Development of assessment instruments. In the development of the problem of creative thinking skills, it will be compiled with 15 UNRI Chemistry Education students. As for the questions developed in the form of a matter of essay (essay) totaling 19 questions with indicators as follows: (a) identifying the characteristics of acid and base solutions amounting to 3 questions; (b) Analyzing the method of neutralizing acid base amounting to 1 problem; (c) Analyzing the effect of acid and base solutions on the experimental results of 3 questions; (d) Identifying the acid and base strength of a solution totaling 1 problem; (e) combining the strengths of acids and bases with the degree of ionization and the equilibrium ionization constant of 2 questions; (f) Identifying several acid and base solutions with 6 indicators; and (g) Analyzing the effect of the strength of acids and bases on a neutralizing reaction totaling 3 problems.

d. Validation items about the ability to think creatively, the validation of the developed test instruments must meet valid criteria or be appropriate for use. Validity is reviewed from three aspects namely material, construction, and language. The suggestions and input from the validator can be seen in Table 3.

Table 3. Suggestions and Feedback for Improving each Validator

Validator	Suggestion
Validator 1	• Check again and understand the questions and the appropriateness of the answers (questions no. 3c) • Tidy up the writing on the problem grid • The sentence should be adjusted to the writing rules in EYD
Validator 2	• suitability of the questions to the indicators of creative thinking, as well as the suitability of the questions to the learning indicators that were formulated namely in questions number 1c, 2, 4, 5, and 6b • The answers made must be even more varied. • Unclear picture in questions number 2, 3 and 9 • the sentence in the confusing item in questions number 1c and 5a and the rubric of assessment which has not been good so there is no match between the items with the ability to achieve.
Validator 3	• For question number 3, add a picture when the egg is added vinegar, when gas bubbles are formed, then when the eggshell gets thinner and there are more gas bubbles accompanied by information on each picture. • Change the editorial questions number 2 and 4, because the questions developed are not in accordance with the learning indicators.. • The sentence sentences in item number 6b, and 8 are difficult to understand and confusing.

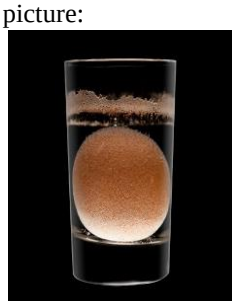
e. Repairing items and assembling items, the results of validation by the validator that have been obtained are used to improve the items that will be developed. The follow-up / improvement of each validator can be seen in Tables 4 and 5.

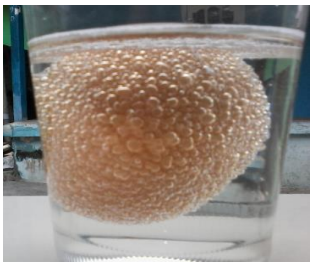
Table 4. Follow-up / Correction of each Validator

Validator	Follow-Up
Validator 1	• Improved answers to questions for number 3c) • Tidy up the study for each question. • Sentences are adjusted to the EYD study rules
Validator 2	• Improving the essay test questions (essays)

	adjusted to the aspects of achieving indicators of creative thinking, the appropriateness of the questions to the learning indicators formulated, and the answers made have more alternative answers. The answers made must be even more varied. • Provide information on each picture in question number 3 and replace the picture in questions number 2 and 9 • Improve the sentence structure in item 1c and 5a to clarify the assessment score and the description of the answers in the assessment rubric.
Validator 3	• Add picture for question number 3, which is a picture when the egg is added vinegar, when gas bubbles are formed, then when the eggshells thin out and there are more gas bubbles accompanied by information on each picture. • Change questions number 2 and 4. • Change the command sentence in item 6b, and 8

Table 5. Examples of problems to be fixed

No	Feedback and Suggestions	Before Revision	After Revision
1	**Validator** Soal no 3: • Add with Figure 1. When the eggshells are reacted with vinegar Figure 2 When gas bubbles are produced Figure 3 When more and more gas bubbles are produced and egg shells thinner.	Consider the following picture:  Zahwa was asked to demonstrate an experiment in front of his classmates namely soaking eggs in a vinegar solution. It turns out that after observing there are bubbles on the surface of the eggshell and if soaking is done continuously then the eggshell will peel off. Based on these observations, try the case analysis above and answer the following	Zahwa conducted an experiment to find out the effect of vinegar on eggshells, by immersing the eggshell in a 25% vinegar solution. After 60 minutes later, it was observed that there were bubbles on the surface of the eggshell and after 1 day the eggshell gave out more gas bubbles and the eggshell was thinner than before. observations obtained by zahwa are as follows:  Figure 1. When vinegar is reacted with eggs

No	Feedback and Suggestions	Before Revision	After Revision
		questions: a. Why are there bubbles on the surface of the egg shell? b. How is the effect of vinegar on the experiment! c. Explain in detail what information you concluded from the experiment!	 Figure 2. After 60 minutes there are bubbles.  Figure 3. After 1 day more and more bubbles and egg shell thinning Based on these observations, try the case analysis above and answer the following questions: a. Why are there bubbles on the surface of the egg shell? b. How is the effect of vinegar on the experiment! c. Explain in detail what information you concluded from the experiment!

After revision and improvement of each validator, the results of content validation using Aiken validation obtained results greater than 0.78, which means that all questions are valid in content and can be tested.

Limited Tryouts

Items that have been proven to have a validity of their contents are then tested for readability, sufficient time, and the feasibility of the questions through limited trials. This trial involved 10 students from SMA Negeri 1 Ujungbatu and 3 chemistry teachers. This trial was carried out through a discussion forum with students and chemistry teachers at the school to get input on the items. The percentage of time sufficiency, readability and feasibility of the questions can be seen from Table 6.

Table 6. Results of question readability questionnaires, sufficient time, and question eligibility

Angket	Average value	Qualification
Readability Problem	50,4	Very good
Adequacy of Time	8,1	Well
Feasibility Problem	57,3	Very good

Revised Preliminary Produt Revision Results

The results obtained in the limited trial are used to revise the items.

Large Scale Testing

In this second field test stage, 20 people from each of the Ujungbatu High School, Ujungbatu High School, and Rambah High School 1 Rambah were involved, each with 90 minutes of questioning. Students are asked to work on the items about the ability to think creatively and the response results of students' answers will be used to characterize the parameters of the items namely the construct validity parameters, the reliability of the instrument, the level of problem difficulty, the power of differentiation. Testing the construct validity, reliability, different power and difficulty level of the questions using the SPSS 23 program.

The construct validity test results obtained Corrected Item-Total Correlation value of each item> 0.304 (r table if N = 60) then the item items have good construct validity or construct valid items. The level of difficulty of the questions obtained from a total of 19 thinking questions that were tested were the results of 2 questions in the difficult category and 15 questions in the medium category. The results of the differentiation test items ranged from good to sufficient.

Wide Scale Product Revision

Product revisions are always done after the product is applied or tested. This is done especially if there are new constraints that have not been thought of at the time of design. Urgent matters to be corrected for example if suboptimal results are found when applying the instrument. After doing a large-scale trial, then the questions that were declared valid were 17 questions.

4. Conclusion

Assessment instruments developed using the problem posing method have been successfully developed with validation results. The assesment instrument can be used in the learning process to assess the creative thinking abilty of the student. The valid questioning instruments can enhance students creative thinking skills in material acid-base materials.

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