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Validity of Student Worksheets Based on Multiple Representations of Electrolyte and Non-Electrolyte Solution Materials

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Abstract

Multiple representations can facilitate the understanding of abstract chemical concepts. Multiple representations can be incorporated into teaching materials, such as Student Worksheets, to create Multiple Representation-based Student Worksheets. This study aims to analyze the validity of Student Worksheets based on multiple representations of electrolyte and non-electrolyte solutions. The research utilized the Research and Development (R&D) model with the ADDIE (Analysis, Design, Development, Implementation, and Evaluation) development stages, reaching the development stage in this study. Data were obtained from material expert and media expert validators. Descriptive statistical analysis was used to analyze the validity results. The Student Worksheets based on multiple representations of electrolyte and non-electrolyte solution materials achieved an average validity percentage of 84.37% from material experts and 95% from media experts, categorizing them as very valid. These worksheets, focusing on the validity aspect, are effective in assisting students in understanding chemical concepts.

Keywords: electrolyte and non-electrolyte solutions; multiple representations; student worksheets validity

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INTRODUCTION

Student worksheets serve as a means to facilitate effective interaction between students and educators, aiming to enhance students' learning activities (Jannah et al., 2017; Lestari et al., 2021; Misbah et al., 2018). The student worksheets also guides students during the learning process, making it easier for them to master specific competencies (Mardiana et al., 2017; Maulani et al., 2018; Wahyuni et al., 2018). In chemistry education, the student worksheets can assist students in understanding abstract chemical concepts, with one approach being the student worksheets based on multiple representations. Multiple representations in chemistry help connect abstract concepts with concrete ones, making it easier for students to understand chemistry conceptually. Students' understanding of this abstract knowledge can be determined by their ability to transfer and connect macroscopic, microscopic, and symbolic phenomena, known as multiple representations (Muslimah, 2019).

One of the abstract chemical topics is the material of electrolyte and non-electrolyte solutions, requiring multiple representations to assist students in understanding it. Macroscopic aspects of electrolyte and non-electrolyte solution materials can be observed after experiments, such as forming a light bulb glow. These phenomena can be translated into symbolic representations, such as reaction equations and microscopic representations in the form of depictions of the species involved in the reaction (Noor, 2018). The connection of multiple representations with electrolyte and non-electrolyte solution materials helps students understand the material, emphasizing the need for Multiple Representation-based Student Worksheets on electrolyte and non-electrolyte solutions.

Interviews and surveys conducted with chemistry teachers and 10th-grade students at MA Hidayatullah Martapura revealed that the use of the student worksheets on electrolyte and non-electrolyte solution materials in schools is not yet based on multiple representations. This fact is supported by a preliminary study conducted at MA Hidayatullah Martapura with a chemistry teacher as the informant, stating that they are not familiar with the student worksheets based on multiple representations. This finding aligns with a study by (Sari, 2017), which interviewed chemistry teachers and distributed questionnaires to students in four public high schools and two private high schools in Bandar Lampung, namely SMAN 9, SMAN 5, SMAN 13, SMAN 15, SMA Yadika, and SMA Al-Azhar 3. The results showed that using LKPD in schools is not yet based on multiple representations.

Based on the researchers' analysis, the results of the preliminary study at MA Hidayatullah Martapura indicated that students face difficulties in remembering chemical symbols or formulas, visualizing molecular or ion structures, analyzing experimental phenomena, writing and distinguishing reactions occurring in electrolyte and non-electrolyte solutions. This is supported by daily quiz data at MA Hidayatullah Keraton Martapura, where 51.72% of the 29 students scored below the Minimum Completeness Criteria of 75.

Based on the results of the preliminary study, it is known that students face difficulties in understanding chemistry concepts. According to the research, developing teaching materials in the form of Student Worksheets based on multiple representations is necessary. This development can assist students in comprehending abstract chemical content, enabling them to discover the concepts being studied and actively participate in learning activities. Consequently, the learning objectives can be achieved effectively. This notion is supported by Sugiyono's research (2016) on the effectiveness of the student worksheets based on multiple representations in improving the mastery of electrolyte and non-electrolyte solution concepts. The results showed that the experimental class had an average normalized gain (n-Gain) of 0.71, indicating a high level.

In contrast, the control class had an average n-Gain of 0.36, categorized as moderate. The average student activity reached 96.53%. It can be concluded that using the student worksheets based on multiple representations effectively enhances concept mastery and student engagement. Considering the research findings related to the development of the student worksheets based on multiple representations, these worksheets are essential to understanding abstract chemistry concepts and acquiring concepts from the topics studied by students. Therefore, the developed the student worksheets is based on multiple representations with a sequence of macroscopic, microscopic, and symbolic representations. The researchers developed Student Worksheets based on multiple representations for electrolyte and non-electrolyte solution materials in this study, aiming to analyze the validity of these worksheets.

