

## A SYSTEMATIC REVIEW: TRENDS SOCIOSCIENTIFIC ISSUES IN CLIMATE CHANGE MATERIALS

Ida Bagus Ari Arjaya<sup>1\*</sup>, Sang Putu Kaler Surata<sup>2</sup>

<sup>1,2</sup>Universitas Mahasaraswati Denpasar

\*Email: [ariarjaya@unmas.ac.id](mailto:ariarjaya@unmas.ac.id)

### ABSTRACT

Socioscientific issues (SSI) is a contemporary educational issue that is for students in social life. The purpose of this Systematic Literature Review (SLR) is to analyze a) the most relevant SSI theories used in Climate change material, and b) The most relevant methodology used in SSI with Climate change material. and c) Conclusions and suggestions for SSI's research direction based on climate change material. This SLR study uses the PRISMA (Preferred Reporting Item for Systematic Review and Meta-Analysis) protocol with search engine websites Wiley, DOAJ, and Springer. From 419 data-based articles search results in the 2017-2021 time interval, 8 articles were obtained that match the search criteria. The results showed that the most widely used SSI theory in research related to climate change material is theory (Herman et al., 2018), while the most relevant methodology used in research is quantitative, mixed methods, and qualitative methods. The synthesis of the conclusions and suggestions of the Systematic Review leads to SSI as place-based instruction being able to develop various types of student competencies beyond their pedagogical competence so that further research recommendations focus more on developing teacher professionalism, students' metacognitive abilities, and designing learning to apply students' understanding of SSI and Nature of Science (NOS).

**Keywords:** systematic review, socioscientific issues, climate change, prisma, nature of science

### ABSTRAK

*Socioscientific issues (SSI) merupakan isu pendidikan kontemporer yang yang menjadi bagi bekal siswa di dalam kehidupan bermasyarakat. Tujuan dari Systematic Literature Review (SLR) ini adalah untuk menganalisis a) Teori SSI yang paling relevan dipergunakan pada materi perubahan iklim, b) Metodologi yang paling relevan dipergunakan pada SSI dengan materi perubahan iklim. Dan c) Kesimpulan serta sugesti untuk arah penelitian SSI berbasis materi perubahan iklim. Penelitian SLR ini menggunakan protokol PRISMA (Preffered Reporting Item for Systematic Review and Meta-Analysis) dengan search engine website Wiley, DOAJ, dan Springer. Dari 419 data based artikel hasil penelusuran dalam interval waktu 2017-2021 diperoleh 8 artikel yang sesuai dengan kriteria pencarian. Hasil penelitian menunjukkan bahwa teori SSI yang paling banyak dipergunakan di dalam penelitian yang terkait dengan materi perubahan iklim adalah teori (Herman et al., 2018), Sedangkan metodologi yang paling relevan dipergunakan dalam penelitian adalah metode kuantitative, mixed methods, dan kualitatif. Hasil sintesis dari kesimpulan dan saran Systematic Review mengarah kepada SSI dalam sebagai place-based instruction mampu mengembangkan berbagai jenis kompetensi siswa diluar kompetensi pedagogisnya, sehingga rekomendasi penelitian selanjutnya lebih berfokus pada pengembangan profesionalisme guru, kemampuan metakognitif siswa, dan merancang pembelajaran agar menerapkan pemahaman siswa tentang SSI serta Nature of Science (NOS).*

**Kata Kunci:** review sistematis, isu sosialsains, perubahan iklim, prisma, nature of science

### INTRODUCTION

The learning context is one of the factors that connects students' conceptions of thinking with scientific phenomena in everyday life. In general, students fail to relate the science problems that are obtained during the teaching and learning

process in the classroom with their daily lives because teachers generally use a less relevant learning approach. Socioscientific issues are one approach to the learning context that is very meaningful for students. The Socioscientific Issues (SSI) framework has proven to have a significant impact over

the last two decades in various fields related to the development of functional scientific literacy in students. (Dawson & Carson, 2020).

The issue of climate change is a very important global issue to be discussed and included in classroom learning because the impact can be directly felt by students, such as increasing earth temperature, global warming, the greenhouse effect, and damage to forest functions in Indonesia. regulate the ecological order and so on. The issue of climate change is very important to give back to students in learning to deal with climate emergencies like today (Reid, 2019). Furthermore, SSI can help students critically debate climate change issues that occur in society. In addition, SSI is complicated and controversial due to different perspectives and lack of clear solutions (Hou & Wang, 2016). So, in the learning process students and teachers need to develop new ways of learning that are effective in changing the mindset or correcting the misconceptions of students who often separate their position from their environment.

