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DEVELOPMENT OF ACID-BASE CHEMISTRY STUDENT ACTIVITY SHEET TO IMPROVE METACOGNITIVE SKILLS IN SENIOR HIGH SCHOOL

Almira Nindya Divamita and Utiya Azizah*
Chemistry Education Study Program, Faculty of Mathematics and Sciences, Universitas Negeri Surabaya, Indonesia
*Email: utiyaazizah@unesa.ac.id

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Abstract: This study aimed to determine the feasibility of STUDENT ACTIVITY SHEET SAS to improve students' metacognitive skills on the acid-base subject. The research used a 4-D development model. Data were collected through interviews, questionnaires, observation, and written tests. The research subjects were 36 students in class eleventh Science at the 5 Senior High School Madiun, East Java, Indonesia. The study used one pre-test and post-test control group design. Results showed that: 1) The average percentage of validity is 87%, which is categorized as very valid 2) The average percentage of practicality, which includes the results of student response questionnaires and student activity observations, is 94% and 100%, respectively, which both of them are categorized as very good; and 3) The n-gain of effectivity, which includes the results of the pre-test-post-test cognitive and metacognitive skills are 0.57 and 0.62, respectively. The inventory questionnaire resulted in a value of 94%, which is categorized as very good, and the observation of metacognitive skills resulted in 100% with very good criteria.

Keywords: *Metacognitive Skills, Experimental Worksheets, Acid-Base*

INTRODUCTION

The development of science and technology at this time is necessary for humans to get a better education because it is the main factor that will affect humans from time to time. Education is a method used so that a person gains an understanding of knowledge and how to behave [1].

According to the Indonesian Minister of Education and Culture, the 2003 National Education System at number 20 has two dimensions according to the curriculum, among others; 1) objectives, lesson/ subjects, and content; 2) the learning activities used [2]. One of the learning activities in high school is learning chemistry. Chemistry is a science in the form of facts, theories, concepts, scientific work, principles, and laws. Chemistry is part of science as it has the same characteristics as science [3].

One way to support learning activities is to provide student worksheets (SAS) to students. SAS is part of the learning tools used by teachers to teach students [4]. SAS is part of the printed teaching materials. SAS contains information on teachers' orders to students to carry out a learning activity in the form of assignments or exercises to achieve learning objectives [5]. SAS for hands-on activities contains only instructions for students on how to take and mix substances. Chemistry is a branch of science established based on scientific products that can be achieved through practical activities [6]. One of the chemistry lessons that require practicum is the acid-base subject. Basic Competency of the acid-base subject contains acid-base theories by determining the nature of the solution and acid-base titration so that students are required to do a practicum to identify the properties of acid-base and identify the type of titration and pH [7].

Aside from the theory being studied, in chemistry lessons, students also have to understand practicum related to the subject [8]. The practicum activities offer opportunities for students to experiment with the subjects practically, from following a process, observing an object, analyzing data, and drawing conclusions about a situation or process of something [9]. The practicum can be used as an activity to train students' scientific thinking skills and disciplined attitudes so that students are motivated in the study of chemistry [10]. The practicum can combine knowledge and metacognition to control how students learn. Based on interviews with chemistry teachers at the 5 Senior High School of Madiun, students sometimes find it difficult to understand concepts and calculations on the acid-base subject. Even when they can understand and try it consistently, students will find it challenging to develop their metacognitive knowledge and learning skills.

Higher mental processes are involved in learning, such as creating curricula, using appropriate skills and strategies to solve problems, predicting outcomes, and adjusting the scope of learning [11]. Put simply, Flavel defines it as thinking about thinking [12].

In its implementation, metacognition is not as simple as its definition because it refers to a high-level mental process, such as making plans, using appropriate strategies to solve a problem, and making alternative assessments [13].

