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Development of Students' worksheets Oriented Socio-Scientific Issues on Salt Hydrolysis Topic to Enhance Problem-Solving Skills and Learning Motivation of High School Students

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Abstract: This study aims to (1) describe the characteristics of students' worksheets oriented towards Socio-Scientific Issues (SSI), (2) test their feasibility, (3) analyze the differences in problem-solving skills and learning motivation among students who use SSI-oriented students' worksheets and those who do not, and (4) determine the effectiveness of SSI-oriented students' worksheets to enhance problem-solving skills and learning motivation. The research method used Thiagarajan's 4D model (Define, Design, Develop, Disseminate) with a quasi-experimental pretest-posttest control group design and a sample size of N=112. Data was analyzed using MANOVA and Partial Eta Square. The results showed that the SSI-oriented students' worksheets : (1) consists of four structured activities (stimulation, problem identification, data collection, data processing, proof, and conclusion) designed to enhance problem-solving skills and learning motivation, (2) was highly feasible based on expert validation of quality by teachers and readability testing by students, (3) MANOVA analysis (Hotelling's Trace) revealed significant differences ($p < 0.05$) in problem-solving skills and learning motivation between the experimental class (using SSI-oriented students' worksheets) and the control class, both simultaneously and partially. (4) SSI-oriented students' worksheets contributed effectively by 12.5% to the simultaneous improvement of problem-solving skills and learning motivation, with a moderate effect category, which indicates a significant influence. Partially, the contribution to problem-solving skills reached 9.1% and learning motivation 4.8%. Although the contribution to learning motivation is relatively lower, the overall use of this student's worksheet still has a significant positive impact on the chemistry learning process. The study statistically proves that these SSI-oriented students' worksheets are a practical and significant intervention to improve students' problem-solving skills and learning motivation in chemistry lessons, providing a bridge between theoretical concepts and real-world issues. However, its effective contribution is classified as moderate.

Keywords: learning motivation, problem-solving skills, salt hydrolysis, socio-scientific issues, students' worksheets.

▪ INTRODUCTION

21st-century education has undergone profound changes (Bayu et al., 2023; Dilekçi & Karatay, 2023). This no longer focuses solely on knowledge transfer, but also on skills development (Nabila et al., 2024). The skills developed in the 21st-century are often known as the 4Cs include Critical Thinking, Creativity and Innovation, Collaboration, and Communication (Rizaldi & Fatimah, 2024). These four skills are fundamental aspects to prepare students to face global challenges (Thornhill-Miller et al., 2023).

In addition, 21st-century skills also include aspects of science literacy. The aspects of scientific literacy are the skills to plan and evaluate scientific investigations, explain scientific phenomena, and interpret data and evidence scientifically (Sarini et al., 2024). These aspects are used in applying the scientific process in solving a problem (Shailaja & Doode, 2022). Problem-solving skills provide sensitivity to make decisions both

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related to oneself and the environment (Gobel et al., 2023). In the context of chemistry learning, these skills are in line to develop students' knowledge, understanding, and analytical skills related to phenomena that occur and the environment (Wissinger et al., 2021). Thus, chemistry learning becomes a way to develop 21st-century skills (Hadinugrahaningsih et al., 2017)

By learning chemistry, participants not only focus on understanding theoretical concepts (Holme et al., 2015), but also focus on developing students' skills. The development of students' skills includes being able to apply the scientific method to investigate a problem, explain chemical processes that occur in nature, analyze experimental data critically, and work together to solve a problem (Fatmawati, 2020; Nugroho et al., 2025). Therefore, 21st-century learning aims to equip students with scientific skills and increase awareness of environmental issues.

A way to increase awareness of social issues is through learning that is tied to social issues. One of them is by applying the SSI approach (López-Fernández et al., 2022). According to D. Zeidler (2015), effective SSI must be controversial, require evidence-based scientific reasoning, and have social consequences that encourage learners to engage in dialog, discussion, and argumentation. The SSI approach helps students develop decision-making skills and science literacy by analysing controversial scientific issues in society. Through discussions on real problems related to chemistry concepts, students practice critical thinking, argumentation, and problem-solving skills that are applicable in everyday life (Chowdhury et al., 2020). Therefore, SSI has an important role in chemistry education by presenting a social problem, so that it can encourage students' understanding of chemical problems related to life or the environment (Ke et al., 2020).

