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Socioscientific Issues Approach in Analytical Chemistry Learning for Enhancing Food Safety Literacy

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Abstract. Health issues that occur in society today are increasingly complex. To deal with health issues caused by consuming unsafe food, students need to be equipped with food safety literacy. This literacy can be improved through relevant and humanistic learning approaches, including socioscientific issues (SSI) learning. The SSI approach uses complex, controversial, and contemporary social issues in learning. This research aims to enhance students' food safety literacy through the SSI approach in analytical chemistry learning. The study used a quasi-experimental method with a non-equivalent control group design. The research samples were undergraduate pharmacy students who were taking analytical chemistry courses namely food analysis, at one university. The sample was taken by purposive sampling of as many as 106 students, consisting of 53 class A students as a control group who used problem-based learning and 52 class B students as an experimental group who used the SSI approach to problem-based analytical chemistry learning. The instrument was in the form of food safety literacy questions total of 40 multiple-choice questions, which have been declared valid and reliable. The research was conducted in seven class meetings over seven weeks. Pretests and posttests were carried out in each class, followed by the N-Gain test to determine the increase in the average grade of the class and the Mann-Whitney difference test to determine the significance of the difference in scores between the two classes. The results showed that the experimental class experienced a higher average score increase with an N-Gain value of 0.62 compared to the control class with an N-Gain value of 0.47, even though both were still in the medium category. The pretest results of the experimental class were no different from the control class with a significance value of 0.681. The posttest results of the experimental class were significantly different from the control class with a significance value of 0.013. Therefore, the SSI approach in problem-based analytical chemistry learning enhances food safety literacy.

INTRODUCTION

Health issues that occur in society today are increasingly complex. To face those complex problems, students need to be equipped with a set of skills that are often known as global competency. This competency can be achieved through humanist and relevant education to overcome problems involving several areas of life (UNESCO, 2013a). One component of global competency that is useful for dealing with complex problems in the field of public health is health literacy (UNESCO, 2013b).

Health literacy needs to be provided to students so they can actively participate in overcoming health problems in their personal and community (Vamos et al., 2020). Health literacy is a cognitive and social skill that underlies a person's motivation and ability to understand and use health information to achieve sustainable health (WHO, 2008). According to Subiantoro et al. (2021a), health literacy is the adequate ability to respond wisely to health problems.

SSI (Socioscientific Issues) learning is one of the relevant and humanistic learning methods to overcome complex societal issues. SSI learning is multidisciplinary learning that uses societal issues that are controversial, contemporary, and open-ended (Atabey, 2021; Dawson & Carson, 2018; Zeidler & Nichols, 2009), as well as relating to science and technology conceptually and procedurally (Sadler, 2011; Zeidler et al., 2002). Therefore, SSI increases the relevance between the abilities acquired in the classroom and their usefulness in society (Ewing & Sadler, 2020).

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Public health issues related to food safety have the potential to serve as a context for SSI learning. Food is a primary need that has a major impact on people's health. Food safety has become a public health issue because almost one in three diseases in the world today is caused by the consumption of unsafe and unhealthy food (Sulistyawati, 2021). Since 2007, food-causing diseases have been one of the main world health problems in the 21st century (WHO, 2007).

Food safety issues have been used in several learning development studies. Choi & Lee (2021) developed inquiry learning using food additive safety issues to improve mastery of scientific concepts and problem-solving. Wiyarsi et al. (2021) also, develop inquiry learning using food additive safety issues to improve scientific thinking habits and chemical literacy. Subiantoro et al. (2021b) use the issue of food preservative safety in problem-based learning to improve mastery of science concepts. Calik & Karatas (2019) and Wiyarsi & Calik (2019) use functional beverage safety issues to improve scientific thinking habits.