The relationship between metacognitive knowledge and problem-solving skills is the same as that correlates Metacognitive Awareness Inventory (MAI) test scores as metacognitive knowledge data

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with the results of the post-test of problem-solving skills in the experimental class [14]. A positive correlation indicates a positive relationship because if metacognitive knowledge is high, problem-solving skills will be high [15]. Metacognitive skills can help students solve problems through effectivity design that involves knowing the problem, understanding the problem that needs to be solved, and understanding effective strategies for solving it [16]. In the learning process, it is to develop metacognitive skills for students so that the learning atmosphere becomes more meaningful, and improving cognitive performance in the future is the point why learning metacognitive skills needs to be empowered [17].

Therefore, this research focuses on discovering the development of the acid-base SAS to enhance metacognitive abilities.

RESEARCH METHOD

The present research used R&D with a 4-D development model. The research procedure consisted of four main phases, among others: (1) define, (2) design, (3) development, and (4) disseminate [18]. However, the current research was only conducted up to the development phase due to the researcher's limitations.

Definition Phase

This phase serves to determine and define needs in the learning process. In this phase, these five types of activities were carried out, i.e.: (1) front-end analysis to raise and determine the basic problems faced by students in learning chemistry; (2) analysis of the characteristics of students to obtain an overview of the characteristics of the students; (3) tasks analysis in the form of an analysis of standards of competence and basic skills on the acid-base subject based on the implementation of students' practices; (4) conceptual analysis on the topic, standards of competence, basic skills and performance indicators of subjects used as a practice; and (5) objectives formulation to determine learning performance indicators following the conceptual analysis in the development of practical instructions.

Design Phase

This phase aims to produce a prototype that will be produced in the form of experimental worksheets to improve students' metacognition. In this phase, these three types of activities were carried out: (1) collect references on concepts; (2) select a good and correct chemistry practice guideline criteria format; and (3) make an initial design of chemistry practice procedures that are following indicators of achievement of learning outcomes.

Development Phase

This phase aims to produce learning tools and tools after passing the reviews based on the input of validating experts or professionals. After obtaining the validation, a field test was carried out with the subjects of class XI students at the 5 Senior High School Madiun.

Based on this research, the practicality of research conducted on acid-base practices to improve student metacognition could be gained. The goal of this research was the feasibility of a practical acid-base procedure to enhance students' metacognitive in terms of validity and practicality. The subjects of this restricted test were 36 students of the 5 Senior High School Madiun in the even semester of the 2021/2022 academic year.

This research project was practical tests on the acid-base subject. This research was pre-experimental research with a group pre-test-post-test project. A pre-test-post-test group was used to measure the student's metacognitive level after completing the practices. The research project was conducted, so the students were first given a preliminary test, then a hands-on procedure. Next, the students were given a subsequent test after receiving the treatment. The results can be known by comparing before and after treatment. The design can be seen in Table 1.

Table 1. The research design used in this study

O_1	X	O_2

Description:
O_1 = pre-test (the test carried out before practicum procedures are given)
X = treatment (explanation of practicum procedures and execution of the practicum)
O_2 = final test (the test performed after the practicum)
Analysis = calculation of significance (O_2 - O_1)

We identified the initial conditions in a group of samples by performing a pre-test (initial test). Subsequently, we did the internship according to the procedure at the end of the post-test (final test). The pre-test results were afterward compared with the post-test and then analyzed and concluded.

The data, data collection methods, and tools used to support SAS development are shown in Table 2.

The SAS validation provides experts on each component of assessing the feasibility of SAS content. The assessment components were assessed by validators who are experts in their fields. The results obtained were then analyzed by calculating the overall value using the following formula:

$$P = \frac{n}{N} \times 100\%$$

Whereas:
P: the percentage of eligibility
n: the total score of the average aspects of the assessment
N: maximum total score evaluation

The criteria for evaluating the score average and percentages are depicted in Table 3.

