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IMPLEMENTATION OF SSI CONCEPT MAPPING AS A DYNAMIC LEARNING ENVIRONMENT TO ENHANCE STUDENTS' SCIENTIFIC PERFORMANCE

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Introduction

For an efficient learning environment, students must recruit and accommodate their scientific performance, especially their findings of potential influence in socio-scientific issues (SSI) in the classroom. Developing a basic SSI concept mapping (SSICM) for problem-solving guiding is the main challenge for students in their comprehensive understanding of the learning process. Scholars focus much on the enhancement and narrative of students' conceptual reasoning skills rather than on the conceptualization of their dependence (Eichler & Peebles, 2016; Norris & Philips, 2012; Sadler et al., 2016). They use comprehensive conceptual approaches of reasoning skills to guide their learning, which is an innovative educational trend in science. Most students demonstrate they are cognitive by implementing problem-solving skills for the deductive development of the science curriculum teaching (Lopez et al., 2014). Today, SSI's dynamic focus is on the students' reasoning skills and sustainable development as higher systematic education. Most students with reasoning skills will reveal that participation in decision-making processes and the argumentation of social issues (Barrue & Albe, 2013; Chin et al., 2016; Halim & Saat, 2017; Tekbiyik, 2015).

Socio-Scientific Issues (SSI)

With the emergence of more comprehensive scientific topics, students followed their conceptual reasoning skills in the mind to present. They carefully selected the professional details of the SSI argument to apply reasoning skills to kick-start their development of concept reasoning thinking which had become the basic scientific literacy in reading, writing, and decision-making (Chin et al., 2016; Kolsto, 2006; Uskola et al., 2010). Scholars (Sadler & Zeidler, 2005; Tsai, 2018) pointed out that the SSI's characteristic was related to the connotation of multidisciplinary and cross-disciplinary scientific learning, and that the resolution of issues involved ethical and moral dilemmas. Therefore, SSI teaching was multi-faceted by science and ethical complexities.



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Abstract. *The presented research focuses on verifying the confluent application of concept mapping (CM) and socio-scientific issues (SSI) according to the value-laden and moral dilemma orientation to construct problem-solving performance. This research sets up some perspectives for all 146 participants, including 139 students and 7 experts. All findings reveal that the design of SSICM contexts includes a rebuttal process and incense claim to improve students' argument response (16.4%), to increase content knowledge and illuminate their science learning by argumentations. To develop an assessment tool with high validity and reliability (Cronbach's $\alpha > .9$) and find positive presentations of all learning attitudes in the SSICM context, learning environment and results will concern the best argumentation process. Students' interview responses and SWOT analysis of teachers indicate that SSICM's use of argument in the classroom is a real benefit. The research provided a better paradigm of attempts to combine analytical and academic hypotheses to explain literature sources by teachers, researchers, textbook developers, and editors.*

Keywords: *concept mapping (CM), problem-solving, socio-scientific issues (SSI), SSICM contexts*

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SSI Problem-Solving

In constructing a more effective way, we could divide students' reasoning ability into two demonstration groups. Because most students usually carry out problem-solving in the algorithmic memory of cognitive abilities without authentic reasoning skills for conceptual understanding (Cracolice et al., 2008; Fernandez et al., 2013). Fernandez et al. had adopted the latest reasoning techniques corresponding to their argumentation performance of high order thinking to avoid problem-solving through algorithmic learning. Students had elaborated on Toulmin's (1958) argumentation factors, such as data, claims, quality of supporting grounds, and rebuttals. Toulmin's interpretation of conceptual reasoning techniques provided a direct need for students to have group discussions in argumentative skills and enlighten their applications on enhancing their scientific performance.

Most students could not solve problems by reasoning skills and provide a comprehensive concept of understanding in Toulmin's illustrations since poor basic science backgrounds. Without overall reasoning skills, students would embrace a memory-like learning environment. Cracolice et al. thought that the conceptualization would appear in subordinate status under the guidance of reasoning skills step by step to scrutinize a comprehensive understanding. However, students would be satisfied with their learning motivations under the SSI learning program. The major strategies of SSI learning would help them to develop scientific literacy, interpretation, and narrative skills in small group discussion classes (MoNE, 2013; Sadler, 2011). Bulte et al. (2006) analyzed water quality through SSI teaching and found that 70% of students could answer the question accurately. In addition, students would lift their proposals and scientific reasoning skills to an innovative level of new learning achievement (Day & Bryce, 2011). Dawson and Venville (2013) used quasi-experimental methods to assess the results of SSI biotechnology teaching with students from two learning groups. The results of the experimental group students showed that the strategy application performed better than the students in the control group did. This research also provided another fundamental concept mapping research approach for students to cultivate their conceptual reasoning skills.

