Journal of Natural Science and Integration
P-ISSN: 2620-4967|E-ISSN: 2620-5092
Vol. 7, No. 1, April 2024, pp 39-55

Available online at:
http://ejournal.uin-suska.ac.id/index.php/JNSI
DOI: 10.24014/jnsi.v7i1.24402

Development of Socio-Scientific Issues-Based Worksheets to Increase Learning Interest and Critical Thinking Skills of Students on Buffer Solution Material

Sirmayeni [1], Radjawali Usman Rery [*1], Lenny Anwar [1]

[1] Department of Chemistry Education, Universitas Riau, Indonesia

**Correspondence Author: r.usman@lecturer.unri.ac.id*

ABSTRACT

This study is intended to develop a worksheet based on socio-scientific issues for buffer solution material that is valid and reliable in order to determine the increase in students' learning interest and critical thinking skills. The Research and Development (R&D) method with the ADDIE model was employed, encompassing five phases: analysis, design, development, implementation, and evaluation. Data collection techniques included interviews, student questionnaires, validation sheets, and user response questionnaires. Two methods were used in small-scale trials: one-on-one tests and user response assessments. The one-on-one test involved three students with high, medium, and low abilities. The user response assessment involved three teachers and 30 students from SMAN 4 Pekanbaru, SMAN 8 Pekanbaru, and SMAN 15 Pekanbaru. The difference in the effect of using the worksheet on improving critical thinking skills and learning interest was analyzed using the t-test. To determine whether there was an increase in critical thinking skills, as indicated by improved student grades, the N-Gain formula was applied. The results showed that the developed worksheet obtained average percentages of 92% from material experts and 98% from media experts, indicating valid criteria. The one-on-one test provided students' comments on necessary improvements to the worksheet components. User responses from teachers and students resulted in 93.1% and 93.7% respectively, indicating that good criteria were achieved. The paired t-test on learning interest data showed a significance value of 0.000 (sig < 0.05), indicating a significant difference in students' learning interest before and after using the worksheet. Similarly, the critical thinking skills data showed a significance value of 0.000 (sig < 0.05), indicating a significant difference in students' critical thinking skills before and after using the worksheet. Based on the posttest results of the experimental and control classes, it was found that the student worksheets improved students' critical thinking skills to a medium level, with an N-Gain value of 53.93. In contrast, the control class showed a low improvement, with an N-Gain value of 30.00.

Keywords: *worksheet, Socio-Scientific Issues, interest in learning, critical thinking skills, buffer solution.*

INTRODUCTION

As well known, the government implements the 2013 curriculum in an effort to meet the demands of the 21st century (Haryadi, Djatmika, & Setyosari, 2017). In addition, according to Zakaria (2021), 21st century skills consist of creative thinking skills, critical thinking and problem solving, communication and collaboration, or what is known as the 4C, which must be owned by students in Indonesia as a feature of 21st century learning. Critical thinking skills are skills in analyzing and evaluating existing information to determine reliable information so that it can be used to draw valid conclusions (Fithriyah, Sa'dijah, & Sisworo, 2016). According to Simbolon et al., (2017), critical thinking is the process to find, analyze, synthesize, and conceptualize information in order to develop one's thinking as well as to increase creativity, and take risks.

However, low critical thinking skills are caused by students' tendency to memorize more material and formulas than understand concepts (Sianturi & Aprianingsih, 2021). Meanwhile, according to (Haryanti, 2017), critical thinking is the ability to produce answers that are not just memorization but more about mastery and understanding of concepts. Furthermore, this statement was also described by Winataputra et al., (2010) that students not only learn by rote but can play a strong role in the learning process so that they are able to construct knowledge according to their own ideas. Critical thinking is an ability that students really need to solve a problem (Damayanti, Yunarti, & Widyastuti, 2015). This is reinforced by Razak (2017) that the training process and learning outcomes are strongly influenced by students' critical thinking during the learning process.

In line with this condition, chemistry lessons in high school contain many concepts that are quite difficult for students to understand because they involve chemical reactions, calculations, and many abstract concepts. This condition is one of the causes of students' difficulty in learning chemistry, students often memorize chemical materials such as concepts and calculation formulas but do not understand them (Maria Merianti L, Hairida, & Rasmawan, 2016). Based on the results of interviews conducted with several chemistry teachers from three schools, namely SMAN 4 Pekanbaru, SMAN 8 Pekanbaru, and SMAN 15 Pekanbaru, it was found that the buffer solution material is one of the materials that is difficult for most students to understand. This can be seen from the results of students' daily tests on the material on buffer solutions which are still below the KKM, to be precise, around 40% of students obtained scores below the KKM. The KKM of chemistry teachers in class XI is 85. The low chemistry learning results indicate that the participants' critical thinking skills are also low. This is in line with the opinion put forward (Darwis, Ali, & Helmi, 2020) to determine the level of students' critical thinking skills, which can be seen from the results of the assessment carried out by the teacher. The low learning outcomes of students also show that students are still having difficulty learning chemistry, especially in the buffer solution material. Factors that can cause students to have difficulty learning the buffer solution material are the many formulas contained in the buffer solution material and the similarity between the buffer solution material and hydrolysis, so that students have difficulty distinguishing between them.

Besides that, another factor that causes students to have difficulty learning the buffer solution material is their lack of interest and motivation in learning. Even though students' interest in learning chemistry will determine the responses that will be given by these students to matters related to learning chemistry, Students who have a high interest in studying chemistry tend to have a positive response to learning chemistry. They will tend to have the initiative and willingness to study chemistry more deeply and achieve good achievements in chemistry learning. Interest in learning can also affect students' critical thinking skills (Augustha, Susilawati, & Haryati, 2021). Winataputra et al., (2010) revealed that students who only learn by memorizing cannot play an active role in the learning process, thereby hampering the development of their critical thinking. Factors that cause students difficulty in studying buffer solution material include the large number of formulas that must be memorized and the similarity of the material to hydrolysis, which makes it difficult for students to differentiate between the two. Apart from that, lack of interest and motivation in studying chemistry is also another contributing factor. According to Haryati et al., (2019), interest in learning can influence students' critical thinking abilities. Winataputra et al., (2010) emphasized that students who only memorize cannot play an active role in the learning process, which hinders the development of critical thinking.