The integration of SSI in the learning process must include 1) ill-structured, controversial, evidence-based reasoning, 2) use of scientific concepts that have social consequences to involve students in the process of dialogue, discussion, debate, and argumentation, 3) integrate components ethics both implicitly and explicitly that require some level of moral reasoning, and 4) emphasizing character building as a long-term pedagogical goal (Liu & Roehrig, 2019; Zeidler et al., 2019). With the development of scientific products, scientific methods, and scientific reasoning

in learning instruction, the integration of SSI in learning is not a difficult thing to do.

A systematic literature review is one method that can be used to examine how SSI research trends in climate change materials (Bossér & Lindahl, 2019; Büssing et al., 2020; Dawson & Carson, 2020; Eggert et al., 2017; Herman et al., 2019, 2020; Leung, 2020; Liu & Roehrig, 2019). Knowing research trends, will direct researchers into research topics that are novelty and open up researchers' ideas about how to direct SSI research with the next climate change material.

The previous Systematic Literature Review (SLR) generally did not lead much to the trend of SSI learning by using Climate Change materials. Climate Change material is a fundamental material and it is very important to be taught to students as early as possible. Climate Change is a global problem faced by every human being in the world. Analysing how SSI's research trends related to SLR-based climate change material, will provide an overview of how the research direction and opportunities for further research novelty might be studied.

## **RESEARCH METHODS**

To examine secondary data in the form of research articles related to SSI, this study used a SLR approach. In addition, this SLR research stage uses the PRISMA (Preferred Reporting Item for Systematic Review and Meta-Analysis) protocol to examine in more depth how trends or developments in SSI research are related to the latest climate change material (Zawacki-Richter et al., 2020). The stages of the PRISMA method can be described in the Figure 1.



**Figure 1. Stages of PRISMA**  
(Zawacki-Richter et al., 2020)

Then in detail, each stage can be described as follows:

**Develop Research Question**

To formulate the problem formulation well, this study uses PICOC (*Population,*

*Intervention, Comparison, Outcome, and Context*) (Methley et al., 2014). The description of the PICOC can be displayed in Table 1.

**Table 1. PICOC Formulation**

|                  |   |
|------------------|---|
| Population (P)   | All formal education students at various levels of education from elementary, Middle High School, and University. |
| Intervention (I) | Socioscientific issues with climate Change Material   |
| Comparison (C)   | none  |
| Outcome (O)      | Various types of student ability dimensions   |
| Context (C)      | Qualitative, Quantitative, and Mixed Methods Research   |

Based on the PICOC considerations, the following research questions can be formulated: RQ1: What theory of Socioscientific Issues (SSI) is most relevant to use in climate change material?

RQ2: What research methodology is most relevant to use in SSI with the subject of climate change? RQ3: What are the

conclusions and suggestions for the future direction of SSI research based on climate change issues?

**Selection Criteria**

The selection criteria in this study can be described in Table 2.

**Table 2. Inclusion Criteria & Exclusion Criteria**

|                    |  |
|--------------------|--|
| Inclusion Criteria | <ul style="list-style-type: none"> <li>a) articles that are by research topics regarding socio-scientific issues related to climate change material, both in biology, science, and other learning.</li> <li>b) Scopus-indexed international journal articles published in Springer, Wiley, and DOAJ. site</li> <li>c) Articles in English.</li> <li>d) Publications for the last 5 years, namely from 2017-2021</li> </ul> |
|--------------------|--|

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|                    |   |
|--------------------|---|
|                    | e) Full text  |
| Exclusion Criteria | a) Research articles that are outside the topic of Socioscientific issues |
|                    | b) Articles from international journals that are not indexed by Scopus    |
|                    | c) Articles that are not in English.                                      |
|                    | d) Publication of research articles 2017-2021                             |
|                    | e) Research articles that are only in the form of abstracts               |

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### **Developing the Search Strategy**

The search for reference articles used in this SLR uses the Google Chrome platform to access the three sites, namely Wiley, Springer, and DOAJ. Strings are used in the process of searching for more specific articles and to avoid too many selections.