Concept Mapping

As scholars had pointed out, concept mapping (CM) was an effective cognitive learning tool with many characteristics of scientific paradigm transfer, such as integration, parsimony, visibility, and versatility (Rumelhart & Norman, 1985; Su, 2018). CM was a meaningful teaching method proposed by Novak and Gowin (1984) 37 years ago, based on Ausubel's theory (1968) of meaningful learning. CM was also a learning strategy for students' organization, categorization, analyses, estimation, and reasoning (Peng et al., 2009; Schultz, 2008; Selvaratnam & Canagaratna, 2008). Students could use CM to operate their cognitive learning tools in science classes and present their problem-solving skills in scientific learning (Nicoll et al., 2001; Sevia et al., 2015; Su, 2017). Many researchers pointed that CM was more than just a potential learning strategy with a meaningful model and authentic teaching tool with efficient assessment.

SSICM Problem-Solving

To cultivate students' logical critical thinking, promote the hierarchical development of cognitive knowledge, activate scientific inference, solve controversial problems and realize the goal of scientific learning, needs to propose strategic skills. These skills included tactic argumentation skills of SSI (Tsai, 2018), effective cognitive learning tool of CM (Sadler, 2011), and reasoning skills of problem-solving (Su, 2017). The combination of SSI and CM would provide students with better learning guidance on the decision-making of "reducing or extinguishing incense between indoor and outdoor" by the SSICM strategy. As a result, SSICM's strategic promises made instructors' teaching effective and students' learning interests. On these grounds, there were three SSICM problem-solving skills in science class, such as guiding positive learning attitude, stimulating enthusiasm for learners, and improving students' thinking ability. Therefore, the purpose of this research was to provide specific guidance on value-laden and moral dilemma orientation based on SSICM's performance and feedback analysis of students' problem-solving.

Research Purpose

To students' requirements of science learning, this research developed a newly designed SSICM project to assess thinking ability in science. Because of the scientific understanding of students' core concepts, this research proposed four research objectives, as follows:



- 1) To design student SSICM argumentation contexts and guide students through learning subjects;
- 2) To stimulate enthusiasm for learning and improve students' high-level argumentative thinking ability through SSICM contexts;
- 3) To construct validity and reliability of SSICM perception questionnaire as an effective evaluation instrument;
- 4) To assess learning attitude, feedback, and SWOT analysis.

Research Questions

Based on the above four objectives, three specific research questions were designed to assess the conceptual performance of students, as follows:

- 1) What do SSICM optimal contexts design to evaluate their high-order argumentation skills?
- 2) What does an assessment instrument fulfill in their practicable performance of validity and reliability?
- 3) What does the domain of students' thinking skills examine with an assessment instrument?
- 4) What is students' learning attitude, feedback, and SWOT analysis to promote their fundamental scientific understanding through argumentation?

Research Methodology

General Background

The primary research background included students' real-world learning guidance, data collection, group argumentation, decision-making, and presentation of SSICM contexts. The scope of this research came from students' elective natural science education courses, which it took from the author's general education program. The program lasted two hours a week and a total of 12 hours on SSICM argumentation teaching. Therefore, there were certain restrictions on students' learning scenarios and scientific inference. The research topic involved the life science demonstration of "reducing or extinguishing incense between indoor and outdoor." The research results needed to indicate SSICM research topics, teaching methods, discussion modes, and study evaluation to construct a positive learning environment and improve students' scientific cognition performance. All students' arguments provided a reasonable claim to persuade each other and made a final decision after two controversial argumentation discussions. Students achieved effectiveness argumentation assessment following the natural science learning objectives within six weeks during the 2019/9~2020/6 academic year. They took part in SSICM's rebuttal and claimed incenses from a new perspective of argumentation to improve their scientific learning skills and abilities.

Participants

To enhance students' reasoning skills, problem-solving, and decision-making in science by integrating SSI subject design into CM. As above results, all 146 participants included 139 respondent students and 7 specific experts. In terms of students, a total sampling of 139 participants (including aged distribution from 20 to 22; gender distribution 75 males and 64 females) came from the Hungkuo Delin University of Technology in Taiwan. There were 75 students to engage in the pilot study for development with the pre-knowledge of general nature course at the first stage. Other 64 students took part in the evaluations of the experimental research with new perspective of argumentation at the second stage as the required sample of this research. All 139 students who took part in the study gave information and agreed with ethical approval in conjunction with this research (Su, 2021; Taber, 2014). In terms of experts, seven participants engaged in the research, including three science educators, two social experts, and two psychologists. In the light of some suggestions and comments received from all experts, they logically revised and reviewed the intelligibility of the questionnaire draft and their suitability to the student level to construct optimum experts' content validity. All validities included assessing the readability, accuracy, and applicability of the questionnaire content.