SSI-oriented learning can be carried out effectively if it is supported by appropriate teaching topics, because SSI-based teaching topics can link the topic to the context of life (Ke et al., 2020; Parlan & Surya, 2024; Presley et al., 2013). However, the teaching topics used have not been tied to SSI. This is due to the unavailability of teaching topics, and educators have difficulty designing teaching topics related to SSI (Bossér et al., 2015) The implementation of SSI in South Korea faces various challenges, including teachers' lack of understanding of this approach, limitations in the curriculum structure, and resistance to changes in conventional teaching methods (Park & Kim, 2018). This was also the case for teachers in Sweden, where science teachers found it difficult to fully understand SSI or teach about SSI (Högström et al., 2024). Similar challenges were also found in Ciamis Regency, Indonesia, where the results of field studies and interviews with chemistry teachers showed that SSI-oriented teaching topics had never been used in learning. Most of the teachers in Ciamis claimed to be new to the SSI approach and had no experience in applying it in the classroom. Research on the implementation of SSI in regions such as Ciamis is still minimal, especially in the development of SSI-based teaching topics, even though this approach has proven effective at the global level.

Problem-solving skills are the main thing that must be discussed in mathematical and abstract learning, one of which is in chemistry learning (Widyorini & Rahayu, 2023). The skills of students to solve a problem are also influenced by their cognitive skills (Siew & Ahmad, 2023). A key factor in enhancing problem-solving skills is students' learning motivation (Urhahne, 2021). Learning motivation can affect the accuracy of the problem-solving process (Baars et al., 2017). Increasing learning motivation can be done by encouraging students to be active and involved in the learning process, which will also

result in increasing the problem-solving skills of students (Hasrawati et al., 2020). Previous research results show the effect of learning motivation on improving problem-solving skills (Hasrawati et al., 2020; Urhahne, 2021). Learning motivation is needed in the learning process to increase the enthusiasm for learning (Filgona et al., 2020; Hidajat et al., 2020). Students with high learning motivation will have a passion for learning and a strong desire to follow the learning process (Liu et al., 2024). Lack of motivation in learning chemistry will affect students' learning activities (Omari et al., 2024; Saputri et al., 2025).

In observations and interviews conducted with chemistry teachers in Ciamis Regency, the students' motivation to learn is diverse and depends on individual characteristics. One of the factors that can affect learning motivation is the teacher's topic presentation strategy, especially the use of stimulus questions at the beginning of learning to increase curiosity. Learning motivation can be enhanced using facilities, teaching topics, and learning resources (Harapan & Puspita, 2020; Wahyuningtyas et al., 2022). One of the effective teaching topics in the learning process is the students' worksheets (Marian & Suparman, 2019; Serevina & Heluth, 2022). The use of students' worksheets provides an opportunity for students to actively participate in the learning process, either individually or in groups (Ruku & Rusmini, 2019)

Making students' worksheets that integrate with problem issues is one way to motivate students to seek solutions to challenges actively. Students' worksheets not only focus on the learning process, but can also be one of the supporters of students to develop problem-solving skills (Widodo et al., 2023). One of them is by developing SSI-oriented students' worksheets, which will become a new pattern in learning (Septiawati et al., 2021). The SSI approach in chemistry learning has proven to increase student motivation and can support students in making better decisions (Hewitt et al., 2019).

Engaging learners in SSI can deepen their understanding of relevant issues, help them apply scientific knowledge in a broader social context, and reflect on the interactions between science and social factors that influence their perspectives on complex issues (Ke et al., 2021). The integration of SSI in learning trains learners to answer complex questions or solve real-world problems, while encouraging critical attitudes (Högström et al., 2024; Suwono et al., 2021). Previous research has shown that the SSI approach successfully engages learners actively, especially when they ask questions about relevant issues, thus raising awareness of socioscientific problems that need to be addressed (Evagorou et al., 2020) This finding is in line with the research of Nugroho et al. (2025) that states the SSI approach effectively improves problem-solving skills, providing opportunities for learners to engage in in-depth decision-making processes. The SSI approach promotes problem-solving skills by encouraging students to find innovative solutions to environmental and health issues, and increases their social awareness and responsibility (Sari et al., 2025).