METHOD

The type of research used in this study is Research and Development (R&D), which aims to produce and test the effectiveness of a product. Additionally, this developmental research aims to discover, develop, and validate a product (Sunyono, 2015). The development model employed is the Analysis, Design, Development, Implementation, and Evaluation (ADDIE) model. Due to time constraints and the researchers ' insufficient capacity to proceed to the next stages, this study is limited to the product development stage, which subject matter experts and media experts then validate.

Analyze

The analysis phase involves defining what students will learn through needs analysis and performance analysis (Syahyani, 2018). Needs analysis is conducted to determine the competencies that students need to learn. This analysis includes defining core competencies, basic competencies, competency achievement indicators, and learning objectives and determining the concept of electrolyte and non-electrolyte solution materials based on multiple representations. Performance analysis aims to identify and clarify problems that require a solution by developing teaching materials based on multiple representations. The performance analysis involves interviewing chemistry teachers from MA Hidayatullah Martapura and distributing questionnaires to students in class X MIA 1 at MA Hidayatullah Martapura.

Design

In the design phase, the researchers designed the student worksheets components based on multiple representations for electrolyte and non-electrolyte solution materials. The researcher also creates an instrument grid used to assess the validity of expert lecturers in subject matter and media.

Develop

During the development stage, the researchers created student worksheets based on multiple representations for electrolyte and non-electrolyte solution materials. Two chemistry professors from UIN Antasari Banjarmasin conduct validation tests and act as subject matter and media experts. This stage is carried out before the group test to ensure that the product meets the feasibility standards and students' needs. The subject matter expert evaluates the student worksheets based on material and presentation, while the media expert assesses graphics, consistency, readability, and print quality.

The data obtained in this developmental research include qualitative and quantitative data. Qualitative data consists of notes, suggestions, or comments from the validation sheet assessment by validators and described validation sheets. Quantitative data in this study are obtained from validation scores. Data sources come from validators, reviewers, and expert lecturers in subject matter and media. The instrument used in this study is the validation sheet.

The analysis of validation results employs descriptive statistical analysis. The collected data are processed to obtain summary data using specific formulas (Astutik et al., 2017). The summary data obtained includes the total, average, and percentage, followed by a presentation of the data in tabular form. Data analysis techniques include scoring, calculating averages and categorization, calculating percentages, and interpreting percentages.

1. Calculate the validity questionnaire scores

Table 1 Scoring criteria for the validity results of the student worksheets

Criteria	Score
Strongly Agree	4
Agree	3
Disagree	2
Strongly Disagree	1

(Sugiyono, 2016)

2. Calculate the average validity score of the student worksheets (Syafril, 2019)

$$\overline{X} = \frac{\Sigma\overline{X}_I}{n} \quad \dots (1)$$

Information: $\overline{X}$ is the mean; $\Sigma\overline{X}$ is a sum of each data; n is the number of data.

Table 2 Categories of the student worksheets validity results

Criteria	Information
$1 \leq X < 2$	Invalid
$2 \leq X < 3$	Quite Valid
$3 \leq X < 4$	Valid
4	Very valid

3. Calculate the percentage of LKPD validity results (Syafril, 2019)

$$p = \frac{F}{N}\, x\ 100\% \quad \dots (2)$$

Information: p is the percentage; F is the frequency; N is the total frequency.

4. Interpret the percentage of the student worksheets validity results

Table 3 Interpretation of Validity Questionnaire Percentage

Percentage (%)	Criteria
80.1% - 100%	Very High
60.1% - 80%	High
40.1% - 60%	Medium
20.1% - 40%	Low
0.0% - 20%	Very Low

RESULTS AND DISCUSSION

The product developed in this research is Student Worksheets based on Multiple Representations of electrolyte and non-electrolyte solution materials with a total of 40 pages. The cover appearance of the student worksheets based on multiple representations can be seen in Figure 1.