Food safety can be guaranteed through a series of tests. Food safety in terms of chemical content can be tested using chemical analysis. The chemical concept of qualitative analysis is useful for identifying what substances are contained in food. The chemical concept of quantitative analysis is useful for determining what levels of substances are contained (Gandjar & Rohman, 2015). Safe and nutritious food plays an important role in improving the level of health and intelligence in society (PP RI No. 28, 2004). Food safety is closely related to the presence of chemicals and biological substances that disturb and endanger health (PP RI No. 86, 2019). Therefore, food safety literacy includes chemical literacy, biological literacy, and health literacy.

Achieving food safety literacy through learning can be made easier with the SSI approach. Subiantoro et al. (2021b) implemented SSI learning based on food additive safety issues to increase health literacy in biology learning, which is carried out in an inquiry manner. Besides that, Wiyarsi et al. (2021) also use the SSI approach in a health context in biochemistry courses to increase chemical literacy. However, there has been no SSI learning research that specifically aims to increase food safety literacy, especially for students who will later work in the health and food sector, such as pharmacy students. This research aims to increase students' food safety literacy using the SSI approach to analytical chemistry learning.

RESEARCH METHODS

The research was carried out using a quasi-experimental method by taking samples not randomly so that a homogeneous sample was obtained. The independent variable is the SSI approach to analytical chemistry learning. The dependent variable is food safety literacy. The research design was a nonequivalent control group design, which was carried out by providing unequal treatment between groups. The control class was given problem-based learning with cases created by a team of lecturers, and the experimental class was given problem-based learning using the SSI approach. However, both classes were given a pretest and a posttest using the same questions.

The research was conducted at one of the pharmacy faculty in Central Java, Indonesia. The population studied were all undergraduate pharmacy students who were taking courses in food analysis, one of the analytical chemistry course groups. Samples were taken by purposive sampling based on considerations so that the samples met the inclusion requirements according to the research objectives. The sample consists of two classes, namely class A as the control group and class B as the experimental group.

The research procedure consists of two stages. The first stage is the learning implementation. Problem-based learning using the SSI approach (SSI-PBL) was adopted and modified by Subiantoro et al. (2021a) and Choi & Lee (2021). Learning was carried out through six stages over 7 weeks: (1) orientation and problem analysis; (2) clarifying the background of the problem; (3) determining the socio-scientific dimension; (4) discussing and evaluating different points of view; (5) reflection; and (6) evaluation. The second stage is analyzing pre-test and post-test data and then concluding.

Data analysis in this study used descriptive and inferential analysis techniques. The qualitative-descriptive analysis is expressed in the form of a description of information based on certain categories. Meanwhile, quantitative descriptive analysis uses the N-Gain calculation formula to analyze the increase in score average before and after learning. The N-Gain value consists of three criteria, namely low (0.00–0.29), medium (0.30-0.69), and high (0.70–1.00) (Hake, 1999). Inferential analysis with the Mann-Whitney test to determine the differences in food safety literacy between the experimental class and control class was carried out with the SPSS software.

DISCUSSION

This research aims to increase food safety literacy through the SSI approach to analytical chemistry learning for pharmacy students. Analytical chemistry was chosen for implementation because this course studies various analytical methods to identify and determine the levels of chemical compounds contained in a product (Gandjar & Rohman, 2015). One of the analytical chemistry course groups in the undergraduate pharmacy study program that has the potential to increase food safety literacy using the SSI approach is Food Analysis. This course studies the theory and application of analytical chemistry to determine the substances contained in food, both nutrients and anti-nutritional substances or dangerous substances (Rohman & Sumantri, 2013). Food analysis is a mandatory course with prerequisite courses in instrumentation chemistry and organic chemistry.

The subjects studied were pharmacy students because they met the inclusion criteria, students who were required to have the competence to assure the safety of food and drug products based on regulations of the health minister. The sample consisted of 105 students, consisting of 53 students from class A and 52 students from class B. Class A as the control group used PBL learning, and class B as the experimental group used PBL learning with the SSI approach.

