



## ENHANCEMENT OF HIGH SCHOOL STUDENTS' SCIENTIFIC LITERACY USING LOCAL-SOCIOSCIENTIFIC ISSUES IN OE3C INSTRUCTIONAL STRATEGIES

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### ABSTRACT

Guided inquiry learning has improved scientific literacy skills in various studies. This fact, however, contradicts new findings from the 2015 PISA survey. The research aims to assess inquiry-based OE3C learning methodologies that incorporate local socioscientific issues (SSI) to improve students' scientific literacy. The research method used quantitative and qualitative methods to evaluate the planned strategy for teaching thermochemistry and rate reactions. The local SSI-based OE3C was used in a sixteen 90-minute lesson with 72 eleventh-grade students (experimental group) at an Indonesian public high school. A control group of 68 students from the same school was taught using guided inquiry learning. The experimental group received a 17-item questionnaire on students' opinions of the instructional process using the OE3C based on local SSI and a 24-item scientific literacy test (Cronbach alpha = 0.717) from pretest and posttest. The control group also received the scientific literacy tests from pretest and posttest. The finding shows that OE3C learning based on SSI effectively enhances students' scientific literacy skills. These findings are consistent with the results of the student perception questionnaire, which are supported by semi-structured interview findings 7.78% of students are highly pleased to learn using local SSI-based OE3C learning, and 95.83% of students think that learning to use local SSI-based OE3C learning steps helps them gain a better knowledge of the material. The findings of this study suggest that local SSI should be integrated into chemistry classes to help students build scientific literacy skills.

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Keywords: instructional strategy; local socioscientific issues; scientific literacy

### INTRODUCTION

Science and technology in the 21st-century have developed rapidly (Holbrook & Rannikmäe, 2014; Rizal et al., 2020). Such development reflects that chemical knowledge and the social, political, and economic decisions for such innovations are entailed (Gilbert & Treagust, 2009). However, many of the improvements that have been made have detrimental consequences for people's lives (e.g., climate change, global warming, nuclear leaks, acid rain, environmental pollution) and requires a scientifically literate society to solve these problems (Pratiwi et al., 2016).

As members of society, students require scientific knowledge that contributes to scientific literacy, which is commonly regarded as science education's core purpose (Holbrook & Rannikmäe, 2014). As they are connected to the application of science, technology, and society, students' scientific literacy skills should be improved in the classroom (Asrizal et al., 2018). Appropriate teaching materials and learning methodologies are also required to facilitate scientific literacy skills (Cigdemoglu & Geban, 2015).

There are various methods to define scientific literacy. Scientific literacy, for example, is described as a person's knowledge and comprehension of scientific ideas and processes that are

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required for making decisions and engaging in social, cultural, and economic activities (Dani, 2009). Scientific literacy is also characterized as the capacity to apply scientific knowledge to identify questions, make evidence-based conclusions, explain and anticipate events, and solve natural issues (Deboer, 2000). When a person can use scientific concepts and process skills in making decisions about other people or the environment and understands the relationship between science, technology, and society, social and economic development, as well as producing useful scientific products, he or she is said to be scientifically literate (OECD, 2015). Choi et al. (2011) assert that science content knowledge is one of the three key aspects of scientific literacy because it uses scientific ideas to explain phenomena and predict problem-solving. As a result, scientific literacy focuses on increasing students' knowledge to use science concepts (including chemistry) meaningfully, think more critically and creatively, and take balanced and appropriate actions on problems in their lives.

However, there are still issues regarding studying chemistry that must be addressed immediately. Curriculum overload, isolated facts, lack of transfer, lack of relevance, and inadequate focus are five issues that arise when studying chemistry (Gilbert, 2006). For example, when it comes to issues of relevance, students believe that chemistry ideas are difficult to master and that they give little (O'Dwyer & Childs, 2017) or no value in real life or will have little impact on the workplace in the future (Eilks & Hofstein, 2015). It appears that students in many nations do not believe chemistry to be a mandatory subject to study and that the outcomes of chemistry studies are unimportant in the future. The sophisticated traditional chemistry curriculum has influenced this student's viewpoint. The traditional curriculum has failed to integrate the theories learned as information with real-life situations. (Eilks & Hofstein, 2017). This does not help students enhance their scientific literacy skills.