This is reinforced by the results of interviews with a number of teachers who stated that the level of students' critical thinking skills in the material of buffer solutions is still low, this is because the learning process applied by teachers does not train students' critical thinking skills. In the learning process, teachers explain more material by occasionally asking students. When teachers ask questions to students, most students are enthusiastic about answering the teacher's

questions but cannot provide valid reasons for their answers. Students have difficulty giving reasons because they cannot relate one concept to another, even though it is found in the notes and worksheets they have. The role of students in the learning process is still lacking, namely, only a few students show activeness in expressing opinions and asking questions. This shows that there are still many students who tend to only focus on the teacher without analysing, criticizing, evaluating, or rethinking what the teacher conveys. The methods used by the teacher to teach chemistry subjects are lecture methods, discussions, and practicum. In learning, the teacher already uses teaching materials in the form of worksheet. The teacher has made his own worksheet, which is used in learning. The worksheet uses a lot of material in written form and lacks attractive images and examples that have not been adapted to social issues in the student's environment when explaining material. Zeidler & Nichols (2009) further explain that socio-scientific issues (SSI) represent an open approach to teaching science that places scientific knowledge within social issues, thereby requiring students to engage in dialogue, discussion, and debate. SSI incorporates elements that demand moral reasoning standards to arrive at decisions regarding possible solutions to the presented problems. According to Hancock et al., (2019), chosen socio-scientific issues should be current, controversial, relevant to students, related to scientific content, and suitable for open discussion among students.

In addition, the material used does not relate to the lives of students, so students are less interested in worksheet. Even though worksheet is a guide for students to do something that produces critical thinking skills (Putriana, Suryawati, & Suzanti, 2020), The development of worksheet teaching materials is very much needed in the world to facilitate the achievement of the expected learning objectives. One of the advantages of developing worksheet is that it can be designed according to the circumstances of the students and the characteristics of the school. Chen et al., (2011) stated that student achievement at a school in Taiwan increased when taught using teaching material that was developed according to student needs. The development of scientific-based worksheets on buffer solution material can support activity and have a positive effect on student learning outcomes (Rahayu, Sutikno, & Indriyanti, 2023). According to Putriana et al., (2020), the development of worksheet based on socio-scientific issues (SSI) is valid and practical for use in science learning. worksheet, which is integrated with SSI, can increase student motivation and stimulate students' critical thinking Handayani & Hastuti (2018). According to Ashari et al., (2023), an integrated worksheet on socio-scientific issues is important to develop.

Based on the description above, the development of worksheet based on a socio-scientific issue approach was carried out to increase students' interest in learning and critical thinking skills in buffer solution material. This research shows the urgency of developing effective student worksheets to overcome students' low critical thinking abilities and their difficulties in studying complex chemical material.

METHODOLOGY

The method used is the Research and Development (R&D) method with the ADDIE model, which consists of 5 phases: the analysis phase, the design phase, the development phase, the implementation phase, and the evaluation phase. Data collection techniques included interviews, student questionnaires, validation sheets, and teacher and student response questionnaires. Validation was assessed by four experts, namely three material experts and one media expert. Two methods were used in small-scale trials: one-on-one tests and user responses. The one-on-one test involved three students with high, medium, and low abilities. User response assessment involved three teachers and 30 students at SMAN 4 Pekanbaru, SMAN 8 Pekanbaru, and SMAN 15 Pekanbaru in the teacher response questionnaire technique as a tool to get teacher responses to the use of worksheet in the chemistry learning process. Teacher response questionnaires were given directly to chemistry teachers in class XI at SMAN 4 Pekanbaru,

SMAN 8 Pekanbaru, and SMAN 15 Pekanbaru in March 2023. Student response questionnaires were given directly to 30 students at SMAN 4 Pekanbaru, SMAN 8 Pekanbaru, and SMAN 15 Pekanbaru in March 2023.The data from the user's response and the evaluation of the validation sheet are put on a scale. The type of scale used is a Likert scale with a score of 1-4. This scale enables the validator to more easily assess the validity of the developed worksheet based on socio-scientific issues (SSI). Validation aspects assessed by experts or practitioners are made in the form of a rating scale. The type of scale used is a Likert scale with a score of 1-4. This scale provides flexibility for validators in assessing the developed learning device in the form of worksheet. The validation of media experts and material experts on the developed worksheet is determined by the average score given by the validators. The rating categories include: 4 (Very Suitable), 3 (Suitable), 2 (Less Suitable), and 1 (Not Suitable) (Sugiyono, 2016).

The data from the media validation results by the expert validator is calculated using the average score formula, which provides the percentage of the validation score. This percentage is used to determine the eligibility of the learning media. The criteria for decision-making for media validation can be seen in the eligibility criteria for percentage analysis. The learning media is used if the average validator assessment is categorized as good or valid. The eligibility criteria categories are as follows: a percentage of 80.00-100 is considered Good / Eligible / Valid, 60.00-79.99 is Fairly Good / Fairly Eligible / Fairly Valid, 50.00-59.99 is Poor / Less Eligible / Less Valid, and 0.00-49.99 is Not Good / Not Valid (Replaced) (Riduwan, 2016).

From the Likert scale rating category, the average percentage of each component will be calculated using equation (1). (Sugiyono, 2017) The average score results from the validation questionnaire and user responses that have been obtained are then converted into qualitative data to determine the criteria for using multiple representation-based e-modules with augmented reality, which can be seen in Table 1.

Table 1. Questionnaire Criteria Interval

Percentage (%)	Criteria
81-100	Very good/ very feasible/ very valid/ does not need revision.
61-80	Good/ eligible/ valid/ no need for revision
41-60	Good Enough/ Inadequate/ Invalid/ Revision Required
21-40	Not good/insufficient/invalid/requires revision
< 20	Extremely Unfavorable/ Extremely Inappropriate/ Extremely Invalid Needs Revision

(Arikunto, 2010)

The data obtained from the pretest and posttest were examined to find out the normality by using the Kolmogorov-Smirnov test with the help of IBM SPSS 22.0 software. The normality test was carried out to find out whether the data distribution follows the standard normal distribution law or not (Rusydi, 2018). Moreover, the testing hypothesis of this study is conducted by employing the t test method, namely the paired sample T test using IBM SPSS version 22 software. To find out whether there was an increase in critical thinking skills seen from the increase in students' ability to analyze and be able to answer questions around related to the buffer solution material (in this case means the results of increasing critical thinking skills) obtained during the pretest and posttest.