The instrument used to collect pre-test and post-test data is 40 multiple-choice questions with a maximum score of 40 points. The instrument has been declared valid by three experts in the fields of education, pharmaceutical sciences, and health sciences. Apart from that, the food safety literacy instrument has also been declared reliable. The food safety instrument is composed of 7 dimensions with 12 indicators adopted from 4 chemical literacy dimensions (Schwartz et al., 2006; Witte & Beers, 2003) and 3 health literacy dimensions (Nutbeam, 2000). The preparation of the instrument was based on aspects of food safety that are closely related to the presence of chemical and biological substances that disturb and endanger health (PP RI No. 86, 2019).

This research applies a problem-based learning (PBL) model because several researchers have succeeded in developing this learning model within global health issues for pharmacy students, although none has aimed to increase health literacy. McKeirnan et al. (2023) implemented problem-based learning using childhood HIV issues to improve the knowledge and attitudes of pharmacy students in the United States. Subin et al. (2023) also applied PBL to increase mastery of the concept of side drug reactions among health students in India, including pharmacy students. Anaam (2023) also implemented PBL using the COVID-19 issue to improve the knowledge and attitudes of pharmacy students in Yemen.

The research was conducted for 7 weeks with 7 meetings in class. The learning model applied is problem-based learning with the SSI approach (SSI-PBL), which was adopted and modified by Subiantoro et al. (2021a) and Choi & Lee (2021). Learning was carried out through six stages: 1) orientation and problem analysis; 2) clarifying the background of the problem; 3) determining the socio-scientific dimension; 4) discussing and evaluating different points of view; 5) reflection; and 6) evaluation. Activities per week are shown in Figure 1 below:

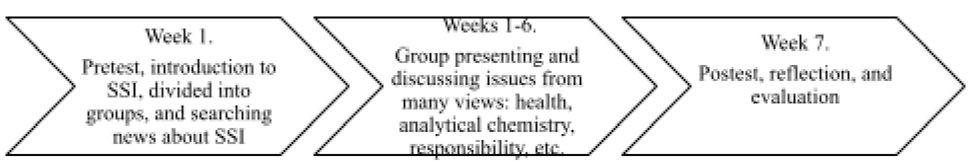


FIGURE 1. *Stages of SSI-Problem-Based Learning.*

In Figure 1, it can be seen that students did the pretest questions in the first week and did the posttest in the seventh week. After taking the pretest, students are then divided into groups consisting of 3 or 4 people per group, taking into consideration the effectiveness of group work. The division is based on topics discussed in the food analysis learning material, which include the safety of sweeteners, colourings, preservatives, and genetically modified food products.

Students who have been grouped then searched for news about food safety issues from several web-based news sources using their gadgets and laptops. News sources are limited to only national news portals with consideration the news has gone through a guaranteed editorial process. The topics chosen by students are discussed first with the lecturer so that they get the appropriate issues for the learning objectives. Selecting the right issue topics to be discussed in learning is key to implementing SSI (Hancock et al., 2019). Three examples of news about food safety issues that students chose are shown in Figure 2 below.