Assessment tools are a crucial part of developing students' scientific literacy. Scientific literacy has been measured by various assessment tools (Naganuma, 2017). The OECD's PISA (Program for Worldwide Student Assessment) and TIMSS (Trends in Mathematics and Science Studies) are two international survey programs that aim to examine students' scientific literacy skills globally. The concept of scientific literacy was developed and defined in PISA 2015 and 2018 (OECD, 2015, 2018) as the ability to participate in science-related topics, scientific con-

cepts, and scientific understanding, and this capability might represent students' self-awareness as citizens. PISA 2015 (OECD, 2015) outlines three core skills for assessing scientific literacy: competency, knowledge, and attitude. The degree of cognitive demand is a new aspect in the PISA 2015 framework. The cognitive demand evaluates and reports students' scientific literacy skills across all three framework components. The cognitive demand is divided into three categories: low (Lo), medium (M), and high (Hi).

Whether scientific literacy is exclusive to science majors (physics, chemistry, and biology) or not, many teachers and researchers have worked to enhance scientific literacy. These efforts are carried out through the reconstruction of learning syntax and the provision of new learning designs. Guided inquiry learning is one of the lessons broadly employed in numerous research to promote scientific literacy. Guided inquiry learning is beneficial in boosting scientific literacy skills in several studies (e.g., Putra et al., 2016; Aulia et al., 2018; Wen et al., 2020). The conclusions of these investigations are bolstered by data from the last PISA analyses (e.g. Lau & Lam, 2017; Hwang et al., 2018; Tang & Williams, 2019). However, contrary to prior research, fresh findings in the 2015 PISA results (OECD, 2016; Forbes et al., 2020). However, contrary to prior research, fresh findings in the 2015 PISA results revealed that students in nations with the most outstanding levels of scientific literacy reported that inquiry-based learning occurs only at particular times, if at all, and that it is practically never done. It was also claimed that the learning method employed was direct teaching, which consisted only of teacher lectures or teacher-led debates and demonstrations. Forbes et al. (2020) ascertain that students in nations with poor levels of scientific literacy were more likely to adopt guided inquiry learning in general. Aditomo & Klieme (2020) reported that inquiry is positively correlated with the result when it includes teacher guidance and negatively correlated with the result if it does not. Zhang & Li (2019) also reported a negative correlation between student participation in inquiry-based learning investigation and their scientific achievements. In particular, these researchers found that "as a skill involving higher cognitive skills, from recognizing applications and reasoning, the more students participate in the survey, the more their scores drop." This might be linked to various studies that claim inquiry learning ignores variations in students' knowledge and creativity since it merely follows the strategy outlined in the textbook for inquiry

activities (Kim & Tan, 2011). The undemocratic exploration method does not help students develop their creative thinking skills. The absence of this guided inquiry learning technique will damage students' capacity to issue scientific concepts; it can also be a barrier to creativity in conducting investigations, resulting in a decision-making process that is unrelated to reality.

Furthermore, Oliver et al. (2021) found that "In Australia, Canada, Ireland, New Zealand, the United Kingdom, and the United States, students who reported experiencing high-frequency inquiries in their classroom strategies consistently show low levels of scientific literacy. Teig et al. (2018) also studied data from Norway and found a curve relationship: "inquiry-based learning is positively correlated with achievement in science, but the high frequency of inquiry activities is negatively correlated with achievement."

These findings highlight the need to pay attention to learning syntax in a science learning environment, where the "subject explanation stage" and teacher guidance are critical (Zhang & Cobern, 2021). The OE3C learning strategy (Orientation, Exploration, Explanation, Ethical Discussion, and Consolidation) aims to increase students' scientific literacy skills by bridging the significance of "explanation phases" and inquiry learning skills. In this strategy technique, students' inquiry activities are paired with the teacher's capacity to communicate significant information in a lesson.

To make scientific learning successful, Forbes et al. (2020) underlined the necessity for learning that supports the flexibility of local or cultural learning features, both in curriculum and syntax. According to the belief that context-based chemistry education would be more relevant and enjoyable to study (Broman et al., 2020) and important to constructing a coherent knowledge base (Gilbert, 2006). With this OE3C strategy, students are introduced to Socioscientific Issues (SSI). SSI is defined as a social dilemma with a conceptual or technological relationship to science (Steffen & Hößle, 2017). Chowdhury et al. (2020) present an overview of the literature on controversial, ill-structured, real-life oriented aspects of SSI in science learning (including chemistry), as well as aspects of moral, ethical, and value reasoning, scientific context, contextual learning related to the science curriculum, and argumentation. The use of SSI in the classroom is the first step in developing scientific literacy (Zeidler et al., 2019).