Research Framework

This research developed the SSICM questionnaire as an assessment instrument to examine students' comprehensive profound understanding and learning attitude in life science. The results were discussed with compared, analyzed, and critically considered with other published articles. Therefore, the framework of this research would state as follows:

To control variables, this research would control some characteristics, such as teachers' teaching, the same content, the same time, the same evaluation instruments, and other variables, to reduce interference with the results.

- 1) To dependent variables, the research included two controversial argumentation groups, one in group E1, which made positive arguments, and the other group, E2, which made opposite arguments. At the end of the course, all students conducted posttests and learning attitude questionnaires and used all scores as a dependency variable.
- 2) To independent variables, the statistical data of students consisted of gender, age, and experimental group as independent variables.

Instrument Design

The argument learning attitude questionnaire included three parts, such as all participating students' fundamental background, open-ended argumentum test items, and learning attitude questionnaire test items. In the first part, students' background data included their gender and age as independent variables. Next up were the open-ended argumentum test items, which scored according to the criteria in Table 1 (Sadler & Donnelly, 2006) as prior knowledge of pre-test and subsequent dependent variables for the SSICM post-test. To assess students' learning achievement through argumentation participation and advanced thinking ability of SSICM problem-solving skills by taking pre-test and post-test (Lopez et al., 2014). Marzano's learning objectives kept from retrieval, compression, analysis to knowledge utilization, included in the pilot test items (Sadler & Donnelly, 2006; Su, 2021; Toledo & Dubas, 2016) as the revised resources. Finally, the attitude questionnaire test items according to the 5-point Likert scale and Su's draft (2018) to design. Seven experts acted as consultants to review and examine the content validity of the questionnaire design of the argumentation and learning attitude. This research resulted in a two-stage construction validity from a valid sample of 75 pilot tests. The first stage with significant Kaiser-Meyer-Olkin (KMO) and the second stage with six Eigenvalue ($E > 1.0$), and Cronbach's α value ($> .9$) displayed internal consistency inspection. According to Salta and Tzougraki's research (2004), the questionnaire considers with more reliable than others do. There are a total of 30 questions in the learning attitude questionnaire, some of which are summarized as follows: Item 1, SSICM is integrated into the curriculum design of teaching, which is the type of learning I want; Item 2, SSICM is integrated into the curriculum design, which can guide me to study with all my heart; Item 3, The curriculum design of SSICM integrated into teaching is helpful to my study.

Table 1

Response Scored Standard of Students for Open-ended Argumentum Test Items

Contents of response	Score
Blank, no answer or vindicate	0
Only accept, agree or vindicate without argumentation	1
Give some simple argumentations to vindicate	2
Provide some smart argumentations	3
Not only provide some smart argumentations but also have opposite views	4

Six subscales named from six Eigenvalue as the following:

- Q1, students' learning attitude towards SSICM text design style;
- Q2, students' learning attitude towards the presentation of SSICM context;
- Q3, students' learning attitude towards SSICM teacher teaching;
- Q4, students' learning attitude towards SSICM's argumentation environment;



Q5, students' learning attitude towards problem-solving activation SSICM argumentation participation; and Q6, students' perception attitude towards SSICM argumentation text learning results.

Based on the above structural questionnaire, this research provided semi-structural interviews to present their opinions and critical thinking on their SSICM argumentative learning feedback. It included SSICM content design, demonstration process, problem-solving ability, strategy learning perception, and SSICM overall teaching feeling.

Research Design

For this research, all 64 participants needed to separate two controversial argumentation groups. After completing the six-week SSICM class for 12 hours, students took a post-test and learning attitude questionnaire. Finally, six students from two controversial argumentation groups were randomly selected for interviews to understand their learning feedback. Previous studies had shown that argumentation was a teaching method to help students reason, demonstrate and solve problems. The three components of argument included data, justifications, and claimed to review reasonableness and made decisions to accept or refute (Toulmin, 2003). Two controversial students' groups used rational expressions to support or refute opinions about the disputation scenario.

According to Toulmin's argumentation factors, data, claims, supporting reasons, and rebuttals, indoor and outdoor gave to reduce or extinguish incense because incense burning was the source of the environmental hormone, with low toxicity dangerous substances, often neglected in life. Zeidler et al. (2005) suggested that SSI demonstration teaching would integrate social culture, basic science, and dilemma issues to improve the functionality of scientific concepts. Therefore, based on the students' claim or rebuttal of the debate about burning incense and the environmental hormone, under the guidance of their instructor, they would construct authentic scientific learning literacy.