The analysis of the difference test of the effect of giving worksheet on improving critical thinking skills and students' learning interests was analyzed using the t-test. To find out whether there was an increase in critical thinking skills seen from the increase in students, it was analyzed using the N-Gain formula. Then analyzed using the N-Gain formula.

$$N - Gain = \frac{skor\ post - skor\ pre}{skor\ post\ max - skor\ pre}$$

The N-Gain score classification can be based on the N-Gain value or formed from the N-gain in the form of a presentation (%). The following table shows the distribution of N-gain value categories:

Table 2. N-Gain Interpretation

N-Gain	Upgrade Classification
g > 0,70	High
0,30 < g ≤ 0,70	Medium
g ≤ 0,30	Low

(Yolanda, 2021).

RESULT AND DISCUSSION

a. Analysis

Needs analysis at this stage was carried out by observing and interviewing three chemistry teachers who taught at schools that had implemented the 2013 curriculum, namely SMAN 4 Pekanbaru, SMAN 8 Pekanbaru, and SMAN 15 Pekanbaru. The results of the interviews show that chemistry is considered as a difficult and less interesting lesson. This may be because chemistry deals with complex materials and requires greater intellectual intelligence and effort to understand it (Susilaningsih, Drastisianti, Lastri, Kusumo, & Alighiri, 2019). According to Akram et al., (2017), students' lack of interest in chemistry can be caused by several factors, including the methods used by the teacher in the learning process that are not in accordance with the methods students prefer. This problem is a challenge that must be faced by teachers in presenting chemistry lessons to students, so the selection of teaching materials, methods, and learning models is an important thing that must be considered.Based on the results of the questionnaire, important points can be drawn from the three aspects asked of students. The important points are that students tend to judge chemistry as an unpleasant lesson (62%). In addition, students are more interested, happy, and interested in learning with worksheet (58%), and worksheet, which contains a summary of material that presents environmental issues, will make students more interested in learning chemistry (75%).

To be concluded, curriculum analysis is required to review the curriculum used by schools so that the preparation and development of worksheet based on the socio-scientific issues approach are in accordance with the curriculum used. Analysis of the buffer solution material curriculum based on the basic competence of the buffer solution material.

b. Design

At the planning stage, there are aspects of media design that will be developed. The design of worksheet is based on the socio-scientific issues approach as a form of solving the problems found in the preliminary analysis and research phase.The instrument used to assess the quality of teaching materials is a questionnaire that contains an assessment of teaching materials in the form of worksheets based on this socio-scientific approach. In this stage, the researcher made a product assessment questionnaire grid. The product assessment instrument of this study was in the form of a checklist questionnaire for material experts, media experts, and learning practitioners, namely chemistry teachers, and a questionnaire for students. The product assessment instrument was consulted and validated by a chemistry education lecturer at the University of Riau. The results of the assessment of the material from the learning media were validated by three material experts as "Easy to Use Without Revision".

The contents of the worksheet are taken from sources such as high school/MA chemistry books, college chemistry books, and the internet, that are relevant to the material on buffer solutions. The learning activities arranged in worksheet refer to aspects of the socio-scientific issues approach, namely: (1) Presentation of socio-science issues: observing and understanding

the socio-science issues presented, then formulating problems related to these issues. (2) Analysis of socio-science issues: conducting a simple investigation to collect data, evidence, or information and then analysing the data or information in order to answer the formulated problem. (3) Clarifying issues and making decisions: the results of the analysis are used as a basis for clarifying the truth of the issues presented and making decisions. (4) Discussion and evaluation: present findings, provide arguments and responses, and debate. (5) Reflection: Take a moral message related to the issues presented.

The design of the e-module cover page is created using the Photoshop program, utilizing the polygon tool menu, clipping mask, blending, and type tools. The cover page consists of several elements: the title of the worksheet, the name of the subject, class, and semester, the logos of Tut Wuri Handayani, the University of Riau, and K-13, pictures depicting e-module titles or subjects, and the identity of the author. For the worksheet content display design, Canva's shape menu, shape fill, text box, and background tools are used. The content is organized into three main sections: introduction, core, and closing. The introductory section includes a preface, drafting team, table of contents, instructions for using the worksheet, instructions for working on the worksheet, core competencies, basic competence, and a concept map. The core part consists of four learning activities corresponding to the material to be provided in the learning process. Each learning activity in e-modules 1-4 follows this order: competency achievement indicators, learning objectives, material description, summary, independent assignment, problem practice, and feedback. The closing section contains the bibliography, serving as a reference for the material in the worksheet.

c. Development

The development phase of the e-module involves two key processes: prototyping and material validation. Prototyping is the initial step where the design, as outlined in the storyboard, is brought to life as a prototype worksheet. This prototype is developed using Canva to ensure that the presentation of learning material is engaging and effective. The aim is to create a visually appealing and functional worksheet based on the socio-scientific issues approach.

Validation is the subsequent stage, which includes both material and media validation. This phase involves four expert lecturers who evaluate the worksheet based on its material content, learning design, visual communication, and usability. The validation process utilizes specific validation sheets and rubrics to assess these aspects. Three material experts and one media expert are involved in this process, providing suggestions, comments, and feedback. Their evaluations serve as a foundation for analyzing and revising the developed media and will guide the product trials conducted with students.

a) Material Validation

Assessment by three material validators uses a validation sheet in the form of a 1-4 Likert scale. Material expert validation assessment is based on content, pedagogic, language, and graphic aspects. The results of the average percentage of each aspect of the material validation assessment can be seen in Table 3.

Table 3. Percentage of Material Expert Validation Results

No.	Rated aspect	Percentage (%)	
		Validation I	**Validation II**
1	Content Eligibility	72,2	86
2.	Pedagogic	84	98
3.	Language Assessment	63	94
4.	Graphics	71	93
	Average	**77**	**92**

The material validation stage was carried out twice. In the first validation, the average percentage of the 4 aspects was 77% with a valid category. Even though valid results were

obtained, in the first validation, suggestions were also obtained from each material validator for worksheet improvement, so the researchers carried out a second revision and validation in order to obtain even better worksheet based on the socio-scientific issues approach. After the revision was carried out based on suggestions from the validator, in the second validation, the percentage rose to 92% with a very valid category.