Numerous investigations have examined the correlation between SSI and other components of science education, such as learning outcomes (Topçu et al., 2018), science concept (Villarín & Fowler, 2019; Saija et al., 2021), nature of science (NOS) (Khishfe, 2017; Khishfe et al., 2017), argumentation (Khishfe et al., 2017), socioscientific reasoning (Romine et al., 2017), critical thinking skill (Pratiwi et al., 2016), decision making (Eggert et al., 2013), character and values (Kim et al., 2019). However, there is currently a limited number of studies on applying SSI learning to promote scientific literacy (Widodo et al., 2020).

The context of SSI is both global and local, although climate change, the use of technology, and genetics to address environmental problems and crises are the most prevalent contexts employed by SSI researchers (Sadler, 2011). SSI incorporates contentious problems, making it more difficult (Hsu & Lin, 2017). Because students deal with real difficulties daily, they are incredibly significant and valid for them. SSI ties the science curriculum to real-world applications and societal ramifications, the problem-solving knowledge transfer process making learning more engaging and relevant for students (Chen & Xiao, 2021).

The fundamental focus of SSI-based learning is SSI teaching, which implies that SSI-based challenges are offered from the start of learning (Presley et al., 2013). Students are given a chance to apply relevant SSI subjects to evaluate material through SSI-based tasks, which may be used to promote and test scientific literacy (Ke et al., 2021), make decisions, and participate in discourse, debate, and discussion (Yuliastini et al., 2018). Teachers play a critical role in SSI contextual learning by enabling students to think about evidence-based alternatives. However, in Indonesia, the application of SSI in education is still quite limited (Nida et al., 2021). It is intended that by employing locally-based SSI, instructors and students would be able to grasp the genuine meaning of the SSI context provided.

This study aims to assess local SSI OE3C learning strategies to improve students' scientific literacy. The research questions are: (1) Is the OE3C strategy with local SSI more effective in increasing students' scientific literacy than the guided inquiry learning strategy?; (2) What are high school students' perceptions of the OE3C strategy based on local SSI to increase scientific literacy and students' perceptions of the teaching-learning process?

## METHODS

This study was conducted with the following stages: 1) Planning. We construct an OE3C learning strategy, develop and validate data collection instruments; 2) Implementation of learning. At this stage, a pretest was carried out before implementing the learning program; implementation of learning; and posttest was conducted at the end of the program; 3) Post-Implementation. Student perception questionnaire and semi-structured interviews were conducted to support the results of the student perception survey, and

4) Analysis and interpretation of research data. This study involved quantitative and qualitative methods (Ivankova & Plano Clark, 2018) with an intervention instructional program consisting of 16 lessons (@ 90 minutes). Pretest and posttest were analyzed using ANCOVA. The questionnaire data were analyzed descriptively.

The quantitative portion was a quasi-experimental pretest-posttest control group comprising two sample groups (Table 1), the experimental and control groups. The sample was selected using a random sampling method.

**Table 1.** Experiment Design of Pretest-Posttest Control Group

Group	Pretest	Treatment	Post-test
Experimental	✓	OE3C based on local SSI	✓
Control	✓	Guided inquiry	✓

Both the experimental and control groups were required to take a pretest before receiving treatment: Students in the experimental group were taught the OE3C learning strategy in a local SSI setting, while students in the control group were taught through guided inquiry. Thermochemistry and reaction rate were the chemical topics employed in this study. Porna Sago, Durian Festival, Maluku Peace Gong, and the Borneo Coal Mine were all mentioned in the local SSI debate for the thermochemical idea. The Fireworks Party at Jembatan Merah Putih, Traditional Wine, Plastic Waste at Losari Beach, and Saparua Brown Sugar in Its Usage, all for the notion of reaction rate. The experimental group used a student worksheet and textbook based on Local SSI.

This study included 140 eleventh-grade students at public senior high schools in Ambon, Indonesia. The students were divided into experimental and control groups. Both groups took part in a chemistry lesson taught by two properly licensed teachers. The experimental and control groups were determined after an equivalency test was completed using the test scores from the last semester exam before the research was conducted. Each group was taught by a separate teacher and consisted of 72 students (two classes) in the experimental group and 68 students (two classes) in the control group. The Maluku Provincial Government granted research licenses prior to the start of the study. Teachers and students are eager to participate in research initiatives as volunteers.