Several studies have shown that SSI-oriented students' worksheets can improve science literacy and environmental awareness (Hanifha et al., 2023), as well as conceptual understanding of chemical topics such as reaction rates and thermochemistry (Saija et al., 2021). However, SSI-oriented implementation still faces several challenges. A study by Septiawati et al. (2021) revealed that teachers' perceptions of SSI-oriented e-worksheets are still low, with many teachers preferring conventional students' worksheets. This perception is mainly related to students' science literacy and collaboration skills, which

are still categorized as low. In addition, SSI-oriented students' worksheets on the climate change topic are considered valid and very feasible to use (Ameliawati et al., 2023). In addition, there is a significant difference in improving problem-solving skills before and after using students' worksheets with an SSI-oriented PBL model on the environmental pollution topic (Alpianti & Amelia, 2024). The difference between this research and previous research is the use of students' worksheets with an SSI-oriented discovery learning model on the salt hydrolysis topic that has not been widely explored in previous studies, as well as measuring its effectiveness on problem-solving skills and student learning motivation.

The purpose of this research is to develop SSI-oriented students' worksheets, determine the feasibility and effectiveness of SSI-oriented students' worksheets to enhance learning motivation and problem-solving skills on the salt hydrolysis topic. These SSI-oriented students' worksheets are designed as an innovative teaching topic that presents a contextual problem in the stimulus section to provoke students' curiosity and motivation to learn the topic. With the discovery learning model with the SSI approach, students are encouraged to solve contextual problems in everyday life, which can stimulate problem-solving skills, improve critical thinking skills, and stimulate collaboration skills through group discussions. Therefore, this research focuses on three main aspects: 1) describing the characteristics of SSI-oriented LKP, 2) determining the differences in improving problem-solving skills and learning motivation between students who use SSI-oriented students' worksheets and those who do not, and 3) measuring the effective contribution of using SSI-oriented students' worksheets to problem-solving skills and learning motivation. It is expected that the results of this study can contribute to the development of teaching topics that will help teachers in learning, support students to solve problems well and motivate students in the learning process.

▪ METHOD

Participants

The subjects of the research and development trial of SSI-oriented students' worksheets included students in grades XI and XII of high school science in Ciamis Regency. The subjects of the limited trial were five chemistry teachers and XII science class students of SMAN 1 Lumbung, totaling 28 students. The subjects in the field trial were students of class XI IPA SMAN 1 Kawali and SMAN 1 Lumbung. The implementation of the field trial was carried out in four classes, which were divided into two groups, namely the experimental group using SSI-oriented students' worksheets, and the control group using learning based on the discovery learning model without the context of SSI, with each group consisting of two classes. The total experimental class students was 59, and the control class was 53. The sampling technique is cluster random sampling with a quasi-experimental method with a pretest-posttest control group design. The sample selection was carried out by purposive sampling with the following criteria: (1) high schools in Ciamis Regency that are still implementing the 2013 Curriculum in grade XI, (2) accredited A (BAN-S/M), (3) have adequate chemistry laboratories, and (4) organize science programs with at least two parallel classes.

Research Design and Procedure

This research uses the Research and Development (R&D) method by developing an SSI-oriented students' worksheets. R&D method is a process or method used to validate and develop a product (Sugiyono, 2016). Developing products in a broad sense means either updating existing products (so that they become more practical, efficient, and effective) or creating products that have never existed before. The 4D development model was developed by Thiagarajan et al. (1974). The stages of this development model consist of 4 stages, namely Define, Design, Develop, and Disseminate. The 4D model is used because it has clear, detailed, and systematic stages that make it easier to collect data.

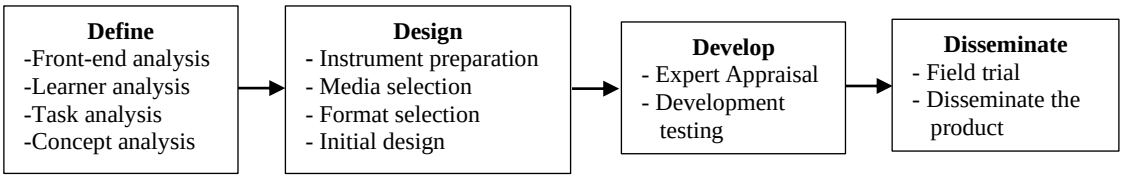

Figure 1. 4D development stage

The define stage in the research aims to collect data related to problems and needs in the learning process. Data collection was carried out by unstructured interviews with chemistry teachers and students who had studied the salt hydrolysis topic. The results of interviews with chemistry teachers showed that the teacher stated that he had never applied the SSI approach in learning and had not used the SSI-oriented students' worksheets. The problem-solving skills and learning motivation of students in chemistry are still considered low based on teacher observations. The results of interviews with students revealed that the salt hydrolysis topic has conceptual complexity involving many chemical calculations and requires a lot of intensive practice questions. The learning process has not been associated with SSI that are relevant in everyday life, adjustment of learning objectives with the curriculum used in schools. The results of this analysis are the basis for formulating specifications for the development of SSI-oriented students' worksheets with a discovery learning approach to overcome these problems.

