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Using Scaffolding Set to Help Student Addressing Socio-Scientific Issues in Biochemistry Classes

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Most students have difficulty explaining socio-scientific issues (SSI) scientifically due to lack of relevant prior knowledge, difficulty connecting with science ideas, and societal concerns of SSI. Unfortunately, scaffolding sets that can be used to help students explain SSI have not available yet. This study aimed to develop a scaffolding set to help students have sufficient prior knowledge of biochemistry relevant to SSI, connect with biochemistry ideas and societal concerns of SSI. A scaffolding set model was developed using instructional design model. Validity and practicality of the scaffolding set data were analyzed descriptively, while effectiveness of scaffolding set was analyzed descriptively and using dependent t-test and N-gain. Data analysis results showed that the scaffolding set was valid, easy to implement, and effective aiding 88 students (21 excellent and 67 non-excellent students) explain SSI scientifically. More than 95% of excellent and 80% of non-excellent students were in high (some medium) connection with biochemistry ideas and societal concerns. The scaffolding set helped students explain biochemistry aspects and context of SSI. The finding implies that students need scaffolding, while teachers need scaffolding set to aid their students in SSI-based science teaching and learning to scientifically explain SSI.

Keywords: biochemistry ideas, college student, prior knowledge, scaffolding set, socio-scientific issues, societal concerns

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INTRODUCTION

In Indonesia, the widespread use of social media makes it easier for students to receive and share information, including socio-scientific issues (SSI). Most SSIs spread on social media in Indonesia are written in social language in macroscopic fashion, communicative, and easy to understand (Erman et al., 2020). Some of the SSIs are hoaxes, such as weather manipulation by solving salt in the water to form rain and controversial news such as athletes who lost in a sports competition due to fatigue. Many studies considered currently hoax and controversial SSI that are relevant to students and science content as the productive context in science learning, especially for developing critical thinking skills and logical argumentation (Hancock et al., 2019; Hofstein et al., 2011; Marks and Eilks, 2010; Stolz et al., 2013) and even scientific literacy (Erman et al., 2020; Sholahuddin et al., 2021). Unfortunately, many students and teachers were found to have difficulty explaining SSI scientifically and contextually (El Arbit & Tairab, 2020; Erman et al., 2020; Erman & Sari, 2019; Erman et al., 2021). This condition creates the potential for misleading information for students (Zeidler & Nichols, 2009) and even misconceptions (Erman, 2017; Taber, 2011).

Viewed from the framework of SSI-based learning, to explain SSI, a connection with SSI's science ideas and societal concerns is needed (Friedrichsen et al. 2016; Hancock et al., 2019; Presley et al. 2013; Sadler et al. 2017). The results of our previous research (Erman et al. 2020) found that several factors determine the ability to explain SSI, such as prior knowledge of science relevant to science ideas of SSI, ability to understand academic textbooks as well as context (Dunlop & Veneu, 2019; Erman et al., 2021; NRC, 2012), and the ability to transform across contexts, such as transformation from a biochemical context (textbook) to a social context (SSI) or vice versa (Linn & Elyon, 2006). In addition, the difficulty of connecting with science ideas is mainly due to the macroscopic nature of SSI so that science only appears to be implicitly involved (El Arbit & Tairab, 2020; Erman et al., 2020).

Students who have previously participated in conventional teaching and learning of biochemistry (such as listening to lecturer' explanations) may have sufficient prior knowledge to be used in explaining SSI (Erman et al., 2020; Erman et al., 2021). If the initial knowledge is still lacking, students can add to it by reading relevant textbooks to have sufficient prior knowledge of biochemistry to explain SSI. However, this did not happen because students had difficulty understanding biochemical material through lecturer' explanations and textbooks. Biochemical material in textbooks is challenging to understand because it is complex, symbolic, abstract, and uses scientific language (Dunlop & Veneu, 2019; Erman et al., 2021; NRC, 2012). Consequently, students were difficult connect with biochemistry ideas of SSI.

From a cognitive constructivist perspective, students who have difficulty connecting with science ideas and societal concerns need help to explain SSI (Palmer, 2005; Vygotsky, 1998). Unfortunately, there is very little research, and we have not even found any study on scaffolding to help students connect with SSI's science ideas and societal concerns. Therefore, research is needed to find the best way to help students connect with science ideas and societal concerns in various life contexts.