There are several steps in the OE3C learning strategy: 1) The Orientation stage, which introduces students to what SSI is and current SSI discourse in the local SSI environment, is the first step in the OE3C learning strategy. Learning in the SSI context has the distinct feature of making SSI the primary focus of learning (Presley et al., 2013), necessitating the presentation of SSI issues at the start of the learning process; 2) Students gain hands-on experience while learning science subjects during the Exploration stage (Hanuscin & Lee, 2008). Learning is more focused on experiential learning, so students could adapt to direct experiences in the laboratory or small group discussions; 3) The Explanation stage allows teachers to directly lead students in understanding ideas, practices, or skills. The teacher briefly introduces science (Bybee, 2014). According to constructivist theory, one key component is that the instructor encourages the autonomous construction of students' knowledge, and students actively form cognitive structures in their interactions with the environment (Slavin, 2011). Then students actively form cognitive structures in their interactions with the environment (Slavin, 2011; Schunk, 2012); 4) Ethical discussion stage. Students are invited to make judgments in the SSI setting based on initial ideas, acquired facts, appropriate scientific concepts, and moral ramifications; 5) The goal of the Consolidation stage is to let students reflect on their learning experience and final result. Students' learning will be more relevant if they can apply what they

have learned in the classroom to real-world situations. A scientific literacy exam and a perception questionnaire were the two data-collection devices employed in this study. The scientific literacy pretest and posttest were used to obtain quantitative data. Data from pretest and posttest were utilized to assess student progress in scientific literacy. The research team created and verified the test instrument before using it in the real research class. The PISA 2015 features were used to create the scientific literacy test instrument. Item difficulty, which was experimentally generated, was frequently mistaken with cognitive load in assessment frameworks. The proportion of students that correctly solved the item was used to determine the difficulty of the empirical item; hence, the “medium cognitive demand” question was the most common in our scientific literacy instrument test. The scientific literacy test consisted of three true/false choice questions (one with low cognitive demand (Lo) and two with medium cognitive demand (M), as well as 21 essay questions (two with low cognitive demand (lol), fifteen questions with medium cognitive demand (M), and four questions with high cognitive demand (Hi). The instrument was declared valid on content and construction by two professors and three lecturers in chemistry education. Inter-rater reliability analysis was utilized to analyze essay questions during the small-scale trial stage of designing scientific literacy test instruments. The results of the inter-rater reliability analysis, namely questions number 1-5;7-21, are in the “Excellent agreement” category; and question number 6 “Good” category (Fleiss et al., 2003). Then, the overall (average value) coefficient of agreement between raters is 0.884, which falls into the “Excellent agreement” category. In addition, the reliability study of the scientific literacy ability test instrument reached a Cronbach’s Alpha score of 0.717, which met the “good” requirements (Taber, 2018). The elements in the scientific literacy test instrument are shown in Figure 1.

A questionnaire on student impressions of the OE3C strategy in the SSI setting was used to collect qualitative data, supplemented with semi-structured interviews using audio recordings of 15 students who volunteered. After the OE3C learning program execution with the local SSI setting, the experimental group was handed a student perception questionnaire. Researchers created the questionnaire, verified and evaluated it with a Cronbach’s Alpha reliability rating of 0.869. The instrument was reliable (Taber, 2018). This questionnaire had three evaluation

components: a) seven statements about feelings during learning; b) four statements about comprehending the subject and tasks given; and c) six questions concerning reactions to learning features. Students respond to component a) using a four-point Likert scale: very happy (SS), happy (S), quite happy (CS), and very dissatisfied (STS); component b) using a four-point Likert scale: very good (VG), good (G), moderate (M), and very poor (VP); and component c) using two choices (dichotomies): yes (Y) and no (N). Additionally, a column is provided for students to comment on ideas, reactions, or critiques concerning the OE3C learning strategy in the local SSI context used throughout this research.