The Design stage is carried out to develop the initial design of the product being developed. At this stage, the preparation of instruments to be used, such as product feasibility instruments based on experts' and teachers' validation, and students' problem-solving skills and learning motivation instruments. At this stage, the selection of media to be used is also carried out in accordance with the learning objectives. The media developed are teaching materials in the form of printed SSI-oriented students' worksheets on the salt hydrolysis topic. The design of students' worksheets includes the title, instructions, material, and learner activities in accordance with the stages of discovery learning. The discovery learning stage is integrated with the SSI approach. The integration of the SSI approach in the students' worksheets involves inserting actual social issues at the stimulus stage, such as the controversy over the use of aluminum salts in deodorant products on skin health.

The develop stage is to produce products in the form of SSI-oriented printed students' worksheets that have been revised based on comments and suggestions from validators by expert lecturers, product quality tests by chemistry teachers (reviewers), and readability by students so that they are suitable for use. The dissemination stage aims to

disseminate products that have been developed and have been assessed to be used in classroom learning, especially on the salt hydrolysis topic. The disseminate stage consists of effectiveness testing, printing, and product distribution.

Instrument

The data collection instruments in this study consisted of 1) the feasibility of SSI-oriented students' worksheets on the salt hydrolysis topic using instruments (a) media expert validation sheet covering aspects of design and presentation, (b) topic expert validation sheet covering aspects of learning objectives, topic and language, (c) students' worksheets quality sheet assessed by chemistry teachers covering aspects of feasibility/content of topic, language, presentation and design, (c) readability sheet by students covering aspects of topic, language, graphics, practicality and usefulness. 2) The effectiveness of SSI-oriented students' worksheets is assessed using test and non-test instruments as follows: The research instruments consisted of two types: (a) a problem-solving skills test instrument that includes eight pretest and posttest questions, with each question designed to measure four aspects of problem-solving according to Polya (1988), namely understanding the problem, planning a solution, implementing the solution, and re-examining the results; and (b) a non-test instrument in the form of a learning motivation questionnaire containing 21 statements given at pretest and posttest to measure four aspects of motivation: initiative, intrinsic, interest, and optimism.

Data Analysis

Data analysis techniques were used after data collection was completed. Data analysis was carried out qualitatively and quantitatively. Qualitative data from suggestions, input, comments, and corrections from expert lecturers, chemistry teachers on the developed students' worksheets. For the assessment of media feasibility by experts, teachers, and students using a Likert scale of 1-5 is used, where 1: very less, 2: less, 3: enough, 4: good, and 5: very good. The results of the Likert scale are then interpreted as each aspect is categorized according to the value category. The product eligibility category is determined based on Table 1 (Sugiyono, 2019):

Table 1. Criteria for product feasibility

No.	Percentages (%)	Category
1	81 –100	Very Feasible
2	62 – 81	Feasible
3	41 – 60	Feasible Enough
4	21 – 40	Less Feasible
5	>21	Very Less Feasible

Products that are categorized as feasible if that have good criteria and can be used as learning resources. The validity of the problem-solving skills and learning motivation instruments is assessed based on three criteria: outfit MNSQ (0.5-1.5), ZSTD (-2.0 to +2.0), and Point Measure Corr (0.4-0.85). If it meets both criteria, it is said to be valid. Sari & Ihwan (2024). Instrument reliability was tested using Cronbach's Alpha, with values ≥ 0.7 indicating high reliability. (Taber, 2018). Before the prerequisite test of the metrics, the N-Gain value was calculated. The measure of n-gain (normalized gain) is a method to measure the effectiveness of a learning (Navarrete et al., 2024; Nissen et al.,

2018). N-gain analysis was conducted on each participant of the experimental class and control class by comparing the pretest and posttest scores (Hake, 1999).

The results of empirical validation of the learning motivation instrument obtained 21 valid statements and 1 invalid statement, and failed in the analysis, namely, statement 19. Invalid statements with MNSQ 1.59 > 1.5, ZTSD 3.36 > 2, and Pt Mean Corr 0.31 < 0.40; these three values do not meet the criteria for item fit. As for the results of empirical validation of the problem-solving skills instrument, seven items of package A are valid, 7 items of package B are valid, and two items from both are invalid and invalid because they do not meet the item fit criteria. Therefore, invalid questions are replaced with valid questions with the same indicators. The results of the reliability test of learning motivation and problem-solving ability can be seen in Table 2.