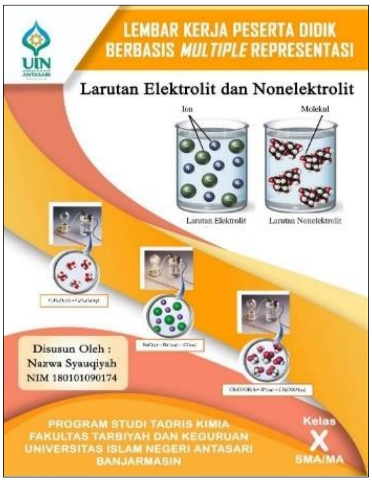

Figure 1 The cover of multiple representation-based student worksheets

Results of the Validity of Multiple Representation-Based The Student Worksheets from the Material Expert Validator

Material expert validation aims to assess the multiple representation-based student worksheets on electrolyte and non-electrolyte solution materials from the aspects of material and presentation. The validity test results from the material expert yielded an overall average score of 3.33, and an overall percentage average of 84.37%, categorized as highly valid. The material aspect received a percentage of 95.45%, while the presentation aspect received a percentage of 75%. The suggestions and input from the material expert validator are presented in Table 3.

Table 3 Suggestions and input from material expert validator

No.	Validator's Name	Validation Type	Comments and Suggestions	Follow-Up
1.	Siska Oktapianti, SPd,Si., M.Sc	Material Validation	Correct writing errors.	Writing errors have been corrected.
			Capitalization consistency is needed.	Capitalization of letters in writing has been made consistent.
			Clarify the given task instructions.	Task instructions have been clarified.
			Overall, the Student Worksheets seem coherent, but it is not clearly written which part is macroscopic, microscopic, and symbolic.	Added writing for macroscopic, microscopic, and symbolic aspects.
			It is illogical because students try to feel the sensation of an electric current on their tongue.	Corrected by deletion, as its purpose was only to add new information.
			It would be better if students were also taught to create visualizations of ions and molecules independently.	The Student Worksheets already include tasks to create visualizations of the breakdown of ions and molecules in the solution.
			It does not include the phase of matter in chemical reactions and its load in the breakdown of ionization reactions.	The phase of matter and its load in chemical reactions were added.
			Accuracy of writing, neatness of writing, and even incorrect symbolizations of charge in the writing.	Chemical formulas that are still less accurate have been improved.

Results of the Validity of Multiple Representation-Based The Student Worksheets from The Media Expert Validator

Media expert validation aims to assess the multiple representation-based student worksheets on electrolyte and non-electrolyte solution materials in terms of graphics, consistency, readability, and print quality. Based on the validity test results from the media expert, the entire developed multiple representation-based the student worksheets was validated by the media expert. The graphics aspect received a percentage of 93.18%, consistency received a percentage of 91.66%, readability quality received 100%, and print quality received 100%. Overall, the average score for all aspects was 3.8, and the average percentage was 95%, categorized as highly valid. The suggestions and input from the media expert validator are presented in Table 4.

Table 4 Suggestions and input from media expert validator

No.	Validator's Name	Validation Type	Comments and Suggestions	Follow-Up
1.	Trining Puji Astutik, S.Si., S.Pd., M.Pd.	Media Validator	The Student Worksheets (LKPD) are divided into two parts.	Student Worksheet 1 covers electrolyte and nonelectrolyte solution materials, while Student Worksheet 2 covers strong electrolyte and weak electrolyte solution materials.
			Improve the cover logo and add a symbolic level.	The cover has been improved according to suggestions and feedback.
			Syntax in the Student Worksheets includes a scientific approach that involves observing, questioning, collecting information, associating, and communicating.	Each Student Worksheet 1 and 2 includes a scientific approach.
			Add symbolic, macroscopic, and symbolic representations.	Symbolic, macroscopic, and symbolic representations have been added.
			Add points for the resulting species.	Points for the resulting species have been added before drawing ions and molecules in the microscopic stage.
			Work safety is emphasized, and additional emphasis is given to making chemical materials more interesting in daily life.	Work safety information has been moved to the beginning of the Student Worksheets.

Validity Results of Student Worksheets Based on Multiple Representations by Content Expert Validator

The results of the validity of the worksheet based on multiple representations by expert content validators are shown in Table 5.

Table 5 Validity results of the student worksheets by content expert with percentage interpretation criteria

No.	Aspect	Average	Percentage	Criteria
1.	Material Aspects	3.09	95.45%,	Very High
2.	Presentation Aspects	3.00	75.00%	High
	Average Score			**3.33**
	Average Percentage			**84.37%**
	Criteria			**Very High**

Based on the validity results from the content expert, although the multiple representation-based student worksheets are highly suitable, some aspects still do not meet 100%. Specifically, the symbols, signs, and images are not accurately written in the content aspect. For instance, the symbols for ions at the symbolic level lack their charges, and the chemical formulas for each solution used are not mentioned. Such inaccuracies in symbol and chemical notation may lead to misconceptions. Additionally, the concept and content are drawn from books with the latest publication year, which is considered less suitable, as some references in the student worksheets are more than ten years old. This includes using books by Ari Harnanto and Ruminten in 2009, M Justiana in 2007, Bakti Mulyani et al. in 2009, Irvan Permana in 2009, and Hasmiati et al. in 2009.