To respond to the first research question, the experimental and control groups’ pretest and posttest data were analyzed using a one-way analysis of covariance (ANCOVA). The grouping (experimental and control groups) was the independent variable, the scores on the posttest were the dependent variable, and scores on the pretest were the covariate. The 0.05 alpha level was used to evaluate statistical significance. Cohen’s d test for effect size was used to evaluate the amount of an experimental and control group difference to give an alternate way of interpreting statistical significance results (e.g., ANCOVA) (Chen et al., 2020). The formula to calculate the effect size is as follows (Cohen et al., 2018).

$$d = \frac{(\bar{X}_t - \bar{X}_c)}{SD_{pooled}}$$

d is Cohen’s effect size;  $\bar{X}_t$  is mean treatment condition;  $\bar{X}_c$  is mean control condition; and  $SD_{pooled}$  is pooled standard deviation = (standard deviation of treatment group + standard deviation control group). The criteria for identifying the magnitude of Cohen’s d effect size are as follows: trivial effect size is < 0.2 standard deviation units; the small effect is between 0.2 and 0.5; the medium effect is between 0.5 and 0.8; and the large effect is 0.8 or more (Chen et al., 2020). Furthermore, the pretest and posttest results were descriptively analyzed using the level of cognitive demand (Widodo et al., 2020) to examine the development of students’ scientific literacy skills at each cognitive level.

The questionnaire data were examined descriptively to address research question 2 concerning students’ impressions of local SSI-based OE3C strategy. In addition, semi-structured interviews were conducted to support the students’ perception survey results.

**Exhaust Filter**

Exhaust filters, which are devices that limit the pollutants contained in vehicle exhaust gases to make them less dangerous to humans and the environment, are standard equipment in the most current automobiles. Approximately 90% of the gas is transformed to a safer form. Take a look at the schematic of the exhaust filter below.

Questions:

- Why can the exhaust filter transform gases into safe for humans and the environment, as shown in the diagram? (State the substance's name and function in the chemical reaction process.)
- Use the information in the diagram above to demonstrate how exhaust filters reduce the harmfulness of exhaust gases!
- When gasoline burns in an automobile, heat is emitted in the form of  $\text{CO}_2$  and  $\text{H}_2\text{O}$ . This heat energy causes the piston to move, allowing the automobile to drive. If the gas in the piston expands by 451 J and the system loses 325 J as heat to its surroundings. Calculate the energy (E) change in J.
- What is the value of the energy change (E) in kJ and kCal units?
- Give your opinion based on the above circumstances.  
 "Observe the gases that the exhaust filter produces. Name one issue with exhaust filters that engineers and scientists should work to overcome in order to produce less harmful exhaust gases."

**Figure 1.** An Item Sample of Scientific Literacy Instrument

**RESULTS AND DISCUSSION**

ANCOVA statistics were used to examine data from students' scientific literacy test results. The normality test findings  $p = 0.200^* > 0.05$  for the two study groups; homogeneity test  $p = 0.409$

$> 0.05$ ; regression homogeneity test  $p = 0.219 > 0.05$ ; and linearity test  $0.000 < 0.05$  for the ANCOVA analysis have all been completed and the conditions for the ANCOVA analysis have been satisfied.

**Table 2.** ANCOVA Statistical Results for Local SSI-based OE3C Learning Effectiveness

Group	N	Mean Difference	F	Sig.(p)
All	140	63.42	142.464	.000
Experiment	72	70.02		
Control	68	49.84		

The findings of descriptive statistics (see Table 2) revealed a difference of 70.02 and 49.84 between the experimental and control groups from pretest to posttest, with the experimental group having a better difference of 20.18, which is statistically significant,  $F(1, 137) = 142,464$   $p=0.000$ . According to Table 2, the Sig. for chan-

ge in learning strategies is  $0.000 < 0.05$ , showing that the OE3C learning strategy has a considerable impact on students' scientific literacy skills in the local SSI environment. The d-value Cohen's of  $d > 0.8$  (2.25) for the impact size difference between research groups is viewed as a "large effect."

Table 3 shows the difference between the pretest and posttest levels of students' scientific literacy skills for each cognitive demand. The average score for the low category is greater than the average for the medium and high categories, according to the results of the data analysis gi-

ven in Table 3. When the pretest results for the three cognitive demand categories are compared, the "medium" level of scientific literacy is the lowest. According to Table 3, scientific literacy skills grow during the learning process.

**Table 3.** Descriptive Analysis Results of Students' Scientific Literacy for Each Cognitive Demand

Scores	Cognitive Demand	Categorise	Max	Min	Mean (SD)	SD
Pretest	Lo		20	7	9.12	3.47
	M		7	0	1.29	1.51
	Hi		15	0	3.46	4.41
Posttest	Lo		98	7	64.59	19.49
	M		91	4	59.26	15.77
	Hi		95	10	64.68	19.28

The effect of the OE3C learning strategy on the three levels of the cognitive load was de-

termined using the findings of an ANCOVA data analysis. Table 4 summarizes the findings.

