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Development of Problem-Solving-Based Knowledge Assessment Instrument in Electrochemistry

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The development of knowledge assessment instrument based on problem solving in the electrochemistry. This research aimed to find out the characteristics, teacher responses, and student responses to the problem-based knowledge assessment instrument on the electrochemistry material. The research method used is research and development which consists of four stages namely, research and collection information, product development, field trial, and product revision (Bord & Gall, 2013). This research began by conducting a needs analysis consisting of literature and field studies, product development, initial field trials, and revisions to the trial results. The research instruments are the interview guide of needs analysis, expert validation instruments, and teacher and student response questionnaires. The assessment developed was specifically designed to measure problem-solving skills in students. The research findings indicate that this assessment instrument can be used as a reference for teachers to conduct evaluations at the end of learning. The validity refers to the extent that the instrument measures what it was designed to measure. Content validity measures the extent to which the items that comprise the scale accurately represent or measure the information that is being assessed. Construct validity measures what the calculated scores mean and if they can be generalized. Construct validity uses statistical analyses, such as correlations, to verify the relevance of the questions.

Keywords: assessment, problem solving, electrochemistry, teaching, assessment instrument

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INTRODUCTION

An assessment is a systematic and continuous process or activity to collect information about the learning process and learning outcomes of students (Maisarah, Izam, Syarif & Bentari, 2017; Kyndt & Baert, 2015). Achievement of learning objectives can be known by carrying out learning evaluations (Jaing & McComas, 2015; TauTaut & Rakoczy, 2016). in order to make decisions based on certain criteria and considerations

In order to improve the quality of assessments, there are several principles needed so that teachers are not mistaken in making assessments. These principles are that the assessment must: (1) be an integral part of the learning process; (2) reflect real-world problems, not the school world; (3) use various sizes, methods, and criteria in accordance with the characteristics and essence of the learning experience; and (4) be holistic in covering all aspects of the learning objectives (knowledge, attitudes, and skills) (Fang, Hsu, & Hsu, 2016; Zedda et al., 2017; Bulunuz, 2019)

Given the importance of assessment instruments in assessments, a teacher as an educator is required to be able to develop assessment instruments that can comprehensively measure students' abilities, especially in science, especially chemistry (Andrian et al., 2018; Saeed et al., 2019). The principles of chemistry are divided into chemistry as a product and chemistry as a process. Most chemistry subjects must be taught by presenting facts in the form of problems and solutions; as in the electrochemical material

The electrochemical material is one of the abstract materials that has a high level of difficulty for students to understand (Arsani, 2008). Such material characteristics require facilities that support the learning process in accordance with the curriculum that emphasizes constructive learning (Durmuş, 2016; Thummathong et al., 2016). This material can be associated with problems in everyday life, such as dry cell batteries, which are cells without liquid components used for flashlights. Cell anodes are made of cans that come in contact with manganese dioxide (MnO2) and an electrolyte. Another example is a leaded battery (accu) used in cars and consisting of six identical cells arranged in series. Each cell has a lead anode and a cathode made of lead dioxide (PbO2). Given that the 2013 curriculum expects students to be able to solve problems, the assessment made by the teacher is expected to be able to measure their abilities in problem solving (Chiang & Lee, 2015; Kemendikbud, 2013; Suardana et al., 2018).

Based on the field studies with 5 teacher respondents from 3 public high schools and 2 private high schools in Bandarlampung about the learning process and assessment on the electrochemical material, it was found that all teachers had made knowledge assessment instruments using essay questions of 30%, multiple-choice questions of 30%, and a combination of both of 40%. In making the assessment instruments, all the questions are in accordance with the indicators and 40% of the teachers have made an outline first. They have never made problems-based questions and the questions made have not gone through the expert validation process so that all the teachers stated that problem-solving-based questions need to be developed. Development is a process or a series of steps to develop a new product or refine the pre-existing product that can be accounted for (Borg and Gall, 2013).

Based on interview results with the student respondents, it was obtained that 50% of the students already knew the problem-solving learning model and 40% of the teachers had taught using the problem-solving learning model. For the teachers who have used the problem-solving learning model, the students said that 63% of the problems given comes from the teacher. For the teachers who do not use the problem-solving learning model, the students said that 53.58% of the teachers use lecture and discussion methods in teaching.