Table 2. Reliability results

Aspects measured	Cronbach's Alpha	Item Reliability	Person Reliability	Conclusion
Learning Motivation	0.84	0.96	0.82	Reliable
Problem-solving Skills (A)	0.74	0.94	0.71	Reliable
Problem-solving Skills (B)	0.81	0.95	0.79	Reliable

To analyze the effectiveness and effective contribution of SSI-oriented students' worksheets, a MANOVA analysis test was conducted, namely Hotteling's test and between-subject effect using SPSS 23 software. The MANOVA test can be conducted if all prerequisites for analysis have been fulfilled so that parametric analysis can be carried out. The Hotelling's Trace test results show that there is a significant difference simultaneously between the experimental and control groups if (p-value <0.05). Next, the between-subjects effects test also shows significant differences in each variable, namely problem-solving skills and learning motivation, if the p-value < 0.05.

▪ RESULT AND DISSCUSSION

Product Characteristics Description

The learning media developed in this study is SSI-oriented students' worksheets on the salt hydrolysis topic, based on the constraints of limitations in the use of teaching materials oriented to social issues. Learning with students' worksheets makes it easier for students to understand concepts in chemical topics (Henne et al., 2023). The use of students worksheets provides an opportunity for students to actively participate in the learning process, either individually or in groups (Buffalari, 2022).

The product developed in this research is SSI-oriented chemistry students' worksheets, which are expected to improve students' problem-solving skills and learning motivation. SSI-oriented students' worksheets were developed as a printed students' worksheet designed using the Canva program, with A4 size, in which there are colored pictures. The images presented are taken from Canva, Freepik, and other websites. This is in line with Musdalifah et al. (2024) that Canva can be used to develop students' worksheets and is suitable for use in learning activities. The development of SSI-oriented printed students' worksheets can be an innovative alternative in learning, especially in areas with limited digital access, so that they can be used in various school conditions. This strengthens the role of students' worksheets as an effective learning resource for enhancing students' problem-solving skills and motivation to learn. SSI-oriented printed

students' worksheets offer a learning approach that directly links lesson topics to social and scientific issues through a printed format.

The students' worksheets can develop students' critical thinking and problem-solving skills through the exploration of fundamental issues relevant to their lives. SSI-oriented students' worksheets are designed to present a problem, requiring students to analyze, evaluate, and find solutions. In line with the discovery learning syntax used in this study, this students' worksheets are designed with four activities, each of which includes six discovery learning model syntaxes: (1) stimulation, (2) problem identification, (3) data collection, (4) data processing, (5) verification, and (6) conclusion drawing.

The stimulus in the students' worksheets is designed to trigger students' motivation in learning by presenting relevant, controversial, and contextual SSI issues, such as health claims about Himalayan salt being considered healthier than regular table salt and the debatable impact of using salt in toothpaste. These issues are chosen because they can arouse students' curiosity as well as connect learning with real problems they encounter in their daily lives. At the problem identification stage, students are encouraged to dig deeper into critical questions that arise from the stimulus, such as identifying the type of salt used in commercial products, understanding its mechanism of action, and analyzing its potential impact on health and the environment. This process trains students' skills to formulate problems systematically while increasing their engagement in learning.

The data collection and processing stage is then designed to train Polya's problem-solving skills thoroughly. Students are invited to plan strategies to find information from credible sources, analyze the data obtained, apply various problem-solving methods, and evaluate the results obtained. Through this approach, students not only master academic concepts but also develop critical thinking skills and awareness as citizens who can make evidence-based decisions in dealing with complex issues in real life.

This approach differs from conventional students' worksheets, which tend to focus on practice questions without relating them to real-life problems. By raising issues that are close to the daily lives of students, these students' worksheets can increase their interest and curiosity. The topic and activities in the students' worksheets are presented interestingly and contextually, making it easier for students to understand the concepts and relate them to their daily experiences.

The development of SSI-oriented students' worksheets aims to improve students' problem-solving skills and learning motivation. The SSI-oriented students' worksheets integrate science concepts related to complex and controversial social issues (Sibic & Topcu, 2020). SSI can improve problem-solving skills because the SSI approach includes social problems that are closely related to the concepts and principles of science, so that students can face and solve problems that arise (Chowdhury et al., 2020). The approach in these students' worksheets is designed to train students in identifying problems, finding data, processing data, and solving problems by developing solutions based on scientific principles. The SSi approach can not only improve problem-solving skills but also motivate students to learn actively (Hewitt et al., 2019).