This study will develop a scaffolding set to help students connect with science ideas and societal concerns explain SSI in biochemistry class. The scaffolding set developed in this study consists of 3 components: scaffolding for prior knowledge of biochemistry, 2) scaffolding to connect to biochemistry ideas of SSI, and 3) scaffolding to connect to the context of SSI. The scaffolding is done by providing connection guidance with SSI step by step, which is equipped with examples. Connecting with science ideas and societal concerns are required to explain SSI, learning science meaningfully, and protecting students from information misleading. and even misconception.

Macroscopic View of Biochemistry in Socio-Scientific Issues

Socio-scientific issues of biochemistry are the intersection between biochemistry and the context of social life, such as health, nutrition, and sports. Biochemical processes in cells play a vital role in maintaining health, such as impaired glucose metabolism that causes diabetes mellitus due to lack of the hormone insulin. Nutrients that enter the body are biochemically processed to produce energy and synthesize various new compounds, such as carbohydrates and proteins. Sports activities begin with cell activity and increase cell performance (Viru & Viru, 2001).

Despite biochemistry studies processes in cells (Erman et al., 2021), SSI of biochemistry in various social or digital media is generally written macroscopically (Erman et al., 2020). As a result, biochemistry does not appear even though it is implicitly very closely related to SSI. As a result, reading SSI is identical to reading newspapers or magazines. Without adequate biochemical knowledge, SSI is only understood macroscopically but not scientifically.

Microscopic View of Biochemistry in Textbooks

Biochemistry studies chemical reactions in cells (Viru & Viru, 2001). Textbooks generally present cellular biochemical processes theoretically, microscopic, scientific, and less contextual subjects (Erman et al., 2021). Biochemical aspects include concepts, principles, and theories are written using scientific language, symbols and equipped with complex biochemical reactions (Erman et al., 2020; Erman et al., 2021). Although biochemical indicators are often used as indicators of health and exercise performance, such as lactic acid levels, blood fatty acid levels, and blood glucose levels, they are rarely linked contextually in textbooks. Biochemistry textbooks also contain abstract concepts, symbolic, and complex material (Erman et al., 2020; Johnstone, 1991). Such biochemistry appearance, which is an academic subject and is not contextual, makes biochemistry in the textbook less interesting to read and difficult to understand (Erman et al. 2020; Erman et al., 2021). Abstract thinking skills are needed to understand abstract concepts or microscopic views.

Unfortunately, many studies (such as Erman & Wakhidah, 2021; Çepni et al., 2004; Darwish, 2013) found that students' abstract thinking skills needed to study biochemistry have not been developed optimally. The lacking abstract thinking skills will lead students to have difficulty in explaining microscopic biochemistry aspects of SSI (Wooley et al., 2018).

The Framework of SSI-based Learning

SSI-based Learning emphasizes the importance of connecting with science ideas and societal concerns as shown in Figure 1.

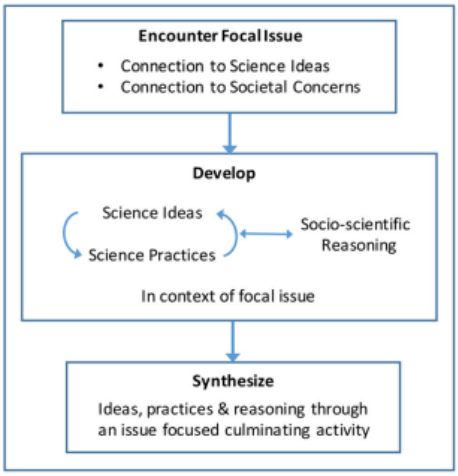

Figure 1
SSI-based teaching and learning framework (Handcock et al., 2019)

These connections are needed to build a frame of mind in the SSI context to explain SSI and even solve problems in the SSI context (Friedrichsen et al., 2016; Presley et al., 2013; Sadler et al. al. 2017).

The SSI-based learning framework is very functional, significantly helping students explain SSI. Unfortunately, the framework has not yet provided a solution to help students who have a connection with science ideas and societal concerns.

Connections with science ideas will occur if all aspects of science involved in SSI, both explicit and implicit, can be explained scientifically (Erman et al., 2021). Likewise, connections with societal concerns (Owens et al., 2021) will be easy to do if students are familiar with and work in that context.