Data Analysis

Scoring and coding techniques were two procedures for data collection and processing. They were further statistical analysis in this research. Proposed three open-ended questions for reducing or extinguishing incense issues of indoor and outdoor in pre-test and post-test. Firstly, to set a blank score of 0 points with no answer or proof. Secondly, to score 1 point for only accept or agree or vindicate without argumentation. Thirdly, to provide some simple argument, and give 2 points; Fourthly, to propose some examples, gave 3 points, and lastly, not only did students offer some clever narrations, but you also had the opposite view, gave 4 points. As a result, the total score could be from 0 to 12 points. Supporting for reducing or extinguishing incenses had to strengthen the argument by arguing about causation. In addition, students' responses to rebuttals pointed out arguments and objections to get 4 points in this research. Scoring students on three open-ended questions, each with a maximum of 4 points and got a total score of 12 points, each question had to provide an argument.

All data included quantitative and qualitative results of open-ended argumentation questions, structural questionnaires, and non-structural interviews. Quantitative data were derived from the scores of three open-ended pre-test and post-test questions and learning attitude questionnaires. Qualitative data for follow-up interviews included the design of SSICM content, the demonstration process, problem-solving discussions, perceptions of strategy learning, and students' learning feedback. Each student's interview took about 15 minutes for each conversation. To use a public code (Strauss & Corbin, 1998) to treat document issues and note each event related to participants. Participants focused on scientific arguments and encouraged the sharing of views on their experiences and social science literacy. To process all pre-test and post-test statistics by SPSS 22.0 Windows software to do a job for students' examination performance and attitude analysis of the strategy application in Cronbach's α and descriptive statistical analysis.

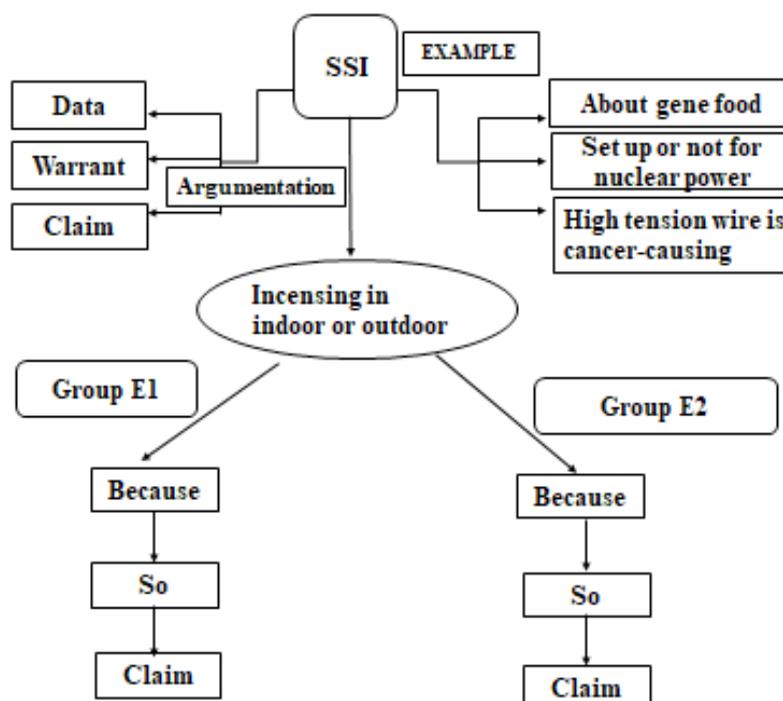
Research Procedures

The SSICM teaching included four categories, such as construction texts, pre-test, learning process, and post-test administrating of learning achievement and perception attitude. In this research, a four-step workflow of the SSICM argumentation learning process is present in Figure 1. Firstly, to identify social science issues and analyze SSICM references in this research. Secondly, to construct SSICM argumentation techniques and complete



the demonstration teaching strategy. Thirdly, to develop learning achievement and questionnaire test items to assess students' learning performance in science. Lastly, to introduce the improvement of students' decision-making behavior and compare it with the students' learning achievements of pre-test and post-test.