Based on the description of the background above, it can be seen that teachers who use problem-solving learning models in their assessment do not use problem-based knowledge assessment instruments. This is supported by the results of the preliminary study with teacher respondents who stated that they never made problem-solving-based test questions. Therefore, it is necessary to carry out the research entitled "Development of Knowledge Assessment Instrument Based on Problem Solving in Electrochemistry".

Theoretical Background

Problem Solving

Problem-solving is learning that can develop students' thinking processes by providing problems to be analysed individually or in groups to find solutions to the problems (Widowati et al., 2017). The problem-learning-based learning model has steps with a clear problem to solve. The steps consist of finding data or information that can be used to solve problems, making hypotheses to the problem, testing the hypotheses, and drawing conclusions (Scherer & Gustafsson, 2015; Orzechowski et al., 2017). The advantages of learning with problem solving models are that it can develop fundamental concepts in students, familiarize students with facing and solving problems skilfully, stimulate the development of students' thinking skills actively, creatively and thoroughly because in the learning process, students do a lot of mental activities by highlighting problems in various aspects in order to find solutions. Teachers often provide strong rationale for not including problem solving activities is school instruction. These include arguments that problem solving is too difficult, takes too much time, full school curriculum and no room for problem solving. It will not be measured and tested. Problem solving is not in the textbooks, and basic facts must be mastered through drill and practice before attempting the use of it. We should note, however, that the student benefits from incorporating problem solving into the curriculum as discussed above outweigh this line of reasoning. Also we should caution against claiming an emphasization on problem solving when in fact the emphasis is on routine exercises.

Electrochemistry

Electrochemistry is the material in chemistry learning in high schools in Indonesia which is closely related to the development and challenges of the globalization era in the 21st century (Tim Permendikbud, 2014). It has goal to perceive students to do observation, asking question, synthesizing, and communication of what they gained after the instructional process in the way of being creative, active, innovative, and productive at electrochemistry lesson regarding to the fast changing era (Puskurbuk, 2014). The electrochemistry material discusses chemical processes involving various concepts, direct experience, and knowledge understanding. This material can be associated with problems in everyday life, such as dry cell batteries, which are cells without liquid components used for flashlights. Cell anodes are made of cans that come in contact with manganese dioxide (MnO2) and an electrolyte. Therefore, this electrochemistry material can be applied in daily life and various fields of science (Uzoamaka, Okafor, & Akusoba, 2014; Vanderlelie, 2013)

Knowledge assessment instrument

The assessment is a tool used to assess student learning outcomes. It is to reveal what students know about the subjects to be taught (Furtak, 2012; Izci, 2018). Assessment is carried out when the learning process is obtained through information gathered from students. An assessment instrument can be used to assess the results of feedback about teaching and learning conducted by teachers and students. The use of assessment instruments is one of the more effective ways to measure the achievement of learning outcomes (Bulunuz et al., 2014; Bulunuz, 2019).

Learning Objectives

Based on the description of the background above, this research aimed to find out: (1) characteristics of the problem-solving based knowledge assessment instrument on the electrochemistry material, (2) teacher responses to the problem-solving-based knowledge assessment on the electrochemistry material, and (3) student responses to the problem-solving-based knowledge assessment on the electrochemistry material.

METHOD

Research Design

The method used in this research is a Research and Development (R & D). According to Borg and Gall (2013), in general, the research and development steps consist of four stages. The 4D flowchart stages is described below:

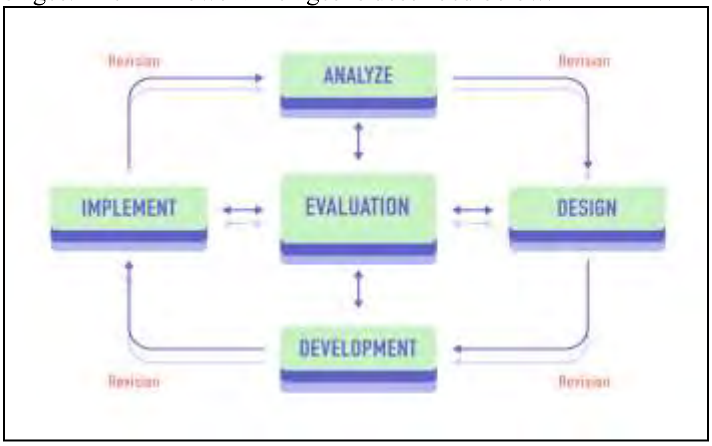

Figure 1
4-D stage in research and development

The detailed explanation of those steps above are; 1) research and information collecting, which includes literature studies and field studies; 2) developing the preliminary form of the product including the development of learning materials, learning processes, and evaluation instruments; 3) conducting the field trial at one school with 1 teacher and 20 students as the test subjects, during which the researcher carried out observations and interviews and distributed questionnaires; 4) revising the main product revision by improving or refining the trial results. At the dissemination stage, the instrument can be resulted in report and disseminate products through meetings and scientific journals, in collaboration with publishers to disseminate products for commercial use, and monitor distribution and quality control.