Scaffolding Principles in Addressing Socio-Scientific Issues

From a cognitive constructivist perspective (Palmer, 2005; Vygotsky, 1998), students who cannot explain SSI are caused by the individual capacities of students, mainly thinking skills, such as abstract thinking skills (Darwis, 2013; Erman & Wakhidah, 2021; Shayer & Adey, 1993; Wooley et al., 2018). Scaffolding is the solution to help students connect with science ideas and societal concerns (Ertmer & Cennamo, 1995), especially when students need it and under assignments that require assistance.

Scaffolding can be divided into conceptual, procedural, and metacognitive scaffolding (Hannafin, Land, & Oliver, 1999). The scaffolding depends on the students and the tasks done by students who need scaffolding (Alake & Ogunseemi, 2013). Therefore, the factors causing learning difficulties or completing student assignments in their actual

zone need to be identified before deciding on the type of scaffolding and how the process is carried out.

In this study, we use cognitive scaffolding to help students connect with SSI. The scaffolding is a guided procedure, including conceptual and metacognitive, and provides examples and instructions for addressing SSI (Erman et al., 2020; Palmer, 2005). The steps in addressing SSI can be done through 4 steps, namely: 1) identifying aspects of science in SSI, 2) defining each identified aspect of science, 3) describing every aspect of science, and 4) explaining aspects of science (Erman et al., 2020). The feasibility of the scaffolding set developed is determined based on validity, practicality, and effectiveness (Nieven & Plomp, 2018). The scaffolding set can be used as a guidance in SSI-based teaching and learning of science, explain SSI and solving related problems, and promoting students' scientific literacy.

This study will focus on four problems: 1) how can students explain biochemical aspects of SSI before and after following the scaffolding set? 2) what is the percentage of students who connect with biochemistry ideas before and after participating in SSI-based biochemistry learning? 3) what percentage of students have connections with societal concerns (SSI context) before and after participating in SSI-based biochemistry learning? and 4) what is the scaffolding set? worth using to help students explain aspects of biochemistry and connections with SSI?

METHOD

To answer the problem of this study, a modification of the instructional design model (IDM) (Ituma, 2015) which consists of four stages, namely 1) designing a scaffolding set prototype, 2) scaffolding set validation, 3) scaffolding set testing, and 4) scaffolding revision was applied in this study. For the pilot study, a pre-post-tests one group design was used to determine the effectiveness of scaffolding.

Participants

A scaffolding set was the subject of this study. To determine the effectiveness of the scaffolding set, a total of 88 students (10 males and 78 females) who were studying biochemistry in Science Education Department in a university in Indonesia voluntarily participated in the SSI-based biochemistry learning. The students were divided into three groups, namely group A consists of 21 excellent students and two groups (B and C groups) consists of 67 non-excellent students. These students are different in English language proficiency skills, but academically are relatively the same. Excellent students (group A) are better in English language proficiency skills than others (B and C groups). The students have previously participated in basic chemistry and basic biology courses during their first-year college and has just also participated in a conventional biochemistry class for 7 weeks. Therefore, it can be assumed that these students had sufficient prior knowledge of biochemistry before attending the SSI-based learning.

Instruments

This study used a set of data collection tools that consists of six rubrics, a questionary, and an observation sheet for the implementation of scaffolding. The list of the rubrics is Rubric 1 to assess the ability to identify biochemical aspects of SSI, Rubric 2 to assess

the ability to define biochemical aspects of SSI, Rubric 3 to assess the ability to describe biochemical aspects of SSI, Rubric 4 to assess the ability to connect to these aspects. Rubric 5 assesses the ability to connect to societal concerns and Rubric 6 to determine the criteria for connection to SSI. The questionary consists of ten statements and ten statements for students before and after following the scaffolding. All the instruments have been validated by three experts from Chemistry Education, Biology Education, and Science Education.