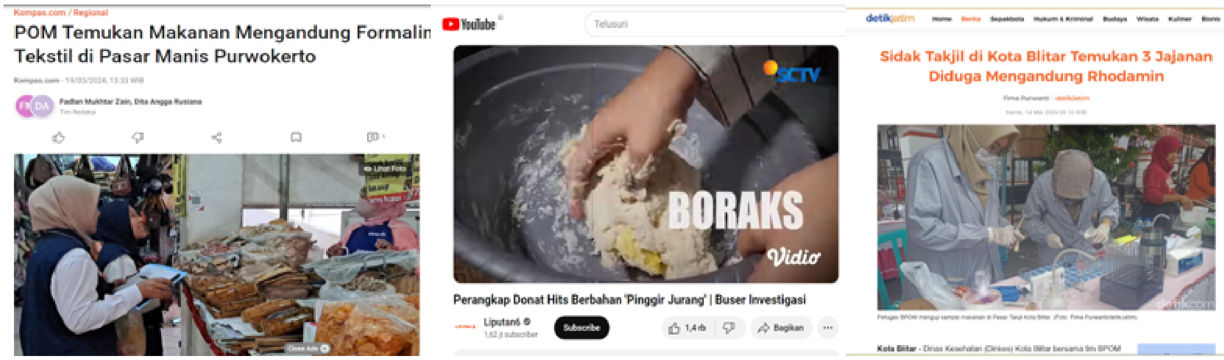


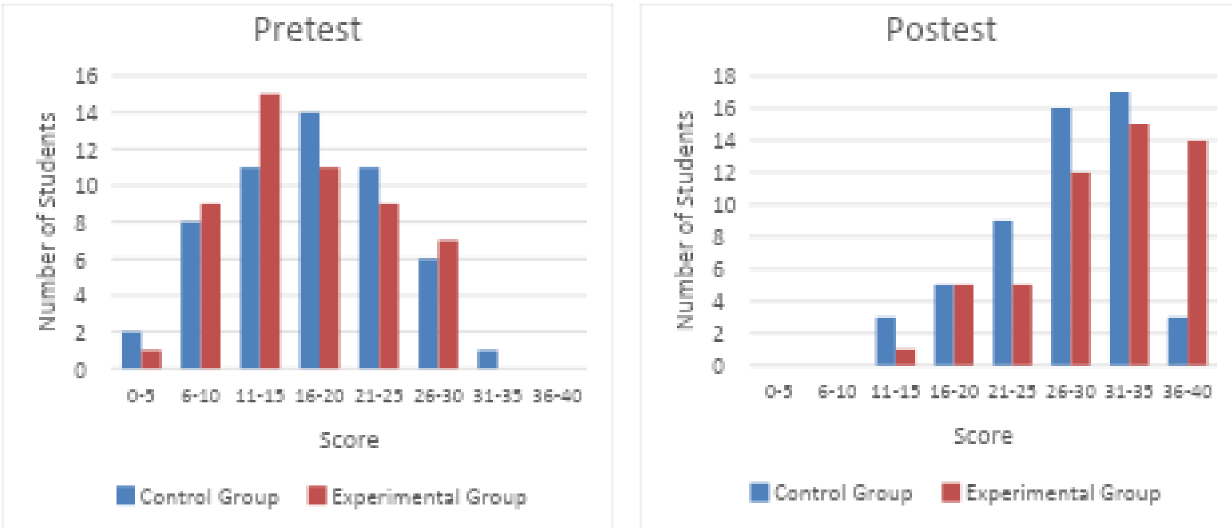
FIGURE 2. *Examples of News About Food Safety Issues.*

From the second to the sixth weeks, students present their group work in the form of PowerPoint presentations in front of the class and during class discussions. The presentation contains the causes of the issues of unsafe food, its impact on health, and analytical chemical procedures for identifying and determining the levels of chemical compounds in food and determining food safety based on health regulations. The presentation and discussion can be seen in Figure 3.

FIGURE 3. *Implementation of SSI-Problem-Based Learning with Food Safety Issues.*

Each group had a 10-minute presentation followed by a 20-minute discussion. So, in one meeting three groups were presenting, guided by one of the students from that group as moderator. Discussions are carried out based on questions from students participating in the class. The lecturer observed and at the end of the meeting, helped students clarify their answers.

Post-tests, reflections, and evaluations were carried out in the seventh week. The pretest and posttest results in class A as the control group and in class B as the experimental group can be seen in Figure 4. The frequency distribution of pretest scores for classes A and B normally follows a normal distribution curve. The highest score range in the control class is 16–20; in the experimental class, it is 11–15. However, statistical analysis needs to confirm this descriptive determination by calculating a recap of centrality values and the distribution of pre-test and post-test score data.