Population and Sample

The research population were all senior high school students in Bandarlampung in 2017/2018 academic year. The sample used was the twelfth grade. The sample was selected using the cluster sampling technique, resulting in 3 public senior high schools and 2 private senior high schools, consisting of 1 chemistry subject teacher and 20 twelfth-grade students, respectively.

Research Instruments

The instruments used in this preliminary research were in the forms of interview guides and questionnaires for needs analysis to obtain the data regarding the learning assessment in several schools. These instruments were also used to determine the obstacles faced in the preparation of assessments and as a reference in the development of the problem-solving-based assessment. The characteristics of this instrument that will be developed to measure problem solving ability contain of instruction for the students to analyse a script of two individuals working through the solution to the problem. This format provides several benefits: 1) motivation for students to work through the entire solution, 2) removes the stress of being analysed 3) scaffolds the problem so that a solution will be reached even if the student has a specific weakness that would have prevented further progress if they were attempting to solve the problem in isolation. The validity refers to the extent that the instrument measures what it was designed to measure. Content validity measures the extent to which the items that comprise the scale accurately represent or measure the information that is being assessed. Construct validity measures what the calculated scores mean and if they can be generalized.

Expert validation instrument

This instrument was used to test the feasibility and identify the existence of problem-solving syntax from the assessment developed. This instrument consists of the instruments as follows:

a. Content validation questionnaire

The content conformity validation questionnaire was prepared to determine the suitability of the assessment content with Kompetensi Inti or Core Competencies (CC), Kompetensi Dasar or Basic Competencies (BC), indicators, and to identify the existence of the problem-solving syntax of the assessment instruments developed. The results of this validation of the content conformity aspect will serve as an input in the development or revision. A consistent scale guarantees that every one of its components or items measure a single construct which is homogeneous. If the scale has an elevated internal consistency, the sum of the scores can represent the measurement of a single construct with which in general, it maintains a linear relationship. It is shown below:

Table 1
Characteristics of the measurement instruments

Term	Synonym	Aspects to consider	Analysis Technique
Validity	Feasibility	Time employed Clarity of questions Registry, coding Result interpretation	Pilot study
	Reliability	Internal consistency	Cronbach Alpha
		Intraobserver	ICC, kappa ind3x, Bland and Altman graphic method
		Interobserver	ICC, kappa ind3x, Bland and Altman graphic method
Validity		Logic (*face validity*)	Postulating questions
		Content	Expert opinion
		Construct	Facorial analysis content
		Criterion	Diagnostic tests
Sensitivity to change	Responsiveness	Intrinsic	In relation to the design and type of change
		Extrinsic	

ICC Indicates intraclass correlation coefficient

b. Readability validation questionnaire

This questionnaire was arranged to find out whether the problem-solving-based assessment instrument can be read well in terms of font size, font selection, font colour, space size, layout, size, colour, and image quality. The results of this validation of the readability aspect will serve as an input in the development or revision.

Preliminary field trial instrument

After the design of the assessment instrument had been validated, the preliminary field trial was carried out on the teacher and students. The assessment instrument by the teacher is in the form of a questionnaire which consists of questions relating to the levels of readability, construction, and conformity of the content. This product trial was conducted to find out the teacher responses to the draft design of the validated knowledge assessment instrument.

a. Product Revision (Assessment Instrument)

This research was only carried out until the product revision stage after the assessment by the teacher and students. The revision stage is based on consideration of the results of the product assessment, namely the reliability and validity of the assessment and the results of the teacher's assessment on the assessment instrument developed. At this stage, the product is improved by reducing unnecessary things and adding necessary things based on the results of the assessment by the teacher and students conducted before.