Table 4. Results of Material Expert Validation Revision

No	Form	Physical Results		Description
		Initial	Final	
1	Adjust learning objectives that are less precise so as not to cause misunderstanding			Replacing images that are not quite right that can cause misunderstandings.
2	Adjust the material to the IPK (indicator of achievement of competence).			Adjust the material with the IPK
3	Writing consistency			Consistent in writing material

b) Media Validation

Media validation involves one validator, who is an expert lecturer in the media field. Media validation uses a validation sheet in the form of a Likert scale of 1–4. The purpose of this media validation is to assess worksheet based on a socio-scientific issues approach based on three aspects: worksheet size, cover design, and worksheet content. The results of the average percentage of each aspect of the media validation assessment can be seen in Table 5.

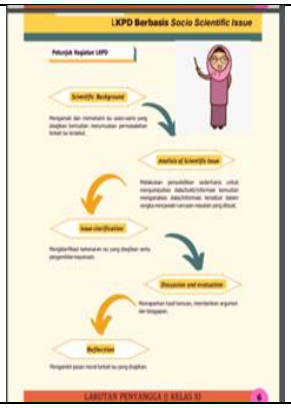
Table 5. Results of Media Expert Validation

No.	Rated aspect	Percentage (%)	
		Validation I	Validation II
1	worksheet size	100	100
2.	worksheet cover design	75	100

No.	Rated aspect	Percentage (%)	
		Validation I	Validation II
3.	worksheet content design	86	96
Average		**87**	**98**

The media validation stage was carried out twice. In the first validation, the average percentage of the three aspects was 78.4% with a valid category. Even though valid results were obtained in the first validation, suggestions were also obtained from each media validator for improvement of the e-module, so the researchers carried out a second revision and validation in order to obtain multiple representation-based e-modules with the help of augmented reality material on molecular shapes and interactions. better intermolecular After the revision was carried out according to the validator's suggestion, in the second validation, the percentage increased to 92.2% with a very valid category.

Table 3. Media Expert Validation Revision Results

No	Form	Physical Results		Description
		Initial	Final	
1	On the cover of the worksheet, increase the font size, add a logo and composition team, and replace the image.			Increase the font size, create a logo, compose the team, and replace images.
2	The layout of the activity instructions is tidy and generalized.			Tidy up the layout of activity instructions and generalize.

d. Implementation

This step is to implement learning media in the learning process at school. By conducting one-on-one trials, small-scale trials, and large-scale trials involving students, we can find out students' responses to worksheet.

1) Test each one one by one

The one-on-one test on worksheet based on the socio-scientific issues approach involved three class XII students at SMAN 4 Pekanbaru who had studied the buffer solution material in class XI by testing one person first, finishing, then continuing with the next person, and so on. All three are students who have different levels of academic ability, namely high, medium, and low.During the test, one by one, students were given worksheets based on the socio-scientific issues approach. Furthermore, students will be guided by researchers in using worksheet directly. Students take part in learning activities and work on the questions contained in the worksheet.

Then the students were interviewed to obtain their comments and suggestions for worksheet. The comments and suggestions given by students can be seen in Table 7.

Table 7. Student Comments and Suggestions on the One-on-One Test

Student Code	Comments and Suggestions
ZHI	Comment: 1. The worksheet used is very interesting, and the color combination is just right, so it keeps me from getting bored quickly while studying. 2. The writing is easy to read and clear.
ZHI	Suggestion: Picture quality was clarified.
SA	Comment: 1. The provided worksheet is interesting and unique, and it can serve as adequate teaching material for online learning. 2. The tasks given are not too many so they are efficient in terms of processing time.
	Suggestion: There are some typos that need to be fixed.
PR	Comment: The given worksheet has a good appearance and is easier to use.
	Suggestion: There are some typo words that need to be fixed.
Conclusion	Comment: worksheet is developed attractively and easy to use. Suggestion: Improve image quality and fix typo words.

Based on Table 7, it is known that students gave positive comments on the worksheet given. They argued that the developed worksheet based on the socio-scientific issues approach could make students more interested, increase their interest in learning, and not get bored easily after learning. This is because worksheet has an attractive appearance, is unique, and is easy to use. The same thing was conveyed by (Adawiyah, Hakim, & Hadisaputra, 2020), namely that interesting teaching materials can make students more interested and motivated to participate in learning. Based on interviews with students in the one-on-one test, the clarity of learning in worksheet is considered good; it's just that there is a vocabulary that is not standard, so it must be improved. In terms of impact on users, students consider that worksheet has a positive impact on them because it can help them better understand the material presented in various multimedia content, and the worksheet provided is also easy to use and in accordance with their mindset.

2) Small-scale trials

At this stage, the researcher acts as an observer and does not interact with users. Responses to the small group trial were obtained from three chemistry teachers and 30 students by providing a small trial response questionnaire. Small-scale trial response data collection was carried out at SMAN 4 Pekanbaru, SMAN 8 Pekanbaru, and SMAN 15 Pekanbaru.

a) Teacher response questionnaire data

User responses with chemistry teacher response questionnaire data at 3 schools, namely SMAN 4 Pekanbaru, SMAN 8 Pekanbaru, and SMAN 15 Pekanbaru User responses involving the teacher's assessment are carried out by first providing worksheet, then giving the teacher time to look at the worksheet carefully before giving an assessment using a response questionnaire. The results of the teacher's response questionnaire are presented in Table 8.

Table 8. Teacher Response Questionnaire Data

Respondent	Percentage (%)	Criteria
Teacher 1	93,1	Very good
Teacher 2	91,7	Very good

Teacher 3	94,4	Very good
Average	93,1	Very good

With a 93.1% achievement rate, the teacher's response to the worksheet is considered to be very good. Table 9 shows that the worksheet is thought to be very easy to use and that the way information and learning activities are presented is organized and in line with the indicators and learning goals. Teachers also give their full support to the creation of this worksheet because they see it as an alternative way to teach that can get students' attention.

b) Student response questionnaire data

The stages of obtaining user responses from the results of student response questionnaires involved 30 students in class XII IPA from three different schools, namely SMAN 4 Pekanbaru, SMAN 8 Pekanbaru, and SMAN 15 Pekanbaru. Response questionnaire data collection involving students was carried out by giving worksheet to students, who were then given time to assess the worksheet using a response questionnaire.