Figure 1
Argumentation Process of Two Controversial Groups



Research Results

In the learning process of SSICM contexts, this research presented the students' quantitative, qualitative results and stylistic performance. Quantitative results included students' open-ended demonstration achievement tests, response rates, and learning attitudes. Qualitative results included student interviews and teacher SWOT analysis. In response to rapid and positive results, students' arguments for SSICM learning activities were consistent with their scientific cognitive comprehension. The results of quantitative and quality argumentation were complementary representations of students' profound understanding of the SSICM. The results of all students' demonstration of SSICM learning activities indicated a positive discussion in the following.

Constructing SSICM Contexts

The research uses Toulmin's argumentative framework to design teaching activities, including two controversial groups and SSICM learning activities (shown in Figure 2). The SSICM argumentation contexts included a rebuttal process and incense claim. The SSICM argumentation context included Ausubel's construction learning theory (1968), Toulmin's framework (1958), and Novak's concept mapping (Novak, 2010). The argumentation issues discuss incenses with a rebuttal and claiming, shows in Figure 2 and Figure 3. In Figure 2, E1 refers to the incense bases on many harmful and toxic chemicals. They will harm the skin, eyes, and central nervous system and even cause to risk of lymphoma and cancer. E1 will claim that students cultivate invisibly, heart incense, and hands-on sacrifices in Taiwan; In Figure 3, E2 claims that the incense is on high-quality traditional handicrafts, high prices, not carcinogens, but purely natural and traditional incense. Chemical incenses are low quality, low prices, carcinogen, harmful to health. Therefore, E2 claims that incense worship provides truth, ethical value, and cultural heritage,

so it will not be reduced or extinguished. All SSICM controversial argumentation activities guide communication and promote their narration in science.

Figure 2
Argumentation Contexts of SSICM -- Rebuttal of Incenses, Group E1

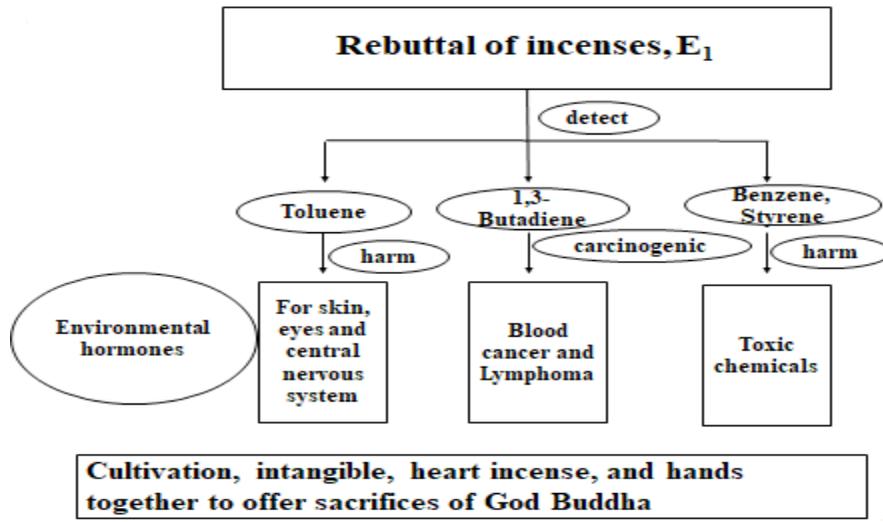
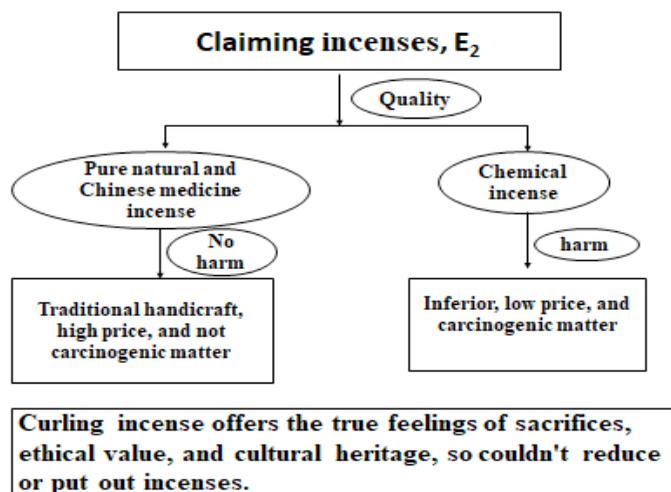


Figure 3
Argumentation Contexts of SSICM – Claiming Incenses, Group E2



Argumentation-based Responsive Results

Students' open-ended argumentation response to pre-test and post-test learning results is related to their scientific understanding of refuting or advocating incense in SSICM contexts, shows in Table 2. In Table 2, students in the three test questions for the argument post-test, in the 0-score answer rate, that blank, no answer or proof, 12%, cut down 28.9% from the pre-test. All students presented low-order cognitive thinking skills to a correct



percentage of 0 and 1, down from 65.5% in the pre-test to 32.3% in post-test one. In the argumentation, students who received two scores for moderate cognitive thinking increased from 31.6% in the pre-test to 48.4% in the post-test, an increase of 14.8%. Further, the students' scientific understanding and SSICM's high-level cognitive thinking ability of the main results proved the correct response rate of 3 and 4 scores, from the pre-test of 2.9% to the measured 19.3% of the post-test. Using scientific demonstration to improve students' learning achievement was a feature of this research.