Data Collection Techniques

The data collection techniques in this research were questionnaires and interviews. According to Creswell (2012), a questionnaire is a technique of collecting data by giving respondents a set of written questions to answer. In this research, the data were collected at the preliminary research and development stages. In the preliminary research, interviews were conducted to the chemistry teachers of twelfth grade of science and the questionnaires were given to students at three public senior high schools and two private senior high schools in Bandarlampung. In product development, interviews or questionnaires are conducted to teachers and students to find out their responses to the assessment instruments developed.

Data Analysis Technique

The data analysis techniques were carried out on the results of interviews and questionnaire data from the research results. The scoring of the respondents' answers in the readability, construction, and content suitability tests is based on the Likert scale.

Table 2
Scoring of conformity test for positive statements

No	Answer Choice	Scores
1	Strongly Agree (SA)	5
2	Agree (A)	4
3	Not Really Agree (NRA)	3
4	Disagree (D)	2
5	Strongly Disagree (SD)	1

Then, the percentage of the overall answers of the questionnaires was interpreted as follows:

Table 3
Interpretation of score (percentage) of questionnaire

Percentages	Criteria
80.1% - 100.0%	Strongly Agree (SA)
60.1% - 80.0%	Agree (A)
40.1% - 60.0%	Quite Agree (QA)
20.1% - 40.0%	Disagree (D)
0.0% - 20.0%	Strongly Disagree (SD)

(1) Technique of question item analysis

The data analyses carried out include the validity and reliability of the instruments. The data analysis was calculated using SPSS software. 17.0 and Microsoft Office Excel. The validity and reliability of the instruments were analysed with SPSS 17.0 (essay questions). The validity and reliability criteria according to Creswell (2012) are shown in below.

Table 4
Minimum Values of CVR and One Tailed Test, p = .05.

No of Panelists	Min Value*
6	.99
6	.99
7	.99
8	.75
9	.78
10	.62
11	.59
12	.56
13	.54
14	.51
15	.49
20	.42
25	.37
30	.33
35	.31
40	.29

When all say "essential," the CVR is computed to be 1.00, (It is adjusted to .99). When the number saying "essential" is more than half, but less than all, the CVR is somewhere between zero and .99.

The validity of the essay questions was determined from the value of r_{table} and r with the criterion as follows: The question is valid if $r_{table} < r$ with a significance level of 5%. The reliability was determined by using Cronbach's Alpha. The reliability criterion for essay questions is if Cronbach's Alpha value $\geq r_{table}$, the question is reliable. The criteria for degree of reliability (r_{11}) according to Guilford are shown in Table 5 (Creswell, 2012).

Table 5
Criteria for Degree of Reliability

Reliability percentage (r_{11})	Criteria
$0,80 < r_{11} \leq 1,00$	Very high
$0,60 < r_{11} \leq 0,80$	High
$0,40 < r_{11} \leq 0,60$	Medium
$0,20 < r_{11} \leq 0,40$	Low
$0,00 < r_{11} \leq 0,20$	Very low

Table 6
Criteria for Degree of Reliability

Reliability percentage (r_{11})	Criteria
$0,80 < r_{11} \leq 1,00$	Very high
$0,60 < r_{11} \leq 0,80$	High
$0,40 < r_{11} \leq 0,60$	Medium
$0,20 < r_{11} \leq 0,40$	Low
$0,00 < r_{11} \leq 0,20$	Very low

Table 7
Criteria for Characteristic of Assessment Instrument (readability, construction, and content conformity)

Reliability percentage (r_{11})	Criteria
$0,80 < r_{11} \leq 1,00$	Very high
$0,60 < r_{11} \leq 0,80$	High
$0,40 < r_{11} \leq 0,60$	Medium
$0,20 < r_{11} \leq 0,40$	Low
$0,00 < r_{11} \leq 0,20$	Very low

FINDINGS AND DISCUSSION

The results of the research and development conducted are as follows:

Results of Needs Analysis

Results of Library Studies Analysis

The literature study on curriculum assessment resulted in learning instruments in the form of mapping of Kompetensi Inti or Core Competencies, Kompetensi Dasar or Basic Competencies (CC- BC), syllabus, concept analysis, and lesson plans (RPP).

Results of Field Analysis

At this stage, observations were carried out by collecting data through interviews and filling out questionnaires. The interviews were conducted on 5 chemistry teacher respondents while the questionnaires were filled out by 100 twelfth-grade science students from 3 public senior high schools and 2 private senior high schools in Bandarlampung.