Table 1
Rubric validation

Validation aspects	Validator			
	1	2	3	Modus
Rubric 1: Identify	3	4	4	4
Rubric 2: Define	4	4	4	4
Rubric 3: Explain	4	4	4	4
Rubric 4: Connect to science ideas of SSI	4	4	4	4
Rubric 5: Connect to societal concerns (SSI context)	4	4	4	4
Rubric 6: Criteria to determine connection level to science ideas and societal concerns	4	4	4	4
Category	High validity	High validity	High validity	High validity

Based on Table 1, all the rubrics used are declared to be valid with high validity categories to be suitable for use in this study.

Table 2
Questionary validation

Validation aspects	Validator			
	1	2	3	Modus
Guidance to response questioner • Guidance is easy to understand • Guidance helps respondents to answer question • Guidance is complete • Grammar and spelling are good	4	4	4	4
Before scaffolding • Statement/question items are complete • Statement/question items are understandable • There are a balance portion of negative dan positive statements • Suitable for learning-based SSI	4	4	4	4
After scaffolding • Statement/question items are complete • Statement/question items are understandable • There are a balance portion of negative dan positive statements • Suitable for learning-based SSI	4	4	4	4
Category	High validity	High validity	High validity	High validity

Based on Table 2, the questionnaire was declared with a high validity category. It was feasible to use it to determine student responses about the scaffolding set that they participated in this study.

Data Collection

Data was collected in three stages. First, the validity of the scaffolding set and its supporting tools through expert consideration using a validation form. Second, the practicality of scaffolding was collected through observing the implementation of learning using scaffolding sets and student responses through questionnaires after participating in scaffolding. Third, the effectiveness of scaffolding sets in helping students explain SSI using ability assessments: 1) identify, define, and explain biochemical aspects, 2) connections with biochemistry ideas and connections with SSI contexts (societal concerns). The effectiveness of the scaffolding set is carried out in 2 stages; namely, stage 1 is limited to the superior class (group A), and stage 2 is carried out on two regular classes (group B and C).

Data Analysis

The data that has been collected was analyzed in 3 stages. First, the theoretical validity of the scaffolding set and its supporting tools was analyzed descriptively using modus scores. Based on modus score, scaffolding set validity are classified into four categories, namely: high validity (modus score 4), medium validity (modus score 3), low validity (modus score 2), not valid (modus score 1). Second, analysis of the practicality of scaffolding set was carried out descriptively using modus scores. Based on modus score, scaffolding set practicality are classified into four categories, namely: very good practicality (modus score 4), good practicality (modus score 3), low practicality (modus score 2), very low practicality (modus score 1). Third, analysis of the effectiveness of scaffolding set to help students' constructing prior knowledge by identifying, defining, and explaining biochemistry aspects of SSI using dependent *t*-test and *N*-gain analysis, with low (*N*-gain score: < 30%), medium (*N*-gain score: 30-70%), and high (*N*-gain score: > 70%) categories (Hake, 1998). Meanwhile, students' connection with biochemistry ideas and societal concerns were analyzed descriptively using four categories of connection, namely: high connection (H), medium connection (M), low connection (L), and no connection (NC). The connection level is determined based on the criteria as shown in Table 3.

Table 3
Criteria to determine students' connection to science ideas and societal concerns

SSI aspects	Rubric	Connection
Science Ideas (Biochemistry aspects)	if all explicitly biochemistry aspects (EBA) and ≥ 50% implicitly biochemistry aspects (IBA) are identified, defined, and explained	H (high)
	if ≥ 50% of EBA and < 50% IBA are identified, defined, and explained	M (medium)
	if < 50% EBA and < 50% IBA are identified, defined, and explained	L (low)
	if < 50% EBA and 0% IBA are identified, defined, and explained	NC (no connection)
Societal concerns (SSI context)	if all question aspects of who, where, when, what, why, and how (W5H) of general information and ≥ 50% biochemistry are answered correctly	H (high)
	if all question aspects of W5H of general information and <50% biochemistry are answered correctly	M (medium)
	if < 50% question aspects of W5H of general information and < 50% biochemistry are answered correctly	L (low)
	if < 50% question aspects of W5H of general information and 0% biochemistry are answered correctly	NC (no connection)

FINDINGS

The results of this study consist of the validity of scaffolding set, scaffolding practicality, and scaffolding effectiveness.