(a) (b)

FIGURE 4. *Distribution of Frequency of (a) Pretest and (b) Posttest Scores for Control and Experimental Classes.*

A centrality of values and distribution of pretest and posttest score data is in Table I below. Both classes produced almost the same average pretest score, 17.0 for the control class and 16.8 for the experimental class. These results indicate that the students's initial abilities between the two groups are equivalent, so they are representative of comparison tests as a control group and an experimental group. These two average scores are below the middle score which indicates that students' abilities in both classes are still low.

Based on Table I, it is also known that the distribution of pretest scores in the control class and experimental class are wide with a standard deviation is 6.99 and 7.02, respectively. These values indicate that students' initial abilities in both classes are evenly distributed. Table I also shows that the centralization and distribution of post-test score data for the control class and experimental class are descriptively different, with respective score averages of 27.7 and 30.48. These results indicate that the use of SSI in analytical chemistry learning has an impact on the class average score.

TABLE I. *Centralization and Distribution of Pretest and Post-test Scores of Control and Experimental Classes.*

Data Centralization and Distribution	Pretest		Postest	
	Control	Experiment	Control	Experiment
Lowest score	4	3	11	14
Highest score	31	32	37	40
Score averages	17.0	16.8	27.7	30.48
Standard Deviation	6.99	7.02	5.83	6.46
Significance of normality	0.074	0.914		

The achievement of food safety literacy competency in the control and experimental classes is shown in Table II, with the respective indicators in detail. Based on Table II, it can be seen that the achievement of competency during

 QRCBN 62-6861-0508-697
https://proceeding.unnes.ac.id/icmse

the pretest on all indicators is still low in both the control and experimental classes. However, both classes in basic and critical health indicators have reached the medium category, which means students already have medium health literacy before learning food analysis.

TABLE II. *Achievement of Food Safety Literacy Competency*.

Dimension	Indicator	Achievement			
		Average of Pretest Score		Average of Postest Score	
		Control	Experiment	Control	Experiment
Content knowledge	1	Low	Low	Medium	Medium
	2	Low	Low	Medium	Medium
Context knowledge	3	Low	Low	Low	Low
High-order thinking and learning	4	Low	Low	Medium	High
	5	Low	Low	Medium	Medium
	6	Low	Low	Low	Low
Affective	7	Low	Low	Low	Medium
	8	Low	Low	Medium	Medium
Basic health	9	Medium	Medium	Medium	Medium
Communicative health	10	Low	Low	Low	Low
	11	Low	Low	Medium	High
Critical health	12	Low	Low	Medium	Medium

Description of score achievement:
Low (0-13), Medium (14-27), High (27-40).

The increase in N-Gain per food safety literacy indicator can be seen in Figure 5. It can be seen that the increase in the average value of the control class is relatively flat for all indicators. The highest average increase value was found in the content knowledge indicator in the medium category, and the lowest average increase value was in the basic health indicator in the low category. Meanwhile, in the experimental class, the highest increase in the class average value was in the effective communication indicator, and the lowest average increase in basic health indicators was also in the low category. These results indicate that the SSI approach cannot improve the basic health literacy of students who, from the start in Table II, already have basic health literacy in the medium category.