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Table 2. Data, data collection methods, and tools used to support SAS development

Data	Collection method	Tool
Validity of SAS	Validation of SAS by experts	Validator
Practicality of SAS	Student answer questionnaires and observation sheets of student activity	Answer questionnaire card and student activity observation sheet
Effectivity of SAS	Cognitive and metacognitive tests	Cognitive and metacognitive pre-test-post-test

Table 3. Interpretation of criteria based on different scores

Percentage (%)	Criteria
0-20	Much less
21-40	Less
41-60	Enough
61-80	Suitable
81-100	Very feasible

Developed SAS can be said to be feasible if it meets the eligibility criteria with a percentage of 61% [19].

In determining student response, questionnaire scores and student activity observation questionnaire scores, as well as their classifications and categorizations, were made using the Guttman scale (Table 4).

Table 4. The Guttman scale

No	Statement	Description	Score
1	Positive	Agree	1
		Disagree	0
2	Negative	Agree	1
		Disagree	0

The score results were then converted as a percentage with the following formula:

$P = \frac{F}{N} \times 100\%$

Whereas:
P = the percentage of responses
F = the number of "Yes" responses for positive statements or the number of "No" responses for negative statements
N = the number of respondents
The percentage of responses was then interpreted into different criteria (Table 5).

Table 5. Interpretation criteria

Percentage score (%)	Criteria
0-20	Not very practical
21-40	Practical
41-60	Quite practical
61-80	Practical
81-100	Practice once

[19]

Then, a written test was conducted to students using pre-test and post-test sheets. In this study, two types of tests were used, i.e., cognitive tests with seven questions and metacognitive tests with 15 questions. The students' pre-test and post-test sheets were analyzed using the following formula:

$$\text{Score} = \frac{\text{score earned}}{\text{max score}} \text{ x } 100$$

Next, the data that were tested were analyzed using the n-gain test as follows:

$$\text{n-gain} = \frac{\text{post} - \text{test}}{\text{value} - \text{maximum value pre}} \text{x} 100$$

Metacognitive skills are believed to be a robust predictor of learning success [20]. Students with good metacognitive skills tend to show better academic performance than those with poor metacognitive skills [21]. There is a positive relationship between achievement and metacognitive learning. In this study, the results of the n-gain calculation were interpreted to determine students' metacognitive abilities (Table 6).

Table 6. The n-gain scale

N-gain scale	Interpretation
g-0.7	High
0.3g <0.7	Medium
g <0.3	Low

A test for normality (Shapiro-Wilk one sample test) was performed using SPSS, and if normal, a paired t-test was carried out to determine if there was a mean difference between the pre-test and post-test of the two types tested. It can be seen that the sig. value (2-tailed) obtained is less than 0.05.

Metacognitive inventory questionnaires were also distributed to students to determine student responses after receiving acid-base practicum learning.

RESULTS AND DISCUSSION

Student worksheets are declared admissible if they meet the facets of validity, practicality, and effectivity.

Validation

Data were obtained from product validation and tool validation results in the descriptive form following the product development procedures, which include the definition, design, and development phases. Validation data were collected and then reviewed for use as a reference for product improvement. The results of the validation of two experts and one chemistry teacher are presented in Table 7.

Table 7. Data analysis of the validation results

Evaluated aspects	Average percentage	Criteria
Content	87%	Very feasible
Language	89%	Very feasible
Presentation	88%	Very feasible
Graphics	86%	Very feasible

The average percentage of SAS validation was 87%, which is categorized as very feasible.

Practicality (Answer Questionnaire)

Student Answer Questionnaire Sheets were used to determine the convenience of using hands-on procedures as a practice to enhance students 'metacognition and determine students' interest in doing acid-base practice. Based on the questionnaire results to evaluate the aspects of contents, linguistics, practicality, and graphics, an average percentage of 98%, 91%, 94%, and 94%, respectively, with a very good category for all the results. The total average percentage of SAS practicality questionnaire sheets is 94%, with a very good category. These results indicate that SAS can be applied to support learning in the acid-base subject in chemistry lessons in senior high school.

Practicality (Observation)

Student activity observation sheets were used to determine the practicality of practical procedures in the acid-base subject and to measure students' metacognitive levels in the acid-base subject by three students from Surabaya State University. Based on the observations, the practicality of the SAS achieved an average score of 100%, which is categorized as very good.