**Table 4.** ANCOVA Test Analysis Results of Students' Scientific Literacy for Each Cognitive Demand

Cognitive Demand	Categorise	N	F	Sig.(p)	Effect Size (d)
	Lo	140	71.92	.000	1.44
	M	140	116.89	.000	1.94
	Hi	140	26.05	.000	1.02

Notes: According to (Chen et al., 2020), effect sizes (Cohen's d) indicate the following differences: < 0.2 standard deviation units; the small effect is between 0.2 and 0.5; the medium effect is between 0.5 and 0.8; the large effect is 0.8 or more.

Table 4 reveals that the OE3C learning strategy has a substantial impact on the development of students' scientific literacy skills at the Lo, M, and Hi levels, as expected, with Lo ( $F(1, 137) = 71.92, p = 0.000$ ), M ( $F(1, 137) = 116.89, p = 0.000$ ), and Hi ( $F(1, 137) = 26.05, p = 0.000$ ). In each area of cognitive demand, the d-value Cohen's for the effect size difference across the research groups is > 0.8 (Lo = 1.44; M = 1.94; Hi = 1.02), which is taken as a "big effect."

The findings of this study back up the claim of Villarín & Fowler (2019) that SSI learning that is relevant to real-world helps students learn information. Furthermore, Herman et al. (2021) noted that internal elements such as culture and emotions hugely impact how pupils respond to SSI issues. The guided inquiry was predicted to increase integration of the SSI context into learning to be meaningful according to real-life to a more considerable extent than the SSI context. When students work on a familiar subject, we expect that they will see how science links to real-

life circumstances and can be applied, which will improve their scientific literacy.

The questionnaire's three evaluation components were evaluated to acquire students' perspectives of OE3C learning strategy in the SSI setting, and the results of the questionnaire semi-structured interviews then validated data analysis. Students' replies clarify the results of the questionnaire data in semi-structured interviews. The benefits of the OE3C learning strategy were obtained in four ways, according to the results of the semi-structured interviews with students: using local SSI in learning, understanding chemical concepts, making ethical decisions related to morals, and using SSI in learning to gain knowledge that can be applied in real life.

Table 5 shows the study results of the "feelings while learning" component of the questionnaire on student views of the OE3C learning strategy implementation in the local SSI environment.

**Table 5.** Students' Feelings During OE3C Learning Based on Local SSI

No	Item	Percentage (%)			
		SS	S	CS	STS
1	Small group conversations, class debates, and creating ethical narratives were used to introduce and learn how to use local SSI.	77.78	22.22	0	0
2	Preparing to do a self-examination	0	81.94	18.06	0
3	Participating in independent practicum activities with members of the group	83.33	16.67	0	0
4	Discussing problems related to SSI in small groups and using data from the practicum to support the arguments	9.72	63.88	26.39	0
5	Participating in class discussions and presenting the results of group investigations	5.56	80.56	13.89	0
6	Reflecting on the learning process and making ethical decisions	94.44	5.56	0	0
7	Teachers' methods in organizing classroom learning activities	16.67	83.33	0	0

SS = Sangat Senang (Very Satisfied); S = Senang (Satisfied); CS = Cukup Senang (Quite Satisfied); dan STS = (Not Satisfied) Sangat Tidak Senang

The first stage in OE3C learning activities introduced students to socioscientific issues (SSI). In OE3C chemistry class, most students responded that they prefer to study local-socioscientific concerns. Most of the students (77.78%) were extremely satisfied to work through OE3C based on local-SSI. The students recognized that incorporating socioscientific topics into the classroom had various benefits, including enhancing students' desire and enthusiasm in studying and making the chemical topic more critical. Student 1 said in an interview, "I am thrilled to discover what SSI is and be able to apply it in studying. It makes studying chemistry more meaningful when I found out about the SSI context in learning chemistry," In line with it, Student 2 added, "The discussions I had, aroused my interest in learning more about chemistry. Learning chemistry entails more than just remembering formulas and working on problems; it also entails being pushed to tackle real-world difficulties."

Students were provided an early grasp of SSI, after which they were presented with a dialogue in the local SSI context. This practice became exciting for students since it is unique to them. Students were shown a local SSI that depicted students' daily lives faced difficulties. Students' learning motivation and interest can be boosted by presenting the discourse in an SSI setting (Sormunen et al., 2017; Tidemand & Nielsen, 2017).

Most students (81.94%) were enthusiastic about preparing for the inquiry and overjoyed (83.33%) to be part of the practicum they completed with friends in small groups. Most students (80.56%) were willing to submit their group results in class discussions, and 63.88% of students were eager to talk in their groups.