Product Feasibility

To determine the feasibility of students' worksheets, two expert validations were conducted, consisting of topic and media validation. Expert validation is done by a

lecturer in the Chemistry Education Master's Study Program at Yogyakarta State University. The criteria for assessment by expert validation include aspects of learning objectives, topic, and language. The results of the material expert validation are presented in Table 3.

Table 3. Results of material expert validation

No	Aspects	Total Score	Average Score	Ideal Score	Percentage	Category
1.	Learning Objectives	30	15	15	100%	Very Feasible
2.	Material	53	26.50	30	88%	Very Feasible
3.	Linguistic	47	23.5	25	94%	Very Feasible
	Total	130	65	70	93%	Very Feasible

Based on this table, it is known that the material expert validation score obtained from two material expert assessments is 130, with an average of 65, with a feasibility percentage of 93%. Based on the product feasibility assessment reference, if the feasibility percentage value is in the range 81-100, then the product is categorized as very feasible to use. It can be concluded that the SSI-oriented students' worksheets on the salt hydrolysis topic are very feasible to use. The criteria for assessment by material expert validation include aspects of design and presentation. The results of the material expert validation are presented in Table 4.

Table 4. Results of media expert validation

No	Aspects	Total Score	Average Score	Ideal Score	Percentage	Category
1.	Design	54	27	30	90%	Very Feasible
2.	Presentation	46	23	25	92%	Very Feasible
	Total	100	50	55	91%	Very Feasible

Based on Table 3, it is known that the topic expert validation score obtained from two topic expert assessments is 100, with an average of 50, with a feasibility percentage of 91%. Based on the product feasibility assessment reference, if the feasibility percentage value is in the range 81-100% then the product is categorized as very feasible to use. It can be concluded that the SSI-oriented students' worksheets on the salt hydrolysis topic are very feasible to use, according to media experts.

The quality test was conducted by five chemistry teachers who were selected based on the criteria set. The quality test was carried out to increase the feasibility of the developed students' worksheets and identify shortcomings, and make revisions (Plomp & Nieveen, 2013). The assessment aspects contained in the quality test are four aspects, namely topic, language, presentation, and design aspects. The results of the quality test obtained an average score of 75.2 with a percentage of 95% which is in the very good category, and there are some suggestions for improvement. Furthermore, the readability test was assessed by students; in this test, there were five aspects, namely aspects of topic, language, graphics, practicality, and usefulness. The results of the readability test were carried out to find out the advantages of the product developed, as well as to find out whether the aspects contained in the product are appropriate so that it is easy to understand, in accordance with the needs and objectives of education (Irdalisa et al.,

2023) The results of the readability trial had an average score of 53.54 with a percentage of 89.23% which was in the very good category. The revised product was then used in classroom learning. This is in line with (Widodo et al., 2023) that the use of students' worksheets is effective and gives positive results

Implementation of SSI-Oriented Students' Worksheets

The developed students' worksheets combine the discovery learning model and the SSI approach, which is in accordance with the 2013 curriculum, where learning is centered on students (Yulianti & Wulandari, 2021). So that these students' worksheets are very feasible to use or apply in learning chemistry, especially on the topic of salt hydrolysis. Products that are declared feasible can be used in field trials.

To measure the effectiveness of the SSI-oriented students' worksheet, the pretest and posttest scores of problem-solving skills and learning motivations were analyzed using the n-gain calculation. The data were then tested with MANOVA after fulfilling the analysis requirements. Analysis requirements are met through normality and homogeneity as prerequisites for analysis. Normality and homogeneity tests can be seen in Tables 5 and 6.

Table 5. The normality test result

Variabel	Kelas	Kolmogorov-Smirnov[a]		
		Statistic	df	Sig.
Problem-solving Skill	Experiment	.097	59	0.200*
	Control	.094	53	0.200*
Learning Motivation	Experiment	.069	59	0.200*
	Control	.070	53	0.200*

Table 6. The homogeneity test result

Box's M	F	df1	df2	Sig.
5.005	1.635	3	3483403.002	.179

The results of the Kolmogorov-Smirnov normality test Table 5. results in a significance value (p-value> 0.05), it can be concluded that the learning motivation data and problem-solving skills in the control and experimental classes are normally distributed. Based on the Box's M homogeneity test, Table 6 produces a significance value (p-value> 0.05); it can be concluded that the data on problem-solving skills and learning motivation come from the same or homogeneous population.