Based on the interviews with the teachers in the field study, several facts were found as follows: 1) All the teachers have made knowledge assessment instruments using essay questions of 40%, multiple-choice questions of 20%, and combinations of both of 40%; 2) In making the assessment, all the questions have been adjusted with the indicators and 40% of the teachers have made the outline first; 3) 40% of them have known the knowledge of problem-solving learning models; 4) All of them have never made problem-solving-based questions so teachers need to make problem-solving-based questions; and 5) All of them stated that it is necessary to develop problem-solving-based questions.

The interview with student respondents resulted in some facts as follows: 1) 55% of the students have already known the problem-solving learning model; 2) 44% of the teachers have taught using problem-solving learning models; 3) Regarding the teachers who have used problem-solving learning models, the students said that 63% of the questions given come from the teacher; and 4) The students said that 53.58% of the teachers use the lecture method in teaching.

Results of Development of Problem-Solving-Based Knowledge Assessment Instruments

Based on the results of needs analysis conducted, it is necessary to develop problem-solving-based assessment. The initial step in the preparation of the assessment draft was to arrange the outline in accordance with CC-BC.

Based on the outline, the items in the form of essay questions were made. The researcher developed 10 items. The preparation of the items is determined in two categories, based on the levels of difficulty (difficult, medium, and easy) and based on the cognitive domains (C1 (knowledge), C2 (comprehension), C3 (application), C4 (analysis), C5 (synthesis), and C6 (evaluation)).

The details of each item made in the assessment are as follows:

KD 3.3: Implementing laws/rules in calculating electrochemical cells.

The items of questions in the instrument assessment on KD 3.3 (Basic competence 3.3) are presented in the blueprint below:

Table 8
Blueprint instrument of assessment

No.	Item	Cognitive Domain					
		C1	C2	C3	C4	C5	C6
1	Question 1			√			
2	Question 2				√		
3	Question 3				√		
4	Question 4			√			
5	Question 5				√		
6	Question 6					√	
7	Question 7				√		
8	Question 8			√			
9	Question 9				√		
10	Question 10				√		

Question 1 was made to measure the achievement of indicator 3.3.5, which is students are expected to be able to explain three differences in Galvani cells with Electrolysis cells, as well as indicator 3.3.6 about determining the direct process of redox reactions in Galvani cells and Electrolysis cells based on observational data. In this question, the students were asked to solve the problem from an experimental data presented. From these data, the students were asked to explain the events that took place. There were cathodes and anodes in each cell on the trochemical element. The level of difficulty of this question is medium and difficult with C3 cognitive level (application).

Question 2 was made to measure the achievement of indicator 3.3.7 about explaining the electrolysis process of KI solutions using carbon electrodes and indicator 3.3.8 about determining the gas produced from the results of the electrolysis of KI solutions. In this question, students are asked to solve the problem from an experimental data presented. The data show that more than one species is found in the cathode and anode, and then the students are asked to show what species experience oxidation and reduction at each electrode. The level of difficulty of this question is medium with C4 cognitive level (analysis).

Question 3 was made to measure the achievement of indicator 3.3.9 about explaining factors that affect species strength at the anode and cathode if non-inert electrodes are used. In this question, the students were asked to solve the problem of the data that contains the name of the melt of a substance and its concentration. From the data, the students were asked to determine and explain what species can experience oxidation and reduction in the electrode. The level of difficulty of this question is medium with C4 cognitive level (analysis).

Question 4 was made to measure the achievement of indicator 3.3.10 about explaining the causes of differences in the ability of a solution and melt to be oxidized at the anode and reduced at the cathode. In this question, the students were asked to solve the problem of an image of the electrolysis of NaCl solution and NaCl melt presented. In the image, the students were asked to explain why the reaction at the anode and cathode of a NaCl solution can be different from the result of NaCl melt. The level of difficulty of this question is difficult with C3 cognitive level (application).

Question 5 was made to measure the achievement of indicator 3.3.11 about explaining the causes of differences in the ability of KI solutions to be different from the reaction results when inert and non-inert electrodes are used. In this question, the students were asked to solve the problem of an image of electrolysis of NaCl solution using (a) inert electrodes (carbon) and (b) non inert electrodes (copper). The image asked students to be able to distinguish and explain what species are produced at the anode and cathode. The level of difficulty of this question is difficult with C4 cognitive level (analysis).