The data findings correspond to the interview results. The OE3C strategy in the local SSI context asked students to provide existing data. Not just with the ultimate solution but also with explaining how it was discovered and why they believed in it. The local SSI-based OE3C Strategy created a learning environment that enabled students to become scientists through a self-planned self-investigation process and carried out jointly in small groups. Student 3 noted in the interview, "OE3C's strategy demands me to be entirely independent and accountable while delivering responses. It must be founded on the facts gathered and supported by relevant scientific ideas for my results to be accepted by my peers." Per it, Student 4 added, "OE3C demands me to examine a subject, such as PANAS (HOT)." The challenges presented to me in the SSI conversation must be solved by inquiry; this necessitates more tremendous effort on my part to locate the appropriate and many sources of study so that I may comprehend the topic being studied and, of course, argue with friends." It is important to note that



most students (94.44%) are eager to reflect on their learning processes and outcomes. Student 5 argued, "Aside from SSI and ethical storylines, the worksheet also has a new feature. The worksheet's self-reflection approach appealed to me very much. So now I know which section of the lesson I didn't get. Furthermore, I am happy with the ethical judgments I made in the end."

In line with it, Student 6 claimed, "The process of self-reflection is fascinating in this lesson, Ma'am. For me, the advantages are significant since I now have a better understanding of which learning indicators I do not understand, which ones I currently understand, and which ones should be reinforced." As a result, 16.67% are very satisfied, and 83.33% are satisfied with the teacher's methods in organizing classroom learning activities. Teacher guidance is essential during student scientific investigations to ensure clear content teaching, and the field has not yet discussed in depth the factors that teacher guidance

is essential to the success of student science learning (Zhang & Cobern, 2021).

The results of the five Likert questions in this component's questionnaire data indicate linearity, indicating that students were satisfied in learning chemistry using the OE3C strategy based on local SSI (as shown in Table 6). Most students (77.78%) said using the OE3C technique in conjunction with the local SSI context improved their understanding of the thermochemical principles and reaction rates discussed. Regarding the responsibilities assigned throughout the OE3C strategy's learning phase, most students (83.33%) said they did an excellent job, while 16.67% said they required more explanation from the teacher to finish the work. 88.89% of students reported that they comprehended the teacher's content description. This result shows that the "Explanation" stage is important in class to improve student scientific literacy. The explanation given by the teacher helps students.

**Table 6.** Students' Understanding of the Material and Tasks in OE3C Learning Based on Local SSI

No	Item	Percentage (%)			
		SB	B	S	STB
1	Able to comprehend the content of thermochemical materials and reaction rates taught by SSI-based OE3C learning on a local level.	11.11	77.78	11.11	0
2	Students use the student worksheets given during the local SSI-based OE3C learning process.	15.28	79.17	5.56	0
3	The students understand the teacher's explanation of the content.	0	88.89	11.11	0
4	The importance of tasks in student worksheets that must be completed for students to understand the instructional material	0	83.33	16.67	0

Note: SB = Sangat Baik (Very Good); B = Baik (Good); S = Sedang (Fair); dan STB = Sangat tidak Baik (Very Bad)

Student 7 noted in the interview, "I need an explanation from the teacher, specifically the theory, to explain the facts I acquire." Students stated, "Initially, it was tough for me to finish the assignments in the worksheet. However, with the guidance of the teacher's explanation, I gradually got the hang of it. The teacher also supplied a description of thermochemical materials and reaction rates. It makes it easier to present the results of our group practicum. I need a teacher to explain thermochemical material and reaction rates," Student 8 also argued, "I need the teacher to explain thermochemical materials and reacti-

on rates to me, so that I may be certain of my worksheet answers."

The worksheet results are corrected, examined, and discussed together to evaluate knowledge of the teaching topic and fix faults so that they may be rectified in the next meeting. Students became accustomed to performing tasks at the last stage of the local SSI-based OE3C strategy and were more confident presenting ideas supported by scientific theories and concepts. Table 6 shows that the benefits of employing worksheets during the local SSI-based OE3C learning program are according to the improvements made.

The benefits of utilizing worksheets during class were rated as very good by 15.28% of students. The majority (79.17%) indicated they were good for the worksheet's benefits.

SSI covers moral and ethical components and social science-related topics (Cahyarini et al., 2016; Genel & Topçu, 2016).