Table 2

Students' Pre-test and Post-test of Correct Answering Rate (%) for Open-ended Argumentum Questionnaire

Score	Item 1		Item 2		Item 3		Average	
	Pre-test	Post-test	Pre-test	Post-test	Pre-test	Post-test	Pre-test	Post-test
0	8.8	4.7	49.1	14.1	64.9	17.2	40.9	12
1	47.4	31.3	15.8	20.3	10.5	9.4	24.6	20.3
2	40.4	60.9	29.8	40.6	24.6	43.7	31.6	48.4
3	3.5	3.1	5.3	23.4	0	23.4	2.9	16.7
4	0	0	0	1.6	0	6.3	0	2.6

Table 3 demonstrates a descriptive statistical analysis of learning attitudes based on the SSI argumentation. In Table 3, all six subscales of learning attitude reveal a total mean score (M) of

3.65, standard deviation (SD) .68, and overall Cronbach's α .956. The Cronbach's α values are in the overall internal consistency in total scales achieves satisfactory statistical results (Salta & Tzougraki, 2004). The statistical average score was above 3.50, and all six subscales achieved positive learning attitudes (Su, 2008, 2018). In subscale Q2, students toward SSICM contexts provided the highest statistical average and expressed a positive learning attitude. Subscales Q2, Q4, and Q6 were better than the total average score, and subscales Q1, Q3, and Q5 are slightly lower than the total average score. Positive presentations of all learning attitudes in the SSICM context, learning environment, and results would concern the best argumentation process.

Table 3

Mean Scores (M), Standard Deviations (SD) and Cronbach's α for Descriptive Students' Statistical Analyses

Dependent Variable	Q1	Q2	Q3	Q4	Q5	Q6	Total
M	3.58	3.73	3.62	3.71	3.58	3.69	3.65
SD	0.66	0.64	0.69	0.71	0.68	0.72	0.68
Cronbach's α	0.924	0.892	0.932	0.913	0.928	0.922	0.956

Perceptions of Science Teacher

Science teachers participated in argumentative learning as a visual evaluation process. They assess different reasons used in science curriculums according to their claims. This controversial argument could produce different results for most students who used Toulmin's (1958) framework in this research. In addition, through SWOT analysis, the science teacher expressed his perceptions that students had a profound understanding of their argumentation-based learning. This SWOT analysis was a creative technique for teachers who evaluated and defined argumentation-based strengths, weaknesses, opportunities, and threats (Jain, 2015). Table 4 presents the SWOT analysis and characteristics of argumentation-based learning for students.

1) Strengths

In this research, students demonstrated three positive factors. Firstly, students observed with great enthusiasm, group discussion, and focused on the progressive attributes. Secondly, students liked new information knowledge, created new problems, and felt curious. The curiosity of the students aroused the interest in demon-



strating scientific knowledge. Finally, students dared to take on challenges and strived to prepare for the best. If students didn't understand the claims who consult the teacher or examine the data, I found that students dared to take on the challenge.

Table 4

SWOT Analysis of Teacher for Students' Argumentation-based Learning

SWOT Analysis	Learning Characteristics
Strengths	Learning with great passion, Like the new knowledge, Have the courage to challenge
Weaknesses	Integrated abilities, Higher order thinking abilities
Opportunities	Team cooperation promotes their learning motivation, Creativity, Endurance
Threats	Reliance runs short, Scarcity of narration

2) Weaknesses

Two challenging attributes demonstrated students' argumentation in class. One was the comprehensive ability instructors found students could still gradually progress in the classroom by integrating into observation, discussion, and interview in the class. Furthermore, high-level thinking ability and the analysis of open-ended questionnaires showed that most students could give simple reasons. For some students, the number of those who provided further justification for refinement had decreased by nearly 20 percentages. There were even fewer counter-arguments that went deeper. Therefore, students needed to develop demonstration skills and develop their high-level thinking ability in scientific learning.