Based on research, it can be seen that the results of distributing the questionnaire to get a Student in three schools response obtained an average of 92.9%. This means that the worksheet, based on the socio-scientific issues approach that has been developed, gets a very good response from students. These results are consistent with research on the development of worksheets by Apriani et al., (2021), which obtained the results of assessing student responses with an average percentage of 87% in the very good category. This shows that the worksheet that has been developed is able to grab the attention of students because it is considered to have an attractive appearance, makes them more enthusiastic and motivated to learn, presents material with multimedia so that it is easy to understand, and has learning activities that increase student activity. Based on the results of the small-scale test, it can be concluded that the worksheet based on the socio-scientific issues approach has received a very good response from teachers and students as users. After going through the validation and small-scale testing stages, revisions are carried out so that the final product of the worksheet is produced.

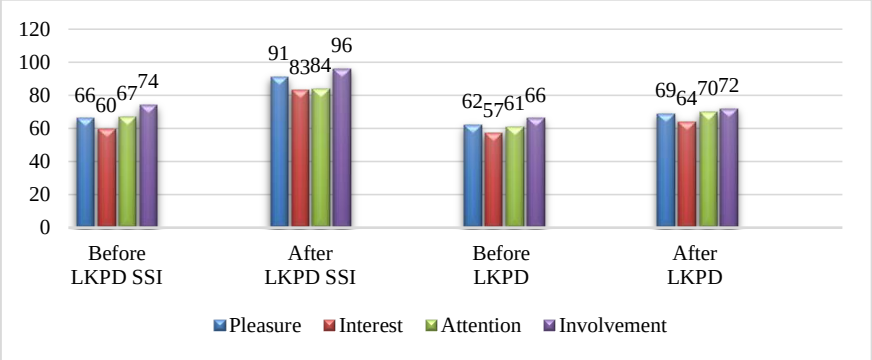
3) Big-scale trials

As for the large-scale trial stage that is being carried out, it is to test the effectiveness of the product. Field trials were carried out at SMAN 4 Pekanbaru on students in class XI IPA 2, totaling 36 people as the experimental class, and class XI IPA 1, totaling 32 people as the control class.

a) Interest in learning

Large-scale trials are the implementation stage of the developed teaching materials. This stage was carried out with the aim of knowing the effectiveness and influence of the worksheet based on the socio-scientific issues approach that has been developed on learning interest and critical thinking skills. The influence of student worksheets on learning interest and critical thinking skills will be seen through the pretest-posttest data of students using questionnaires and multiple choice questions totaling 20 questions based on indicators of interest in learning and critical thinking skills.

Data on interest in learning were obtained from the results of a questionnaire given to students to determine the level of interest in learning before and after using worksheets based on the socio-scientific issues approach. This data can be seen in Picture 1.



Picture 1. Student Learning Interest Results Data

The results of the learning interest indicators before and after the implementation of the Socio-Scientific Issues (SSI) worksheet show a significant increase in students' engagement and enthusiasm. The mean percentages for these indicators show an average increase from 66% to 88% in the percentage of students reporting positive feelings, and from 61% to 68% in the average scores for each indicator. This data suggests that the SSI worksheet has successfully enhanced students' interest and engagement in the learning process, demonstrating its effectiveness in fostering a more interactive and stimulating educational environment. This data shows that students' interest in learning has increased after participating in learning using the worksheet based on the socio-scientific issues approach.The normality test is a prerequisite test before testing the hypothesis. The purpose of doing the normality test is to find out whether the data obtained is normally distributed or not. If the data is normal, the hypothesis analysis is performed using parametric statistics; if the data is not normal, the hypothesis analysis is performed using non-parametric statistics.

The normality test was carried out using the SPSS version 24 application by looking at the results of the Kolmogorov-Smirnov test with a significance level of 0.05. The Kolmogorov-Smirnov method is an effective and valid normality test method used for large samples. For the number of samples to be tested, "If the samples tested are > 50, then Kolmogorov-Smirnov is used, while if the samples tested are 50, Shapiro-Wilk is used" (Dahlan, 2010). Data from normality test results for learning interest data can be seen in Table 9.

Table 9. Data Normality Test Results Interest in Learning

Data Interest in Learning	Kolmogorov-Smirnov		
	Statistic	Df	Sig.
experiment before	0.106	36	0.200*
experiment after	0.146	36	0.050
control before	0.168	32	0.052
control after	0.118	32	0.200*

Table 12 shows that the value of the data on students' learning interest before and after using the worksheet obtained a significance value of >0.05, respectively. This means that the data on students' interest in learning is normally distributed because it has a sig value > 0.05. Based on these results, the interest in learning hypothesis test will be carried out with parametric statistics using the independent sample t test.

The paired t test was carried out with the help of the SPSS version 23 programme. The criteria for testing the hypothesis with the paired t test are that if the sig value is > 0.05, then H0 is accepted and Ha is rejected, but if the sig value is 0.05, then Ha is accepted and H0 is rejected. The results of the hypothesis test on students' learning interest data can be seen in Table 10.

Table 10. Results of Hypothesis Testing Data Interest in Learning

	F	Sig.	t	Df	Sig. (2-tailed)

Value	Equal variances assumed	17.985	.000	9.961	66	.000
	Equal variances not assumed			9.534	39.454	.000

Table 10 shows that the results of the hypothesis test on learning interest data with the paired t test obtained a significance value of 0.000. This means that Ha is accepted because the sig value is 0.05, so it can be stated that there is a significant difference from the implementation of the worksheet based on the socio-scientific issues approach to the learning interests of class XI students at SMAN 4 Pekanbaru. Based on this statement, it can be concluded that the worksheet based on the socio-scientific issues approach has an effect on students' learning interest in the buffer solution material. The results of this study are in line with the research of Muthoharoh et al., (2017) that the application of socio-scientific issues in worksheet affects students' learning interest, as seen from the increased interest in learning after participants use worksheet in chemistry learning.

b) Critical Thinking Skills

The results of measuring critical thinking skills can be presented in the form of descriptive statistics in the form of the average value (mean) and its increase for both the control class and the experimental class. These results can be presented in the following table:

Table 11. Descriptive Statistics Value critical thinking skills

	Experiment Class		**Control Class**	
	Pretest	**Posttest**	**Pretest**	**Posttest**
Sample	36	36	32	32
Average	39.44	72.50	38.91	61.25
Max Value	65	90	60	90
Min Value	20	55	20	40

Based on the data in Table 11, it can be seen that the overall sample for the experimental class is 36 people and 32 people for the control class. The average value of the experimental class before learning was 39.44 and increased to 72.5 at the average value after learning. The average value of the control class before learning was 38.91 and increased to 61.25 at the average value after learning. The highest score in the experimental class before learning was 65 and after learning was 90, while the lowest score before learning was 20 and after learning was 55. The highest score in the control class before learning was 60 and after learning was 90, while the lowest score before learning was 20 and after learning was 40. The results of the normality test for each variable are as follows:

Table 12. Normality test of critical thinking skills

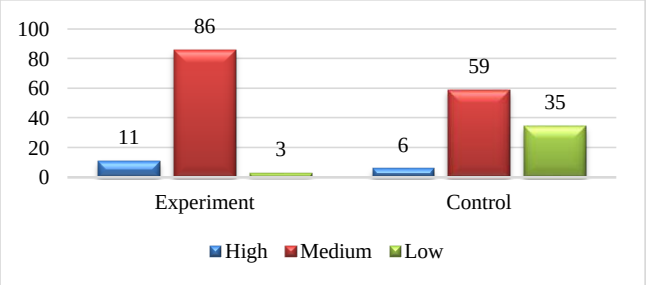
Grade		**Kolmogorov-Smirnov**	**Conclusion**
		Sig.	
Pretest	Experiment	0.189	Normal Distribution
	Control	0.176	Normal Distribution
Posttest	Experiment	0.109	Normal Distribution
	Control	0.178	Normal Distribution

Based on the significance level in Table 12, which has been presented for the normality test, it was shown that the pretest and posttest values of critical thinking skills for the control and experimental classes are normally distributed; this is indicated by a significance level that is greater than 0.005 or p> 0.005. So it can be concluded that all data is normally distributed.

Table 13. Critical thinking skills t-test

Kelas		N	Mean	SD	t-test for equality of means				Conclusion
					F	t	Df	Sig. (2-tailed)	
Pretest	Experiment	36	39.44	12.523	2.694	0.199	66	0.843	Ha Accepted (There are differences)
	Control	32	38.91	9.310					
Posttest	Experiment	36	72.50	9.297	3.274	4.266	66	0.000	
	Control	32	61.25	12.378					

Based on the results of the Independent Sample T-Test statistic above, the sig (2-tailed) t test for students' critical thinking skills is 0.000. Because the sig (2-tailed) value is 0.05, H0 is rejected and Ha is accepted. Thus, it can be concluded that there is a significant difference in students' critical thinking skills between the experimental class and the control class.The improvement of students' critical thinking skills in the control and experimental classes can be seen by calculating the normalised gain score.



Picture 2. N-Gain Score in experimental and control classes

The data on learning outcomes in both the experimental and control classes reveal notable differences in the effectiveness of the educational interventions applied. For the experimental class, which experienced the introduction of the socio-scientific issues (SSI) approach, the mean N-Gain score was 53.93, categorized as medium. Among the students, 11% demonstrated high gains, while a significant 86% showed medium gains, and only 3% had low gains. This distribution indicates a generally positive impact of the SSI-based approach on student learning outcomes, with the majority achieving moderate improvements. In contrast, the control class, which followed traditional instructional methods, had a lower mean N-Gain score of 30.00, categorized as low. In this group, 6% of students showed high gains, 59% had medium gains, and a substantial 35% experienced low gains. This suggests that the control class had less improvement in learning outcomes compared to the experimental class, with a larger proportion of students exhibiting minimal progress. Overall, the data illustrate that the SSI-based worksheets had a more substantial positive effect on learning outcomes than the conventional methods used in the control class. The experimental group, benefiting from the innovative approach, achieved better results, with a greater proportion of students showing medium to high improvements in their learning outcomes. This supports the effectiveness of the SSI approach in enhancing educational achievement compared to traditional methods.

From the results of the analysis above, it can be seen that the average gain score of students' critical thinking skills in the control class is 30%, which is included in the low category. While the average gain score for critical thinking skills in the experimental class is 54% and is included in the medium category, it can be concluded that there is a difference in the value of critical thinking skills between the control class and the experimental class. In the experimental class, there was an increase in learning outcomes, with an average N-Gain of 0.54. This value is included in the medium category (0.30 N $- Gain \leq$ 0.70).

e. Evaluation

This research is also inseparable from several problems that occur during implementation, especially for worksheets based on the social scientific issue approach. Through worksheets based on the social scientific issue approach, students are guided to organize all the knowledge they have and the conditions that exist in life to solve a problem. Learning becomes more meaningful, and students will be able to develop their abilities in applying the concepts they have according to the application situation. This is in accordance with the theory of meaningful learning, which emphasises the importance of associating experiences, certain phenomena, and all the facts that students get with the concepts they have previously had (Korucu-Kış, 2021). Student problem-solving skills are influenced by intelligence. Students with higher intelligence will find it easier to improve their problem-solving abilities (Ausubel & Ausubel, 2000). In addition to improving problem-solving skills, it will also indirectly improve critical thinking skills. Using worksheet can help students discover concepts (Hidayah, Syafi'i, & Fauziah, 2018). Compared to conventional methods, learning using the socio-scientific issues method improves critical thinking skills (Yustina, Irhasyuarna, & Kusasi, 2015). Furthermore, the existence of worksheet in the form of task sheets that are structured and made interesting in such a way will motivate students while studying so that they are able to improve their problem-solving skills. This is in line with research on the use of student worksheets in contextual learning, which influences significant differences in pre-test and post-test scores on students' interest in learning and critical thinking skills. Based on this condition, it is expected that students can improve their critical thinking skills through worksheet based on the socio-scientific issues approach. With this, students can train high-level thinking processes and develop skills in gathering information and understanding buffer solutions.

Research by Kember & Leung (2005) found that problem-based learning, which often includes socio-scientific issues, significantly enhances students' critical thinking and problem-solving skills. Similarly, studies by Lin et al., (2023) showed that contextual learning methods, including the use of real-life problems in educational materials, lead to improvements in students' higher-order thinking skills. These studies corroborate the current research's conclusion that SSI-based worksheets can effectively enhance critical thinking and problem-solving abilities.