Validity of Scaffolding Set

Table 4
Validity of scaffolding set

Aspect of validation	Score modus	Category
Introduction Motivating students, explaining objectives, and guideline	4	High validity
Scaffolding stages Exploring of SSI, identifying, defining, describing, and explaining biochemistry aspects, and applying biochemistry aspects to explain SSI	4	High validity
Scaffolding of students' prior knowledge of biochemistry Stages and structure of scaffolding, relevant to SSI, and spelling and grammar of instruction	4	High validity
Scaffolding to connect to biochemistry ideas of SSI Stages and structure of scaffolding, relevant to SSI, and spelling and grammar of instruction	4	High validity
Scaffolding to connect societal concerns (SSI context) Stages and structure of scaffolding, relevant to SSI, and spelling and grammar of instruction	4	High validity
Ending scaffolding Conclusion, reflection, and strengthening	4	High validity

Table 4 shows that the scaffolding set is valid in the very good category so that it is feasible to use scaffolding for students to address SSI.

Scaffolding Set Practicality

Table 5
Modus score of the implementation of Scaffolding Set in each group

Observation of scaffolding implementation	Group			Category
	A	B	C	
Introduction Motivating students, explaining objectives, and guideline	4	4	4	Very good
Scaffolding stages Exploring of SSI, identifying, defining, describing, and explaining biochemistry aspects, and applying biochemistry aspects to explain SSI	4	4	4	Very good
Scaffolding of students' prior knowledge of biochemistry Stages and structure of scaffolding, relevant to SSI, spelling, and grammar of instruction	4	4	4	Very good
Scaffolding to connect to biochemistry ideas of SSI Stages and structure of scaffolding, relevant to SSI, spelling, and grammar of instruction	4	4	4	Very good
Scaffolding to connect societal concerns (SSI context) Stages and structure of scaffolding, relevant to SSI, spelling, and grammar of instruction	4	4	4	Very good
Ending scaffolding Conclusion, reflection, and strengthening	3	4	4	Very good

Table 5 shows that the implementation of the scaffolding set in the excellent students (group A) and the non-excellent students (group B and C) received an observer rating of each with a mode score of 4 (very good). This shows that the scaffolding set is considered quite practical.

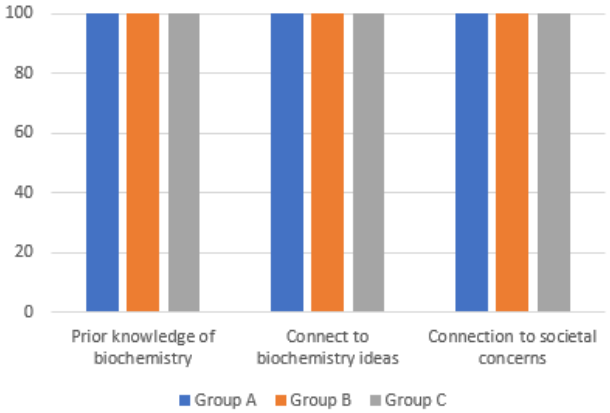

Figure 2
Percentage of the implementation of scaffolding set in A, B, and C groups

Figure 2 shows that all scaffolding set activities were implemented optimally (100%) in excellent students (group A) and non-excellent students (group B and C).

The Effectiveness of Scaffolding Set

Table 6
The *t*-test result of scaffolding students' prior knowledge of biochemistry from group A

Prior knowledge of biochemistry	Scaffolding for group A N = 21				
	Md	Sd	*t*	*p*	η^2
Identify (I) Pre-post-test	51.95	5.08	10.23	.00*	2.23
Define (D) Pre-post-test	51.05	4.92	10.38	.00*	2.27
Explain (E) Pre-post-test	50.90	4.90	10.38	.00*	2.27

Note: Md = mean of the difference; Sd = standard deviation of the difference; p* < .05; η^2: size effect

Table 6 shows that the ability of excellent students (group A) in identifying, defining, and explaining biochemical aspects of SSI has increased significantly with a large effect size after participating in SSI-based learning with a scaffolding set.

Table 7
The *t*-test result of scaffolding students' prior knowledge of biochemistry from group B

Prior related biochemistry	Scaffolding for group B N = 35				
	Md	Sd	*t*	*p*	η^2
Identify (I) Pre-post-test	51.40	2.71	18.97	.00*	3.21
Define (D) Pre-post-test	50.74	2.49	20.39	.00*	3.45
Explain (E) Pre-post-test	50.00	2.42	20.64	.00*	3.49

Note: Md = mean of the difference; Sd = standard deviation of the difference; p* < .05; η^2: size effect

Table 7 shows that the non-excellent (group B) students' ability to identify, define, and explain biochemical aspects in SSI has increased significantly with a large effect size after participating in SSI-based Learning with a scaffolding set.