3) Opportunities

In this research, students' argumentations put forward three positive attributes. For example, constructing teamwork, creativity, and endurance to enhance learning motivation. The first attribute described the student presenting himself and sharing it with you. Therefore, students' cooperative learning would help them to think and demonstrate training. The second attribute was that students could use knowledge to create innovative activation applications through discussions and interviews. The last attribute was the endurance of students to collect data from collaborative learning through patience and perseverance. Students used teamwork, creativity, and self-endurance to find many opportunities.

4) Threats

Two threat attributes included a lack of self-confidence and the scarcity of narratives. Argument processes could present students' intentions during science learning. Students lacked self-confidence and would be affected by group discussions in the future. Students with inadequate narrations could influence their ability to observe matters and communicate with others. In summary, students actively used their achievements to control opportunities and gain a competitive advantage with the use of achievements. Students could figure out where to go in the future because advantage would threaten and then turn it into the best opportunity. Overcoming their shortcomings turned into an advantage, looked for a good chance for future development, and improved their high-level thinking abilities.

Students' Learning Feedback

The interview was the need to realize learning feedback after the teaching process of SSICM argumentation. Specifically, the interviews which were summarized as follows:

Q1 Did the environmental issues of indoor and outdoor combined teaching help alleviate or dissipate incense and help you clarify your point of view? Please propose an example to explain.

S1: Burning incense released chemicals, such as benzene, formaldehyde, volatile organic compounds, and PM2.5 particles. All can disrupt gas exchange and cause inflammation of the lungs. Therefore, I think this is air pollution, which will affect personal health.

S2: Guiding mitigation or put out incenses into public thought in government strategies, and gradually accepted the prohibition in depth.



S3: *Most people accepted religious festival incense and could not change the general public's thinking.*

Q2 Did the SSI concept mapping integrate into teaching to help you promote scientific knowledge?

S4: *My scientific knowledge was weaker than others but applied concept mapping in teaching made my logical thinking clearer. It was easier to judge the advantages and disadvantages of festival incense.*

S5: *Using easy-to-understand models to understand religious festivals, students would gain scientific knowledge to solve problems.*

S6: *SSICM teaching methods enabled me to learn many scientific knowledge structures in life, such as cosmetics choices.*

Q3 What was your comment on SSICM integrated teaching? Please give some examples!

S7: *SSICM's text and the teacher's explanation had given me a lot to gain, such as the variety of emerging technology topics with social science issues.*

S8: *I thought SSICM usually added to my scientific knowledge.*

S9: *It was interesting for SSICM to integrate learning, and I could collect data and judge support to promote learning value.*

In summary, students' learning feedback thought that SSICM issues were helpful and meaningful to their argumentative science learning, motivation, and knowledge growth to improve problem-solving skills and put off from the shackles of traditional courses.

Discussion

Constructing Argumentation Texts of SSICM

To guide learning communication to design SSICM argumentation texts, characteristics, visions, and values were driving forces for their advanced thinking abilities in science learning. It might be applied to examine the validity of the argumentative text to improve students' scientific understanding of the SSICM. These contexts improve students' advanced argumentation and narrative, thereby improving their learning skills in science courses. Yahaya et al. (2015) concluded that SSICM context incorporated into the teaching and learning of controversial issues, students' consciousness would indicate a positive impact on their scientific research. From the point of view of conceptual mapping, scholars (Novak, 2010; Soika & Reiska, 2014; Su, 2018) believed that SSICM was not rote but rather helped students achieve learning through communication and discussion. Therefore, researchers (Lin & Mintzes, 2010; Lindahl & Folkesson, 2016; Sadler & Zeidler, 2005; Tsai, 2018) indicated that SSICM context was meaningful and effective for constructing advanced thinking, argumentation ability, and reasoning skill in this research.

SSICM-based Instruction Increased Students' Science Knowledge

The correct percentage of students answering in the pre-test and post-test open-ended questionnaires showed that they used to promote scientific learning outcomes through demonstrated interaction. Many SSICM controversial issues related to the activities in science classes, such as chemistry, social, and environment, all presented their positive conceptions. However, students strived to put forward the learning willingness and efficacy they were required to learn how to participate in SSICM interactive actions (Lee et al., 2013). SSICM would develop students' thinking abilities for sustainable development and demonstrate personal communication skills among people, science, technology, and environments (Lee et al., 2011; Sadler & Zeidler, 2005). Lee et al. (2013) pointed that SSI played a vehicle to promote students' learning character and educational values of global citizens. Students' argumentations could lead to contradictions and cognitive dissonances in the process of SSICM learning (Senemeaud & Somat, 2009). The views of all students would make an effect by SSI education to deepen their moral and ethical literacy. SSICM-based concepts and reasons were integrated into the science classroom to increase content knowledge and illuminate their science learning by argumentations (Sadler, 2011).