### **Study Selection Process**

This stage is carried out by searching for article selection based on the criteria for the relevance of the title and abstract to the research topic under study (Zawacki-Richter et al., 2020). This stage is very important to do to avoid bias or systematic error in SLR research. Besides that, this stage is also internal validity and external validity which serve to determine which observational variables in a systematic literature review can be used for generalizability and research applicability.

### **Appraising the Quality of Studies**

To assess the quality of an article that is used as material in this study, the following quality assessment criteria are used: QA1: Is the article indexed in a reputable international journal Scopus? QA2. Does the article have a problem formulation or problem focus that is relevant to socioscientific issues about climate change? QA3. Does the article use relevant research methods to develop a model of socioscientific issues? From each article after the screening process, a final selection

process will be carried out related to the quality of the article using the questions above. Each article will be given a checklist or dichotomy statement, namely Yes/No.

## **RESULTS AND DISCUSSION**

### **Developing the Search Strategy**

In the search for articles, three types of data are used, which are generally used to find reputable international article references, namely: Springer, Directory Open Access Journal, and Science Direct. Based on the search results in the three types of data based, 415 journal articles were obtained. Furthermore, journal searches were carried out on other websites that might have a Scopus indexed database of reputable international journals, namely IEEE Xplore. Found 4 journals based on search results so the total number of search results was 419. No duplicate articles were found on the four sites found above so there was no reduction in search results for research articles. The flow of SLR can be seen in Figure 2.

### **Selection Criteria**

This stage uses inclusion criteria and exclusion criteria as described in the research methodology section. Of the 419 articles, 23 articles meet the inclusion criteria based on titles that are relevant to socioscientific issues with climate change material, meet the criteria for the research year interval (from 2017-2021), English

articles, and reputable international articles indexed by Scopus. 396 articles did not meet the qualifications of the inclusion criteria.

### The Study Selection Process

Articles that meet the inclusion criteria will undergo further screening or selection to see at a glance the relevance between the title of the article and the abstract of the article discussed related to socioscientific

issues with climate change material. In this screening stage, 23 articles were found that were relevant to the research topic. So that the number of articles entered in the selection criteria stage with the study process is the same. Thus, all articles that are included in the screening stage are articles that have relevance to socioscientific issues in terms of titles and abstracts.