The parametric prerequisite test is fulfilled, and the MANOVA test is carried out using two approaches. First, Hotelling's Trace Test was used to test for simultaneous significant differences between experimental and control groups on both variables. Second, the Tests of Between-Subjects Effects were applied to analyze the effect of treatment on each variable separately. The Hotelling's Trace test can be seen in Table 7and the Tests of Between-Subjects Effects can be seen in Table 8.

Table 7. Hotteling's trace test result

	Effect	Value	Sig.	Partial Eta Squared
Class	Hotelling's Trace	.2143	.001	.125

Based on Hotelling's Trace test results, which show a significance value of 0.001 ($p < 0.05$), it can be concluded that there is a significant difference between the class that uses SSI-oriented students' worksheets and the control class. Further analysis revealed that the SSI-oriented students' worksheets made an effective contribution of 12.5% to the increase in problem-solving skills and learning motivation simultaneously, which is included in the moderate effect category. This study can identify the effectiveness of SSI-oriented students' worksheets in learning, while reinforcing previous research on the benefits of the SSI approach in the learning process (Elistiyaningsih et al., 2022; Güss et al., 2017).

Table 8. Tests of between-subjects effects results

Dependent Variable	Sig.	Partial Eta Squared
Problem-solving Skill	.001	.091
Learning Motivation	.020	.048

The results of the tests of between-subjects effects analysis showed a significant difference between the experimental and control classes on both problem-solving skills (p-value 0.001) and learning motivation (p-value 0.020). Although the effect size value (partial η^2) is relatively small, it is 0.091 (9.1%) for problem-solving skills and 0.048 (4.8%). In the context of problem-solving, SSI-oriented students' worksheets provide systematic guidance by describing each stage that students must go through when solving problems. This accustoms them to solving problems in a structured and sequential manner, thereby developing metacognitive skills in the learning process (Choo et al., 2011).

Although the contribution to learning motivation was relatively small, based on observation data and interviews conducted during the field trial, there was a significant increase in motivation through changes in student behavior. The initial conditions before the implementation of the SSI-oriented students' worksheets showed that students tended to be passive, rarely asking questions during learning, and having low learning motivation. However, after the implementation, there was a fundamental change where students became more active in asking questions, participating more intensely in group discussions, and showing greater enthusiasm when using the SSI-oriented students' worksheets. These changes indicate that the SSI approach successfully fosters student engagement and interest in learning.

The increase in learning motivation is relatively small. This is due to several factors. The first factor is that the short duration of intervention may not be enough to produce more substantial changes, because the SSI-based approach requires a long time for internalization of concepts and development of metacognitive skills (Кетова & Столбова, 2024). Second, students need a period of adaptation to get used to the SSI learning pattern, which is different from conventional methods (Dominguez et al., 2024). Third, the complexity of the abstract hydrolysis topic makes it difficult for students to relate it to the socio-scientific context (Horvat et al., 2021; Laliyo et al., 2022) This finding is in line with previous research showing that the effectiveness of the SSI approach is highly dependent on the duration of implementation, student readiness, and structural support from the learning system (Zeidler et al., 2019).

Although the percentage contribution of SSI-oriented students' workheets influence is relatively small in the context of education, even the smallest improvement remains significant because it is cumulative and can have a significant impact in the long term (Lipsey & Cordray, 2000). Even educational interventions with small effect sizes can have a meaningful impact if they are consistently applied. This is because sustainable and consistent interventions can gradually improve various aspects of student skills and behavior, which in turn will have a positive influence on learning outcomes and development (Kraft, 2020). According to Cohen (1988) in his guidelines for interpreting effect sizes, in social education research, small effect sizes are still considered practically relevant, especially when supported by strong statistical significance ($p < 0.05$), as found in this study.

The results of MANOVA analysis showed a substantial and significant value (p-value 0.05), indicating that SSI-oriented students' workheets have a positive influence on problem-solving skills and learning motivation. Student worksheets can provide guidance or descriptions of each phase a person must undergo when solving a problem. This way, students can become accustomed to completing the problem-solving process.