Argumentation-based Perception Attitude Questionnaire

Based on this research, the argumentation instruction provided students with two different views on the value and vision of SSICM. A meaningful activity was related to the interaction results between scientific understanding and constructive argumentation skills in the context of the controversial SSICM. Instructors guided students to propose strategic discussions and to make arguments about their claims in two corresponding groups. SSICM-based teaching showed that students had a positive learning attitude towards descriptive statistical analysis. Other researchers had highlighted the findings (Adesope & Nesbit, 2012; Lin & Atkinson, 2011). Such an active learning environment for SSICM would help students present their cooperative attitudes and promote their scientific learning performance (Su, 2018). Tytler (2012) critically evidenced that students could clarify complex scientific concepts and deepen their impressions through SSICM mutual argumentation with classmates.

Teacher and Students' Feedback

Student interview responses and teacher observations indicated that SSICM's use of argument in the classroom was a real benefit. SSICM's argumentation provided benefits, such as students' learning qualities in reading, writing, high order thinking, and problem-solving (Chin et al., 2016; Su, 2020, 2016). From argument to science research, teachers found that students improved scientific knowledge to express the right ideas and positive argumentative attitude in class. Students' feedback from interviews found that argumentation improved learning cognition, meta-cognition reasoning skills, and higher order thinking abilities (Chin et al., 2016). Some student interviews mentioned that SSICM argumentation elements had a warrant, backing, and rebuttal to help cultivate high-level thinking ability in the process of scientific learning. Students were often overwhelmed by controversial social science issues to improve decision-making ability through multiple argumentations. SWOT analysis of teachers indicated that students could use their strengths to identify opportunities and overcome the controversial scientific argumentation in this research. Osborne (2010) and Berland & McNeill (2010) stressed that argumentation would help students build new understandings, give them a chance to justify the claim, and innovate their scientific knowledge. Lee et al. (2013) also reported that students' willingness and effectiveness fulfilled broader interaction with the SSI resolution. This research demonstrated that argumentative thinking would help them achieve a more progressive scientific conceptualization.

Conclusions

The perspective of this research contributed to the SSICM instructional designs, educational researchers, and other related kinds of literature. The function of the SSICM argumentation instrument with high validity and reliability served to assess students' scientific thinking ability, argumentation ability, and reasoning skills about indoor and outdoor areas to inflict reduction or avoidance incenses. The SSICM context was incorporated into the teaching and learning of controversial issues to stimulate more thinking ability in the claim, warrant, backing, and rebuttal arguments by group discussions and teacher guidance. Therefore, the SSICM context was meaningful and effective for constructing their advanced thinking by argumentation ability and reasoning skill in this research.

The three findings of SSICM-based instruction increased their science knowledge to offer several benefits. First of all, the activities of SSICM argumentation related to interdisciplinary learning, such as chemistry, social, and environment, all presented their positive conceptions. Secondly, as students fulfilled collaborative group discussions, they could accumulate more effective and understandable core scientific conceptions to increase content knowledge and illuminate their science learning by argumentations. Thirdly, for sustainable development and demonstrating personal communication skills of SSICM-based instruction, this research offered an authentic lead to contradictions and cognitive dissonances in the process of SSICM learning. The argumentations could promote students' learning character and educational values to deepen their moral and ethical literacy.

A survey of students' argumentation-based perception attitude questionnaire made up more approaches for the value and vision of SSICM learning activities. In activities, students could strengthen their rebuttals on scientific issues, especially when they had claims and reasons. The presentations demonstrated their scientific argumentation techniques and accumulated more cognitive concepts to build the basics of science in the SSICM learning environment. Researchers had agreed that the SSICM active learning environment would take advantage of presenting their cooperative attitudes, improving learning cognition and reasoning skills, and promoting advanced thinking



abilities. These results supported the argument that the SSICM activities established a positive learning environment, cultivated argumentation skills, and constructed thinking skills for most students.

Based on the presented facts, students integrated the controversial social science issues into the SSICM contexts to improve their scientific thinking ability through multiple argumentations. Researchers stressed that argumentation would help students build new understandings and give them a chance to justify the claim and innovate scientific knowledge. The feedback from the teacher and students indicated that students' scientific knowledge inspired open-ended argumentation discussions and greatly clarified their supporting position on evidence in scientific application. Although science learning was crucial to SSICM-based contribution, it was necessary to conduct additional studies of interdisciplinary insights to develop students' global visions and sustainability attitudes. This research is only an initial contribution and needs to deepen further research for SSICM in the future.

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