Table 8
The *t*-test result of scaffolding students' prior knowledge of biochemistry from group C

Prior related biochemistry	Scaffolding for group C N = 32				
	Md	Sd	*t*	*p*	η^2
Identify (I) Pre-post-test	48.31	3.37	14.34	.00*	2.53
Define (D) Pre-post-test	46.34	3.25	14.25	.00*	2.52
Explain (E) Pre-post-test	46.66	3.27	14.28	.00*	2.53

Note: Md = mean of the difference; Sd = standard deviation of the difference; p* < .05

Table 8 shows that the non-excellent (group C) students' ability to identify, define, and explain biochemical aspects of SSI has increased significantly with a large effect size after participating in SSI-based Learning with a scaffolding set.

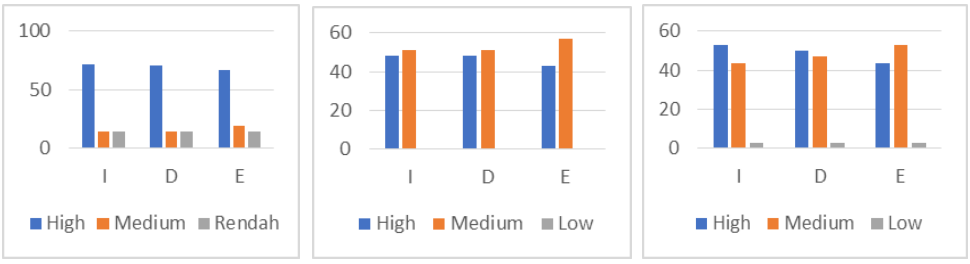

Figure 3
Percentage of students' prior knowledge of biochemistry from group A, B and C groups in each category of *N*-gain

Figure 3 shows that the ability of excellent students (group A) in identifying, defining, and explaining biochemical aspects of SSI increased with a high *N*-gain category after participating in SSI-based Learning with scaffolding. However, in non-excellent groups, the *N*-gain value of the ability to identify, define, and explain biochemical aspects in the high and medium categories, even in class C, was still low (< 5%).

Table 9
Percentage of the student from the excellent group A in connecting to biochemistry ideas and societal concerns

Connect to	Before scaffolding				After scaffolding			
	H	M	L	NC	H	M	L	NC
Biochemistry ideas	0	0	0	100	76.19	19.05	4.76	0
Societal concerns	0	0	0	100	95.24	4.76	0	0

Note: H= high; M= medium; L= low; NC = not connected

Table 9 shows that more than 75% of excellent group A students whose connections with biochemistry ideas have increased to reach the high category and 19% in the medium category. Less than 5% of students are still in the low category. However, 95% of excellent students are connected to the SSI context (societal concerns).

Table 10
Percentage of B grade students who are connected with biochemistry ideas and societal concerns

Connect to	Before scaffolding				After scaffolding			
	H	M	L	NC	H	M	L	NC
Biochemistry ideas	0	0	0	100	42.86	54.29	2.86	0
Societal concerns	0	0	0	100	82.86	17.14	0	0

Note: H = high; M = medium; L= low; NC= not connected

Table 10 shows that only 42% of students from group B are connected with biochemistry ideas in the high category and 54% are still in the medium category. Less than 5% of students are still in the low category. However, more than 80% of students from group B are already connected to the context of SSI (societal concerns).

Table 11
Percentage of class C students who have connections with biochemistry ideas and social concerns

Connect to	Before scaffolding				After scaffolding			
	H	M	L	NC	H	M	L	NC
Biochemistry ideas	0	0	0	100	53.12	34.38	3.12	9.38
Societal concerns	0	0	0	100	59.38	31.25	3.12	6.25

Note: H= high; M= medium; L= low; NC= not connected

Table 11 shows that more than 50% of students from group C are connected with biochemistry ideas in the high category and 34% are still in the medium category. Less than 10% of students are still in the no connection category. As many as 59% of students from group C are connected to the context of SSI (societal concerns) in the high category and 31% in the medium category. As many as 6% are still no connection.