**Table 7.** Response to OE3C Learning Aspects based on Local SSI

No	Item	Percentage (%)	
		Yes	No
1	Does the teacher's explanation help you recognize and understand socioscientific issues (SSI)?	100	0
2	Do you think the teacher's local SSI-based OE3C learning steps helped you understand the material?	95.83	4.17
3	Do you think the student worksheets used throughout the lesson helped you understand the material?	100	0
4	Does the teacher's use of learning media help you comprehend the material?	97.22	2.78
5	Is the teacher allowing you to reflect on what you have learned (the learning process, achievement indicators, or how they are applied in real life)?	100	0
6	Do the tasks given help to make ethical/moral decisions?	100	0

Table 7 reveals that all students agreed that the activities assigned throughout the local SSI-based OE3C learning process were highly beneficial in helping them make ethical judgments. They showed that learning about moral concerns was still new and difficult. Student 6 said, "Since the beginning of the implementation of OE3C learning, I have gained a feeling of empathy for social and environmental issues that have arisen. I am not sure if the ethical statement I made at the start of the meeting was accurate or not, but I can think about it at the conclusion."

Additionally, Student 7 said, "I could not explain my feelings or moral decisions at the first meeting, but now that I have had additional sessions, I can express my own opinion on what happened and back it up with a more rational explanation." All the students reported that they comprehended the teacher's explanation of SSI. At the end of the semester, Student 9 demonstrated a better comprehension of the opinions formed in line with the ethical judgments made in public. He said, "We will not be able to make the proper ultimate conclusion (leading to the right moral option) if we do not grasp what SSI is and how to write ethical views accurately from the start. The arguments must include data and evidence, and the reasoning must be consistent with the idea or theory." Almost every student (95.83%) reported that the OE3C learning processes and learning media assisted him/her in comprehending the content. Furthermore, every

single student (100%) acknowledged that LKS guided him/her during this educational session. Students can form various viewpoints, gain confidence, and build scientific understanding of each issue covered through OE3C learning in the local SSI environment. Students are better equipped to create narratives scientifically as their scientific understanding grows.

Students said they could express their opinions to others using evidence and examples to back up their claims. Student 9 stated, "There is a section of the project that requires me to create an ethical story, which helps me think more creatively and critically. The challenge of producing an ethical story aided me in extensively developing my knowledge and how I used it to solve difficulties in everyday life." The context of socioscientific makes chemistry study more meaningful (Holbrook, 2005). Table 7 shows that all students think that studying using a local SSI-based OE3C is particularly motivating in gaining a deeper comprehension of the content and having ramifications in everyday life.

Studying ethical decision-making and self-investigation in local SSI-based OE3C is a strength of this learning, according to some students, because it helps them solve real-life difficulties. First, it teaches students to explore preliminary investigations by asking questions and collecting relevant facts. Second, the OE3C technique teaches students how to use the structure of scientific reasoning to explain ethical jud-

gments connected to morals to peers. Student 10 stated, "Studying under these circumstances is important for me because I need to develop the habit of communicating more rationally and thinking more about society's common good." Student 11 came to the same conclusion, "I should make excellent judgment feasible while keeping society's moral interests in mind; therefore, scientific evidence, concepts, and theories must be used to support my conclusion." As a result, students believe they can apply the skills and knowledge acquired through OE3C learning in the local SSI context to their everyday lives.

### CONCLUSION

In comparison to guided inquiry learning, the results of this study show that using the OE3C learning technique in the local SSI context increases students' scientific literacy. Students in the SSI-based OE3C group showed higher scientific literacy than those in the guided inquiry group. Students accept the local SSI-based OE3C learning strategy well. In the context of local SSI, most students (77.78%) were very happy to be introduced to and study with OE3C learning strategies. Furthermore, using SSI-based OE3C learning, as many as 11.11 percent (very good) and 77.78% (good) students said they could understand the substance of thermochemical material and the reaction rate. This conclusion is supported by the fact that 95.83% of students consider learning to use local SSI-based OE3C learning steps to develop a deeper comprehension of the content effectively. Furthermore, all students mentioned that they were allowed to reflect on their learning to apply the experience in everyday life. Learning in the context of a local SSI aids students in achieving their objectives and understanding scientific principles that may be implemented in real life. Teachers need to incorporate local SSI into chemistry instruction. This is also done to assist students in developing a grasp of chemical principles, applying their knowledge in everyday life, and improving students' thinking skills in order for them to become responsible citizens in the future.

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