Question 6 was made to measure the achievement of indicator 3.3.12 about explaining the causes of differences in the melting ability of CC, which differed in reaction results when inert and non-inert electrodes were used. In this question, the students were asked to solve the problem from a given discourse. The discourse contains a phenomenon where the students are asked to complete it. The level of difficulty of this question is medium with C5 cognitive level (synthesis).

Question 7 was made to measure the achievement of indicator 3.3.13 about explaining factors that affect the neutral salt electrolysis process. In this question, the students were asked to solve the problem from a given discourse. The discourse asks them to arrange and explain events that occur at the anode and cathode in the event of electrolysis of NaCl and Na_2SO_4 solutions with inert electrodes. The level of difficulty of this question is difficult with C4 cognitive level (analysis).

Question 8 was made to measure the achievement of indicator 3.3.14 about explaining how to assemble tools to obtain 0.5 g of copper in the cathode. In this question, the students were asked to solve the problem from an incomplete table. They were asked to fill in the incomplete table and explain why there are copper deposits in the cathode. The level of difficulty of this question is medium with C3 cognitive level (application).

Question 9 was made to measure the achievement of indicator 3.3.15 about explaining the problem of two series of solutions installed that experience electrolysis. The students were asked to calculate a metal mass that is absent on one of the electrodes and provide the reasons of their answers. The level of difficulty of this question is difficult with C4 cognitive level (analysis).

Question 10 was made to measure the achievement of indicator 3.3.16 about explaining the cause of the reaction on the anode and cathode when electrolysis occurs to coat zinc with silver. In this question, the students were asked to solve the problem from an image presented. The image asks them to be able to write a reaction on the anode and cathode. The level of difficulty of this question is difficult with C4 cognitive level (analysis).

Results of Expert Approval

After drafting the assessment had been complete, the validator validated it. Expert validation includes the aspects of readability, construction, and conformity of the content with the assessment made. The validator carried out the assessment through filling out the questionnaire about the problem-solving-based assessment. The validator was also asked to provide suggestions and inputs so that improvements could be made to the deficiencies contained in the assessment developed. The following are the overall percentage data from the validation results of the assessment developed.

Table 9
The Results of Expert Approval

Aspects	Percentage of Validation Results	Suggestions for Improvement
Readability	98	Font size: guideline for filling out the instrument, language use
Construction	90	The scope of questions must be clear; The length of questions must be homogeneous
Content Conformity	86	The conformity of the material content with CC-BC includes: conformity of (1) the assessment with CC-BC, (2) the indicators with CC-BC, (3) the assessment to measure knowledge indicators, (4) the assessment made in order of the achievement of knowledge indicators

Results of Preliminary Field Trial

Based on the validation conducted by the validator on the aspects of readability, construction, and conformity of the content, it can be said that the problem-solving-based knowledge assessment instrument developed can be used for the preliminary field trial. However, before carrying out the trial, several improvements must be made to produce the more valid product. After making improvements to the product, the next step was that the teacher and students assessed it. The following are the results of teacher responses obtained from the preliminary field trial.

Table 10
Teacher Response to the Results of Preliminary Field Trial

Aspects	Percentage of Validation Results	Suggestions for Improvement
Readability	100	The readability is quite good, including: Font size, guideline for filling out the instrument and language use
Construction	90	The scope of questions must be clear; The length of questions must be homogeneous
Content Conformity	100	The assessment instrument is in accordance with the material content, indicators, and CC- BC

Based on the Likert calculation results, 100% of the teachers strongly agree. This is evident from the teacher's response stating strongly agree (SA) on all statements contained in the questionnaire. The readability aspects assessed include font size, text colour, instrument guideline, image quality, clarity of tables and images, easy use of language, language use in accordance with writing rules, not using local languages, no ambiguous words, selection of fonts, font size, and use of spaces.

The Likert calculation results resulted in the percentage of the assessment of the construction aspect of 90% with the strongly agree category. This can be seen from the teacher's responses to the questionnaire, consisting of three answers of strongly agree (SA) and the rest of agree (A).

The assessment of construction aspects includes the clarity of the scope of the question, the homogeneity of the question length at each point, the conformity of the formulation of questions/statements using question/ command words that require essay answers, clarity and firmness in formulation of the questions, clarity of images and tables in the questions presented, and conformity of the question item independent on the answers to the previous questions.