Table 12
Response of students to scaffolding set

Number of item	Statements	Response	
		Agree	Not agree
	Before scaffolding	(%)	(%)
1	I like learning biochemistry through SSI	92.86	7.14
2, 3, 10	It is easier to learn biochemistry from SSI than textbook	28.57	71.43
4	Understanding biochemistry from SSI is useful for daily life	100	0
5	I have lack prior knowledge of biochemistry	100	0
7	SSI is closely related to biochemistry	100	0
6, 8	It is easy to identify, define, and explain biochemistry aspects of SSI	42.86	57.14
9	It is difficult to apply biochemistry to explain SSI	85.71	14.29
10	It is difficult to understand biochemistry in the textbook	78.57	21.43
	After scaffolding		
1, 5, 10	Scaffolding helps me explain SSI scientifically	92.86	7.14
2, 3, 6	Scaffolding stages are structured systematically and easily	92.86	7.14
4, 9	Scaffolding helps me identifying, defining, and explaining biochemistry aspects of SSI	85.71	14.29
4, 7, 8, 9	Scaffolding helps me explain biochemistry aspects that are not written in SSI text (implicitly)	100	0
6	I am difficult to understand biochemistry in textbooks	42.86	57.14

Table 12 shows that students responded very positively to the scaffolding set because it was considered to help them explain SSI scientifically, including biochemical aspects of SSI.

DISCUSSIONS

The results of this study indicate that before receiving the scaffolding set, excellent students from group A (Table 9) and non-excellent students (B and C groups) (Table 10

and Table 11) were not connected with biochemistry ideas and societal concerns. Although students were interested to learn biochemistry from SSI (Table 12), the student was unable to identify, define, and explain the biochemical aspects of SSI due to lack of prior knowledge of related biochemistry. The inability to explain the biochemical aspects of SSI makes it difficult to explain SSI (Erman et al., 2020) because it is not connected to scientific ideas and societal concerns (Handcock et al., 2020; Owens et al. 2021). However, after receiving the scaffolding set, more than 95% of students from the excellent group (group A) could connect with biochemistry ideas, and 100% of the excellent students were connected with societal concerns (Table 9). A total of 75% and 95% of excellent students connected with biochemistry ideas and societal concerns, respectively. Similar to the excellent group, more than 80% of non-excellent students (B and C groups) were connected with biochemistry ideas and societal concerns (Table 10 and Table 11). However, less than 5% of non-excellent students still have difficulty connecting with biochemistry ideas and societal concerns because they were not actively participating in scaffolding activities.

The results of the scaffolding implementation show that the scaffolding set developed is eligible (Figure 2 and Figure 3) to help excellent and non-excellent students connect with biochemistry ideas and societal concerns that are needed in SSI-based Learning (Figure 1) (Friedrichsen et al. 2016; Hancock et al., 2019; Presley et al. 2013; Sadler et al. 2017). The importance of connection with science ideas and societal concerns has also been found in many previous studies, such as Handcock et al. (2019), Owens et al. (2021), Kampourakis (2016), Steven et al. (2005), Walker and Zeidler (2007), and Zimmerman (2000), mainly to explain SSI. However, none of these studies explained how to help students connect with science ideas and societal concerns in SSI-based teaching and learning.

The scaffolding set consists of 3 components: 1) prior knowledge biochemistry scaffolding, 2) biochemistry ideas connection scaffolding, and 3) societal concerns connection scaffolding. These scaffoldings are unity and hierarchical. To be success in any scaffolding (for example scaffolding 2), student must be success in scaffolding 1. Students' connections with science ideas and societal concerns increase after scaffolding due to their ability to explain related biochemical aspects of SSI increased during the scaffolding set implementation. The finding clarifying to the results of our previous study that students had difficulty explaining SSI due to lack of prior related biochemical knowledge (Erman et al., 2020; Erman et al., 2021). In general, the initial knowledge of biochemistry that students received through a conventional teaching are commonly not contextual. Consequently, it cannot help students connect with SSI's biochemistry ideas in the context of health and sports (Erman et al., 2020). Scaffolding 1 helps students identify, define, and explain biochemical aspects in SSI, starting from what is written explicitly in the illustration of the SSI news to the unwritten (implicit) of related biochemistry aspects of SSI. The role of scaffolding 1 recognized by students (Table 6, Table 7, and Table 8) can help students explain biochemical aspects in SSI.