SAS Effectivity

Learning implementation activities include hands-on activities. The first meeting explored the practical nature of acid-base solutions. Students were presented with a phenomenon related to the nature of acid-base solutions in planning in this SAS. It is followed by identifying the phenomena, determining the formulations of the problems, hypotheses, tools and materials, variables, and practical procedures, as well as activity monitoring. Students analyzed the experiment's results and answered the questions in the SAS from the practicum performed. Evaluation of the students was done by evaluating the results of their experiment by concluding the experiments were performed correctly. The second meeting of this learning began with planning, where students were introduced to a phenomenon related to acid-base titration. Monitoring and evaluation activities, including acid-base titration practice, were carried out later.

The effectiveness of SAS was measured by scores obtained from pre-test-post-test, cognitive pre-test-post-test, metacognitive inventory, and observation of metacognitive skills. Pre-test sheets were used to determine the effectiveness of this study. The pre-test was used to measure students' understanding of the acid-base subject before they received practical procedures on the subject. The tests were formulated in the form of multiple-choice questions based on learning objectives and learning indicators to be achieved and provided at the beginning of the meeting.

The second tool to measure the effectiveness of SAS was the cognitive post-test sheets. Post-tests were used to measure students' understanding and learning independence after doing practical work on the acid-base subject. Post-tests were formulated in the form of multiple-choice questions and were based on learning objectives and indicators to be achieved. The post-test was conducted at the end of the meeting. The results of the post-test cognitive were compared with the pre-test results to determine how much the increase in student understanding of learning. Based on the results of the normality test, it can be concluded that the pre-test and post-test scores are normally distributed. The next test conducted was the t-test and the sig. value (2-Tailed) is less than 0.05, so it can be concluded that there is a difference between the pre-test and post-test results [23]. Further, the n-gain test was performed to know the increase in student learning outcomes after using the developed SAS.

Table 8. Student cognitive effectivity test

Test	Result		Description
n-gain test	0.57		Effectivity of the pre-post cognitive test categorized as medium
Shapiro Wilk's test	Pre-test	0.120 > 0.05	The data or scores of the cognitive pre-test and post-test are normally distributed.
	Post-test	0.149 > 0.05	
Paired sample test	0.000 < 0.05		There is a difference between pre-test and post-test cognitive values.

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Metacognitive skills can be defined as the ability to independently control and understand the learning process to achieve the desired results [7]. In the present study, students' metacognitive skills were assessed from the pre-test and post-test metacognitive inventory questionnaires and the metacognitive observation questionnaires. The pre-and post-questionnaires were in the form of descriptive questions containing the material and skills being trained.

Table 8. Test the effectiveness of student's metacognitive skills

Test	Result		Description
n-gain test	0.62		Effectivity of the pre-post cognitive test categorized as medium
Shapiro Wilk's test	Pre-test	0.124 > 0.05	The data or scores of the cognitive pre-test and post-test are normally distributed.
	Post-test	0.142 > 0.05	
Paired sample test	0.000 < 0.05		There is a difference between pre-test and post-test cognitive values.

The effectivity of the SAS can also be seen from the results of the metacognitive inventory questionnaire and metacognitive observations, which are 94% and 100%, respectively, with a very good category for both percentages. Overall, our study shows that SAS can improve students' metacognitive skills appropriately.

CONCLUSIONS

The validity of the SAS experiment on the acid-base subject to improve students' metacognition reached an average of 87%, so it is very doable. SAS can be said as practical, which can be seen from the student response questionnaire when using the SAS with an average percentage of 94% with very practical criteria and in terms of the results of observing student activities with an average percentage of 100% with very good criteria. The development of SAS effectivity improves metacognitive skills based on good student responses. It can be seen from the increasing trend and positive value of students' cognitive and metacognitive pre-test and post-test learning outcomes on the acid-base subject.

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