QRCBN 62-6861-0508-697
https://proceeding.unnes.ac.id/icmse

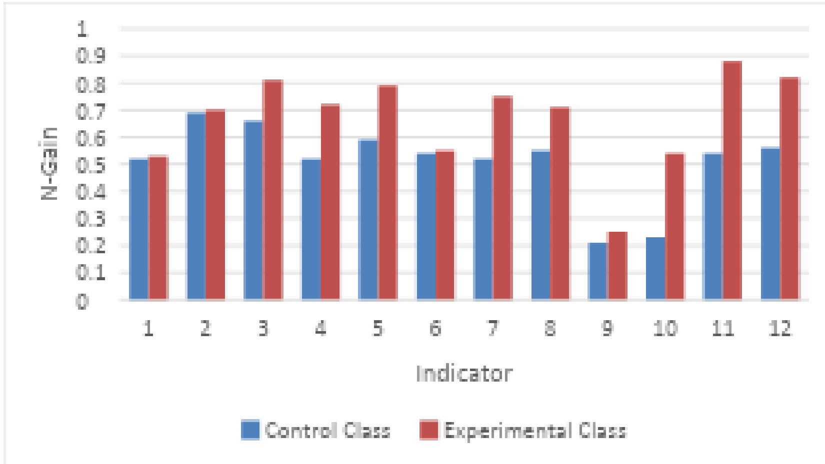


FIGURE 5. *The Enhancement of Food Safety Literacy in Each Indicator.*

Figure 5 also showed that there was a higher increase in the average N-Gain value of the experimental class compared to the control class. Based on analysis, the N-Gain for the experimental class is 0.62 and for the control class is 0.47. These results indicate that the SSI approach to problem-based analytical chemistry learning can increase food safety literacy to a greater extent than problem-based learning with problem cases created by lecturers.

Inferential analysis was carried out to determine differences in food safety literacy levels and increases in average scores in the control class and experimental class. Before carrying out the difference test, a prerequisite test for statistical analysis is carried out in the form of a test of the data distribution for each group and the homogeneity of the data. This prerequisite test aims to determine the type of statistical analysis that will be used, whether parametric or non-parametric, based on the normality and homogeneity of the data.

The data distribution test for pretest and post-test scores in the control and experimental classes was carried out using the Kolmogorov-Smirnov normality test, considering the sample size was more than 50 people. The significance level used is 5%, or 0.05. The normality test for the control and experimental class pretest scores produced significance values of 0.074 and 0.914. These two significance values are greater than the 0.05 significance level, so it means that the pretest scores for the control class and experimental class are normally distributed.

The homogeneity test was carried out on two groups of data, namely pre-test score data for both classes and post-test score data for both classes. This test aims to determine whether an object has homogeneous variants or not. The homogeneity test was carried out using the Levene statistical test with a significance level (α) of 5% or 0.05. The homogeneity test obtained a significance value for the pretest score of 0.072 and for the posttest score of 0.101. These two values are greater than the 0.05 significance level, so it means that the pretest and posttest data are homogeneous, even though the difference between the two values at the significance level is very small.

The results of the statistical analysis prerequisite tests, consisting of data distribution tests and homogeneity tests, are used to determine the type of statistical analysis to be used next. The experimental class posttest scores were not normally distributed, even though the other data were normally distributed and the overall data had a homogeneous variance. Based on these results, the statistical analysis used is non-parametric. This decision was taken because the data was not normally distributed, so it was analyzed using non-parametric statistics with the Mann-Whitney difference test (Sugiyono, 2010).

The difference test was carried out using the Mann-Whitney test with a significance level of 5% or 0.05 on the post-test score in the control class and experimental class. The Mann-Whitney test was also carried out on the pretest score in both of classes. The difference test obtained a significance value for the pretest score is 0.681 which is greater than 0.05, which indicates that the average pretest score for the control class and the experimental class was not significantly different. Meanwhile, the difference in post-test scores between the two classes was 0.013 which is less than 0.05, which indicates that the post-test scores for the two classes were significantly different.

QRCBN 62-6861-0508-697
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CONCLUSION

The SSI approach in problem-based analytical chemistry learning can significantly enhance food safety literacy. The experimental class experienced a higher average score increase with an N-Gain value of 0.62 compared to the control class with an N-Gain value of 0.47, even though both were still in the medium category. The pretest results of the experimental class were no different from the control class with a significance value of 0.681. The posttest results of the experimental class were significantly different from the control class with a significance value of 0.013. Furthermore, the research aims to find a learning model for enhancing food safety literacy in the high category.

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