The implications of these findings are significant for educational practice. The effective integration of socio-scientific issues into worksheets can transform traditional teaching methods, making learning more engaging and applicable to real-world scenarios. Educators are encouraged to incorporate SSI-based worksheets into their curricula to foster not only improved problem-solving skills but also enhanced critical thinking capabilities among students. This approach not only aligns with theoretical frameworks but also responds to the practical need for more interactive and meaningful learning experiences. Furthermore, the research suggests that structured and appealing worksheets can play a crucial role in motivating students and facilitating their development of higher-order thinking skills. As indicated by the positive impact on student engagement and learning outcomes, the use of SSI-based worksheets should be considered a valuable tool in enhancing educational effectiveness and preparing students for complex real-world challenges.

Based on the result and discussion of this research, several recommendations can be made for further improvement and implementation of the socio-scientific issues-based worksheet in chemistry education. Firstly, it is advisable for educators to incorporate more real-world issues into their teaching materials to enhance student engagement and relevance. Secondly, ongoing professional development and training for teachers on how to effectively utilize these worksheets should be prioritized to ensure successful implementation. Thirdly, it is recommended to conduct further research to explore the long-term impacts of using socio-scientific issues-based worksheets on student learning outcomes and critical thinking skills. Additionally, adapting and expanding this approach to other scientific subjects could provide broader educational benefits.

Lastly, schools should consider integrating these worksheets into their curriculum to foster a more engaging and thought-provoking learning environment.

CONCLUSION

Based on the research results, it can be concluded that the validation of materials and media was carried out twice with validation results of 77% and 78.4%, resulting in a valid category with an average percentage of 77% and 78.4%. Teacher feedback indicated a 93.1% rating for the worksheet, highlighting its ease of use and alignment with learning objectives. Students from three schools responded very positively to the worksheet, with an average response rate of 92.9%. Hypothesis testing revealed a significant increase in students' learning interest using the socio-scientific issues approach. Additionally, the Independent Sample T-Test revealed a significant improvement in students' critical thinking skills in the experimental class compared to the control class, with an average N-Gain score of 0.54, indicating a medium level of improvement.

REFERENCES

Adawiyah, S. R., Hakim, A., & Hadisaputra, S. (2020). Pengembangan Modul Praktikum Kimia Bahan Alam Berbasis Generik Sains: Isolasi Fenobarbiton dari Kulit Batang Pohon Api-api (Avicennia marina). *Chemistry Education Practice*, *3*(2), 84. https://doi.org/10.29303/cep.v3i2.1994

Akram, T. M., Ijaz, A., & Ikram, H. (2017). Exploring the Factors Responsible for Declining Students' Interest in Chemistry. *International Journal of Information and Education Technology*, *7*(2), 88–94. https://doi.org/10.18178/ijiet.2017.7.2.847

Apriani, R., Harun*, A. I., Erlina, E., Sahputra, R., & Ulfah, M. (2021). Pengembangan Modul Berbasis Multipel Representasi dengan Bantuan Teknologi Augmented Reality untuk Membantu Siswa Memahami Konsep Ikatan Kimia. *Jurnal IPA & Pembelajaran IPA*, *5*(4), 305–330. https://doi.org/10.24815/jipi.v5i4.23260

Arikunto, S. (2010). *Prosedur penelitian suatu pendekatan praktik*. Jakarta: Rineka Cipta.

Ashari, S. E., Rachmadiarti, F., & Herdyastuti, N. (2023). Analysis of the Science Literacy Profile of Students at State Junior High School. *IJORER: International Journal of Recent Educational Research*, *4*(6), 889–898.

Augustha, A., Susilawati, S., & Haryati, S. (2021). Pengembangan E-LKPD Berbasis Discovery Learning Menggunakan Aplikasi Adobe Acrobat 11 Pro Extended pada Materi Kesetimbangan Ion dan pH Larutan Garam untuk Kelas XI SMA/MA Sederajat. *Journal of Research and Education Chemistry*, *3*(1), 28. https://doi.org/10.25299/jrec.2021.vol3(1).6485

Ausubel, D. P., & Ausubel, D. P. (2000). Assimilation theory in meaningful learning and retention processes. *The Acquisition and Retention of Knowledge: A Cognitive View*.

Chen, Y. T., Chen, T. J., & Tsai, L. Y. (2011). Development and evaluation of multimedia reciprocal representation instructional materials. *International Journal of Physical Sciences*, *6*(6), 1431–1439. https://doi.org/10.5897/IJPS11.066

Dahlan. (2010). *Besar Sampel dan Cara Pengambilan Sampel*. Jakarta: Salemba Medika.

Damayanti, I., Yunarti, T., & Widyastuti. (2015). Deskripsi Disposisi Berpikir Kritis Matematis Siswa dalam Pembelajaran Socrates Kontekstual. *Jurnal Pendidikan Matematika*, *Vol.3 No.4*.

Darwis, N. A., Ali, S., & Helmi, H. S. N. F. Pp. U. (2020). Kemampuan Berpikir Kritis Ditinjau dari Minat Belajar Fisika, Kepercayaan Diri, dan Kecerdasan Emosional Peserta Didik Kelas X MIA SMA Negeri 1 Gowa. *Prosiding Seminar Nasional Fisika PPs UNM*, *2*, 120–123. Retrieved from https://ojs.unm.ac.id/semnasfisika/article/view/14369/8852

Fithriyah, I., Sa'dijah, C., & Sisworo. (2016). Analisis kemampuan berpikir kritis siswa kelas IX-D SMPN 17 Malang. *Konferensi Nasional Penelitian Matematika Dan Pembelajarannya*, (Knpmp I), 580–590.

Hancock, T. S., Friedrichsen, P. J., Kinslow, A. T., & Sadler, T. D. (2019). Selecting Socio-scientific Issues for Teaching A Grounded Theory Study of How Science Teachers Collaboratively Design SSI-Based Curricula. *Science & Education*, *28*.