The Likert calculation results resulted in the percentage of the assessment of the content conformity aspect of 100% with the strongly agree category. This is evidenced by the teacher's response to the preliminary field test stating strongly agree (SA) on all statements contained in the questionnaire. The assessment of the conformity aspect of the content assessed consists of 2 parts, namely 1) the conformity of the material content with CC-BC which includes: the conformity of the assessment with CC-BC, the conformity of the indicators with CC-BC, the conformity of the instrument to measure knowledge indicators, the conformity of the assessment constructed based on the sequence of achievement of knowledge indicators, the conformity of terms and symbols with concepts, the conformity of images with concepts; and 2) the conformity of the material content with the problem-solving model which includes: the questions made have problems related to electrochemical concepts; the problems presented can measure students' conceptual understanding; and the questions made can measure their problem-solving skills.

The results of the assessment on the aspects of readability, construction, and conformity of the material content conducted by the teachers indicate that the problem-solving-based knowledge assessment instrument can already be used as a reference for teachers to evaluate the achievement of indicators at the end of learning (Acarerdol & Yildizli, 2018; Bulunuz et al., 2014; Bulunuz, 2019).

The results of student responses obtained from the preliminary field trial are the readability aspects of the assessment. This assessment was aimed at determining the level of clarity of the sentence, communicativeness, the presence or absence of ambiguous words, the clarity of the writing. Based on the data obtained from the Likert calculation, the result is 86.00% with the category strongly agree. This can be seen from the student responses to the questionnaires, most of which are agreed (A) and strongly agree (SA).

The percentage of students who answered strongly agree is 42.50%, agree was 48.75%, not really agree 4.58%, disagree 3.75%, and strongly disagree 0.41%. These various answers indicate that there is still something to be improved in the assessment. However, when viewed from the overall results, this assessment is good (Hardianti et al., 2017; Yanto et al., 2019)

Validity and Reliability

The assessment instrument was tested directly to students to work on in order to determine the level of validity and reliability in each question. This validity test is useful to find out whether the assessment instrument developed is valid or not so that it can be seen whether this assessment is able to measure students' problem-solving skills.

The instrument is said to be valid by looking at the value of the significance or compare the values rxy with r table product moment. Based on the significant value obtained by the Sig. (2-tailed) of 0.000 <0.05, so it can be concluded to the instrument is valid. The count value obtained rxy 0.610 > r table product moment 0.329. it can be concluded that the instrument is valid.

After obtaining the results of validity, the next was calculating the reliability of the assessment instrument. Reliability analysis is the analysis of constancy of the questions tested. After doing calculations with the SPSS Statistics 17.0 program, it was found that the assessment developed has a reliability coefficient of 0.773 of the high category. This value indicates that the assessment developed can be used in learning to measure problem-solving skills in students (Taber, 2017).

Validity and reliability are used to ensure that the measurements are suitable at the maximum and the implementation in the learning process program runs well. Assessment instruments in education are pivotal. Thus, the concepts of validity and reliability are necessary so that the information needed can be obtained accurately and precisely (Wriht & Craig, 2011; Burton & Mazerolle, 2011). Highly effective assessment instruments make it easy for users to access information and describe the components that are integral and contribute to improving the learning process program developed. Assessment instruments that are valid, reliable, and proven effective will reflect the results of measurements so as to improve the weakness of the learning process in an educational program (Tooth et al., 2013; Widodo & Sudarsono, 2016; Andrian et al., 2018).

CONCLUSION

Based on the results of the research and discussion, it can be concluded that the find out the characteristics, teacher responses, and student responses to the problem-based knowledge assessment instrument on the electrochemistry material. The problem-solving-based knowledge assessment instrument on electrochemistry material developed can be used as a reference for teachers to evaluate in measuring the achievement of indicators at the end of learning to achieve predetermined learning objectives. This is viewed from the aspects of readability, construction, and conformity of the electrochemistry contents. Besides, this is visible from the student responses to the questionnaire obtaining the percentage of 86.00% with the strongly agree category. However, as a future recommendation, it is a call for researchers to activate this assessment instrument and collect data from the field related to measure both indicators and their achievement. Furthermore, it could be also applied to focus on different material of subject or course which are expected to add the knowledge and variation and its impacts on the meeting of learning objectives.

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