Between learning motivation and problem-solving skills are related to each other. Learning motivation is theoretically recognized as a supporting factor in problem-solving because it plays a role in determining the initiation, direction, and intensity of cognitive processes (Baars et al., 2017) In the context of learning, motivation to solve problems can be sourced from internal factors of learners or externally designed through the design of learning tasks (Urhahne, 2021). Distinguish between these two types of motivation: (1) self-initiated effort that arises from learners' internal drive, and (2) task-evoked effort that arises in response to the subjective difficulty of a task (Muenks et al., 2016). Conversely, good problem-solving skills also serve as a strategy to increase learning motivation. Thus, these two aspects are intertwined and reinforcing in a positive learning cycle, where motivation drives problem-solving skills, and success in problem-solving in turn increases motivation to learn further (Gómez-López et al., 2023).

Based on the results of the study, there was a significant increase in students' problem-solving skills after using SSI-oriented students' worksheets. This shows that integrating SSI with learning can stimulate students to identify problems, plan problem-solving, implement problem-solving plans, and re-examining procedures and results. This process is in accordance with the stages of problem-solving skills (Polya,1988). This is in line with previous research that SSI can improve students' problem-solving skills because it encourages students to develop higher-order thinking skills, which include critical and creative thinking, through the presentation of problems that require problem-solving that are directly related to social issues(Kolstø et al., 2024; D. R. Sari et al., 2025).

From the results of learning motivation in this study, students showed an increase in learning motivation after using SSI-oriented students' worksheets, and there was a significant difference between classes that used SSI-oriented students' worksheets and those that did not use them. Topics related to fundamental issues help students learn relevant and meaningful, in line with previous research that SSI can increase students' learning motivation (Choi & Lee, 2021). Besides being influenced by the SSI approach factor, learning motivation can increase due to the use of students' worksheets during the learning process. The use of students' worksheets in the learning process can create an active, effective, creative, engaging, and fun atmosphere (Inderlang et al., 2025). As

research conducted by (Elistiyaningsih et al., 2022) shows that the use of students' worksheets can increase learning motivation. Learning motivation also contributes significantly to improving problem-solving skills (Güss et al., 2017).

Thus, the results of this study reinforce that the use of SSI-oriented students' worksheets has an impact on improving students' problem-solving skills and learning motivation. The application of this approach can be an innovative one in learning chemistry that is relevant, contextual, and meaningful to students. Besides being able to improve problem-solving skills and learning motivation, these students' worksheets are also feasible to use, according to the assessment by topic experts, media experts, teachers, and students.

However, this research only focuses on the salt hydrolysis topic, so the topic coverage is still limited; besides that, this research does not cover the long-term aspects of the use of students' worksheets on problem-solving skills and learning motivation. Recommendations for further research include the use of other topics, a more in-depth examination of the long-term impact of using SSI-oriented NPDS, and how this technology can be more widely accessed and applied in various educational contexts. This study can also be used as a reference for teaching topic developers and teachers in designing student worksheets that not only focus on cognitive aspects but also develop students' affective and social aspects through the integration of contextual issues.

This research provides empirical evidence that the integration of SSI into students' worksheets can increase the relevance and contextuality of chemistry learning, as well as bridge the gap between school science and its application in people's lives. The findings also prove that the use of SSI-oriented students' worksheets significantly improves students' problem-solving skills and learning motivation.

Based on the findings of the study, chemistry curriculum developers need to systematically integrate SSI into learning design through methods such as training in identifying SSI issues relevant to the curriculum, techniques for designing SSI-based worksheets that include learning steps such as stimulus, problem identification, data collection, data processing, verification, and conclusion drawing, as well as simulations of classroom application. Thus, teachers not only understand the SSI conceptually but are also skilled in connecting learning with social issues relevant to real life.

▪ CONCLUSION

Based on the results and discussion, it can be concluded that the characteristics of SSI-oriented students' worksheets obtained a very good feasibility level of 95%, and students by 89.23%. Based on the MANOVA test, there is a significant difference simultaneously and respectively in the problem-solving skills and learning motivation of students who use SSI-oriented students' worksheets compared to students who do not use them. The effective contribution of the use of SSI-oriented students' worksheets to the problem-solving skills and learning motivation of students is 12% simultaneously, the effective contribution to problem-solving skills is 9.1% and to learning motivation is 4.8%. This shows that the development of SSI-oriented students' worksheets has been successfully developed, is very feasible to use, and is effective as a chemistry teaching media on the salt hydrolysis topic. For future research, the author suggests the use of more in-depth analysis such as mediation analysis or Structural Equation Modelling (SEM) to test the hypothesis that learning motivation acts as a mediator in the effect of SSI LPDs

on problem-solving skills. This analytical approach can provide a more comprehensive understanding of the mechanism of the relationship between the variables involved

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