Handayani, A., & Hastuti, P. W. (2018). Pengaruh Pendekatan Socio-Scientific Issues Terhadap Environmental Literacy Siswa Smp. *Pend. Ilmu Pengetahuan Alam* …, 419–422. Retrieved from http://journal.student.uny.ac.id/ojs/ojs/index.php/ipa/article/view/12940

Haryadi, S., Djatmika, E. T., & Setyosari, P. (2017). Suplemen Buku Ajar Tematik Materi Energi Alternatif & Sumber Daya Alam Berbasis. *Jurnal Pendidikan: Teori, Penelitian, Dan Pengembangan*, *2*, 1330–1337.

Haryanti, Y. D. (2017). Model Problem Based Learning Membangun Kemampuan Berpikir Kritis Siswa Sekolah Dasar. *Jurnal Cakrawala Pendas*, *3*(2). https://doi.org/10.31949/jcp.v3i2.596

Haryati, E., Andayani, Y., & Al Idrus, S. W. (2019). Analisis Minat Belajar Dan Kemampuan Awal Keterampilan Berpikir Kritis Siswa Pada Materi Minyak Bumi. *Jurnal Pijar Mipa*, *14*(3), 128–134. https://doi.org/10.29303/jpm.v14i3.1297

Hidayah, M., Syafi'i, W. S. W., & Fauziah, Y. (2018). Implementasi lembar kerja peserta didik (lkpd) berorientasi model pembelajaran guided inquiry untuk meningkatkan kemampuan berpikir kritis dan hasil belajar peserta didik kelas XI MIA 4 SMAN 9 Pekanbaru. *Jurnal Online Mahasiswa (JOM) Bidang Keguruan Dan Ilmu Pendidikan*, *5*(2), 293–306.

Kember, D., & Leung, D. Y. P. (2005). The influence of active learning experiences on the development of graduate capabilities. *Studies in Higher Education*, *30*(2), 155–170. https://doi.org/10.1080/03075070500043127

Korucu-Kış, S. (2021). Preparing student teachers for real classrooms through virtual vicarious experiences of critical incidents during remote practicum: A meaningful-experiential learning perspective. *Education and Information Technologies*, *26*(6), 6949–6971. https://doi.org/10.1007/s10639-021-10555-7

Lin, X.-F., Hwang, G.-J., Wang, J., Zhou, Y., Li, W., Liu, J., & Liang, Z.-M. (2023). Effects of a contextualised reflective mechanism-based augmented reality learning model on students' scientific inquiry learning performances, behavioural patterns, and higher order thinking. *Interactive Learning Environments*, *31*(10), 6931–6951.

Maria Merianti L, Hairida, & Rasmawan, R. (2016). Keterampilan Berpikir Kritis Siswa Menggunakan Model Pembelajaran Inkuiri Terbimbing Pada Materi Larutan Penyangga. *Jurnal Pendidikan Dan Pembelajaran Khatulistiwa (JPPK)*, 139–141.

Muthoharoh, M., Kirna, I. M., & Indrawati, G. ayu. (2017). Penerapan Lembar Kerja Peserta Didik (LKPD) Berbasis Multimedia untuk Meningkatkan Motivasi dan Hasil Belajar Kimia. *Jurnal Pendidikan Kimia Indonesia*, *1*(1), 13. https://doi.org/10.23887/jpk.v1i1.12805

Putriana, A. R., Suryawati, E., & Suzanti, F. (2020). *Socio Scientific Issue (Ssi) Based LKPD Development In Learning Natural Science SMP Class VII*. *4*, 80–89.

Rahayu, R., Sutikno, & Indriyanti, D. R. (2023). Ethnosains Based Project Based Learning Model with Flipped Classroom on Creative Thinking Skills. *Jurnal Penelitian Pendidikan IPA*, *9*(8), 348–355. https://doi.org/10.29303/jppipa.v9i8.3051

Razak. (2017). Hubungan Kemampuan awal terhadap Kemampuan Berpikir Kritis Matematika pada Siswa Kelas III SMP Pesantren IMMIM Putri Minasatene. *Mosharafa: Jurnal Pendidikan Matematika*, *6*(1).

Riduwan. (2016). *Skala Pengukuran Variabel-variabel Penelitian*. Bandung: Alfabeta.

Rusydi, A. (2018). *Manajemen pemasaran*. Bandung: Alfabeta.

Sianturi, S. R., & Aprianingsih, Y. (2021). Hubungan Karakteristik Individu Dengan Tingkat Pengetahuan Masyarakat Tentang Penyakit Hiv/Aids Di Bekasi. *Jurnal Keperawatan Dan Kesehatan Masyarakat Cendekia Utama*, *10*(3), 210. https://doi.org/10.31596/jcu.v10i3.422

Simbolon, M., Mulyono, E., & Surya, E. (2017). The Efforts to Improving the Mathematical Critical Thinking Student's Ability through Problem Solving Learning Strategy by Using Macromedia Flash. *American Journal of Educational Research*, *5*(7), 725–731. https://doi.org/10.12691/education-5-7-5

Sugiyono. (2016). *Metode Penelitian Pendidikan (Pendekaran Kuantitatif, Kualitatif, dan R&D)*. Jakarta: CV Alfabeta.

Sugiyono. (2017). *Metode Penelitian Kuantitatif, Kualitatif, Dan R&D*. Bandung: Alfa Beta.

Susilaningsih, E., Drastisianti, A., Lastri, Kusumo, E., & Alighiri, D. (2019). The Analysis of Concept Mastery Using Redox Teaching Materials with Multiple Representation and Contextual Teaching Learning Approach. *Jurnal Pendidikan IPA Indonesia*, *8*(4), 475–481. https://doi.org/10.15294/jpii.v8i4.18072

Winataputra, S. U., Delfi, R., Pannen, P., & Dina, M. (2010). *Teori Belajar dan Pembelajaran*. Jakarta: Universitas Terbuka.

Yustina, S., Irhasyuarna, Y., & Kusasi, M. (2015). Penerapan metode pembelajaran problem solving terhadap kemampuan berpikir kritis siswa pada materi koloid kelas xi ipa sma negeri 4 banjarmasin. *Quantum: Jurnal Inovasi Pendidikan Sains*, *6*(2).

Zakaria, Z. (2021). Kecakapan Abad 21 Dalam Pembelajaran Pendidikan Dasar. *Jurnal Pemikiran Dan Pendidikan Dasar Islam*, *4*(2), 81–90.

Zeidler, D. L., & Nichols, B. H. (2009). Socio-scientific Issues: Theory and Practice. *Journal of Elementary Science Education*, *21*(2), 49-58.