Cognitive connections with science ideas and societal concerns help students carry out transformations across contexts (Linn & Lyon, 2006; Owens et al., 2021; Hancock et al.,

2019). Linn and Lyon (2006) argue that cross-context transformation is a major challenge in context-based learning, including SSI-based learning. That is why many studies (such as Owens et al., 2021; Hancock et al., 2019; Dunlop & Veneu, 2019) emphasize the importance of connecting with societal concerns in addition to connecting with science ideas when using SSI-based learning. We consider that the connection with societal concerns focuses on the SSI context to facilitate the transformation process, such as from the sports context to the biochemical context.

The success of the scaffolding set in helping students connect with science ideas and societal concerns supports the results of previous studies, such as Walker & Zeidler (2007) and Wakhidah (2016), who scaffolded student learning through scientific inquiry and other scaffolding implementation, such as Alake (2013), Miao (2012), Quintana et al. (1999), about the importance of scaffolding students who have learning difficulties. The scaffolding is needed in some cases to help students learn science, especially to explain information widely spread on various social media and the internet to avoid misleading information (Zeidler & Nichols, 2009; Zeidler et al., 2013) and even misconception (Erman, 2017). According to the framework of SSI-based teaching and learning (Figure 1), connecting with SSI will help students to develop socio-scientific reasoning in the context of SSI, so it can be used to solve related problem and creating new ideas. The scaffolding set also facilitates teachers who found have positive views on the SSI (El Arbit & Tairab, 2020) to promote students' scientific literacy (Erman et al., 2020; Fadly, et al., 2022; Romine et al., 2016; Sholahuddin et al., 2021). In addition, connecting to social concerns facilitating students to develop characters in the context of SSI focal, such as environmental issues (Sholahuddin et al., 2021; Wakhidah & Erman, 2022), health and sports issues (Erman et al., 2020).

The study findings imply that in learning, many students need help or scaffolding to explain SSI and solving problems. Scaffolding is needed in the digital era where all information is packaged macroscopically and but requires mastery of science and technology to explain it.

The scaffolding sets still need to be tested further, even though we believe that scaffolding is still needed. In addition, the scaffolding set that we developed is still tested in biochemistry in the context of health and sports, so it still needs to be tested on other topics that are simpler and more familiar to students' lives.

CONCLUSION

This study concluded that students generally could not explain SSI because of difficulties in explaining biochemistry aspects of SSI, difficulty connecting with biochemistry ideas, and difficulty connecting with societal concerns. Prior to scaffolding, students were unable to identify biochemical aspects, both explicitly written in SSI news and not written but implicitly related to SSI after participating in a conventional teaching of biochemistry. According to SSI-based teaching and learning framework, to explain and solving related problems of SSI and creating new ideas, students must be connected with the science ideas and social concerns of SSI.

The scaffolding set developed in this study is appropriate to help students improve prior knowledge of biochemistry relevant to SSI, connections with biochemistry ideas, and

societal concerns. In this scaffolding set, scaffolding students to identify, describe, and explain biochemical aspects that are written explicitly in SSI (macroscopic) is the initial stage. In these processes, textbooks can be used, and examples can be provided if needed. Second, students are scaffolded to relate the written biochemical aspects of SSI with those that are not written but implicitly related to SSI (microscopic) by identifying, describing, and explaining as many biochemical aspects as possible that are implicitly related to SSI. Third, scaffolding students to connect with the societal concerns of SSI using W5H questions (who, where, when, what, why, and how). Lastly, using biochemistry knowledge and contexts concerns, scaffolding students to explain SSI scientifically. The feasibility of scaffolding sets for use in SSI-based learning is demonstrated by its validation, practicality, and effectiveness in helping students connect with SSI. Scaffolding sets can also be used for scaffolding high, medium, and low ability students. However, this study only tried to scaffold students to explain SSI during biochemistry class. Further research to implement scaffolding set in other subjects and to solve related problems of SSI and promoting students' scientific literacy are urgently recommended to protect students from information misleading and misconceptions.

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