The presentation aspect of the multiple representation-based the student worksheets averaged a score of 75%, categorized as acceptable. Statements that did not meet the highly suitable category include: (1) The content of the student worksheets is presented sequentially and systematically (macroscopic-microscopic-symbolic). While it generally appears sequential, it is not clearly written which part is macroscopic, microscopic, or symbolic. (2) Supporting students' logical thinking, the student worksheets includes tips for making a simple and inexpensive battery, which is considered less logical as students are asked to feel the direct sensation of electric current using their tongues. (3) The student worksheets includes microscopic visualizations of reactions in the experiment. However, it is considered less suitable because, although it generally includes visualizations of ions and molecules from the solutions used, students would benefit from being taught to create their visualizations. (4) The student worksheets does not fully include symbols, reactions, and chemical formulas for electrolyte and nonelectrolyte solution materials because it does not include the phase of substances in chemical reactions and their loadings in the breakdown of ionization reactions. (5) The student worksheets encourages students to understand the concept of the material by linking the three chemical multiple representations. According to the content expert validator, the student worksheets still has shortcomings that need improvement, such as writing accuracy, neatness, and even incorrect symbol charge notation, which could potentially lead to misconceptions.

Validity Results of Student Worksheets Based on Multiple Representations by Media Expert Validator

The results of the validity of the student worksheets by media experts with percentage interpretation criteria are shown in Table 6.

Table 6 Validity results of the student worksheets by media expert with percentage interpretation criteria

No.	Aspect	Average	Percentage	Criteria
1.	Graphic Aspect	3.72	93.18%	Very High
2.	Consistency Aspect	3.67	91.66%	Very High
3.	Readability Quality	4.00	100.00%	Very High
4.	Printing Quality	4.00	100.00%	Very High
	Average Score			**3.8**
	Average Percentage			**95%**
	Criteria			**Very High**

Based on the validity results from the media expert, although the multiple representation-based the student worksheets is highly suitable, there are still aspects that do not meet 100%, namely, consistency and graphics. These include: (1) Illustrations on the initial cover of the the student worksheets do not fully provide an overview of the the student worksheets, as it only includes macroscopic and microscopic levels. The cover is revised by adding symbolic levels as chemical equations. (2) Molecule and ion drawings in the the student worksheets are not entirely by applicable rules. For example, the hydrogen ion illustration lacks full color, only showing half. According to the validator, particle-based depictions of molecules and ions in the the student worksheets are difficult for students to follow. Other notations for ions or molecule drawings are suggested. (3) Icon images displayed do not fully add appeal to the the student worksheets, so icons suitable for chemical content need to be added. (4) Student tasks are given for each sub-material included in the the student worksheets. However, this is considered insufficient because there are no tasks related to the material on the relationship between electrical conductivity and bond types. (5) Chemical reaction symbols and calculations are in the symbolic part. According to the media expert validator, the activities in the the student worksheets are still not sequential according to the scientific approach, so the activities are revised to include the scientific approach sequence. This scientific approach includes observing, asking questions, collecting information, associating, and communicating (Rosidah et al., 2021).

Learning processes from the 2013 curriculum to the current independent curriculum are implemented using a scientific approach for all levels. This approach centers on students, is logical and factual in teaching, and involves science process skills in constructing concepts. This aligns with the multiple representation-based the student worksheets that was developed. The scientific approach in this the student worksheets guides the learning process, which includes all three levels of representation: macroscopic, microscopic, and symbolic (Wang, 2020).

Noor's research on the development of worksheets based on multiple representations using a scientific approach obtained an average practicality score of 95.58% for teacher responses and 88.64% for student responses, meeting the criteria for being highly practical. Additionally, this the student worksheets proved effective as students achieved classical completeness at 79.68% (Wilis, 2013). Therefore, the product developed by the researchers, the student worksheets, based on multiple representations, incorporates a scientific approach, encompassing macroscopic, microscopic, and symbolic levels in the information-gathering activities.

CONCLUSION

Based on the research findings and discussions, it can be concluded that the development of student worksheets based on multiple representations of electrolyte and nonelectrolyte solutions received a valid category from content experts and media experts, with very high percentage criteria. The material expert's validity averaged 84.37%, and the media expert's validity averaged 95%, indicating that this the student worksheets is worthy of proceeding to the implementation stage for testing after receiving feedback and input from the validators.

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