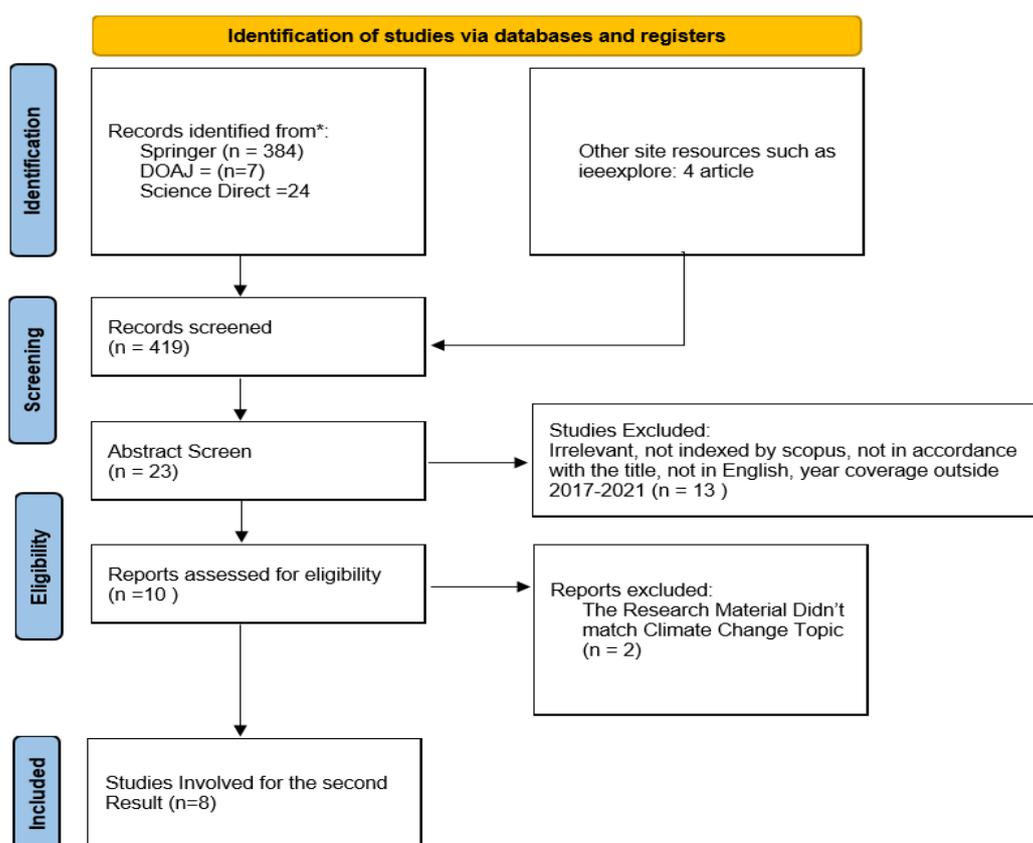


Figure 2. Systematic Literature Review flow by Using PRISMA Model

### Appraising the Quality of Studies

In this stage, all articles read are articles that can be obtained in full paper. To determine the level of conformity between the articles to be analysed, 3 types of criteria are used, namely QA1, QA2, and QA3 which have previously been described in the research method. After analysing the quality and relevance of SSI, there were

only 10 articles that matched and met all three types of criteria. However, 2 research articles have problems with QA2 meeting relevance to socioscientific issues but have no relevance to the context of climate change. In the end, 8 articles were selected that fit the topic of SSI and climate change. In terms of research methodology, all research articles have complied with QA3,

using quantitative, qualitative, case study, and mixed methods research to observe the influence or build a theory of SSI.

**RQ1 The most relevant Socioscientific Issues (SSI) theory used in climate change materials**

The most relevant SSI theory can be seen in Table 3.

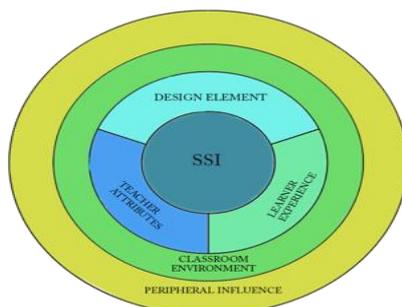
**Table 3. The Most Relevant SSI Theory**

| No. | Author/s                               | Title   | Journal                       | Q  | Index | SSI Theory  |
|-----|--|---|-------------------------------|----|-------|---|
| A1  | Vaile Dawson & Katherine Carson (2020) | Introducing Argumentation About Climate Change Socioscientific Issues in a Disadvantaged School   | Research in Science Education | Q1 | 1.21  | Carson, K., & Dawson, V. M. (2016).   |
| A2  | Ulrika Bossér & Mats Lindahl (2019)    | Students Positioning in the Classroom: a Study of Teacher-Student Interactions in a Socioscientific Issue Context                                       | Research in Science Education | Q1 | 1.21  | Pimentel and McNeill (2013) , Levinson (2004)   |
| A3  | Herman et.al. (2019)                   | Exploring the Complexity of Students’ Scientific Explanations and Associated Nature of Science Views Within a Place-Based Socioscientific Issue Context | Research in Science Education | Q1 | 1.21  | (see, Herman et al. 2018; Herman 2018; Zeidler et al. 2011; Zeidler and Kahn 2014).                         |
| A4  | Herman et.al. (2020)                   | Students’ Emotive Reasoning Through Place-Based Environmental Socioscientific Issues  | Research in Science Education | Q1 | 1.21  | (Bencze et al. 2015; Herman et al. 2018; Reis et al. 2015),, (SEEDS; Newton et al. 2016), Lee et al. (2013) |
| A5  | Jessica Shuk Ching Leung (2020)        | A Practice-Based Approach to Learning Nature of Science through Socioscientific Issues  | Research in Science Education | Q1 | 1.21  | Ratcliffe and Grace (2003)  |
| A6  | Eggert et. al.(2017)                   | Supporting Students’ Learning and Socioscientific Reasoning About Climate Change—the Effect of Computer-Based Concept Mapping Scaffolds                 | Research in Science Education | Q1 | 1.21  | (Taddicken and Neverla 2011),   |

| No. | Author/s                          | Title   | Journal                       | Q  | Index | SSI Theory  |
|-----|-----------------------------------|---|-------------------------------|----|-------|---|
| A7  | Shiyu Liu& Gillian Roehrig (2019) | Exploring Science Teachers' Argumentation and Personal Epistemology About Global Climate Change   | Research in Science Education | Q1 | 1.21  | National Oceanic and Atmospheric Administration (2009). |
| A8  | Büssing et.al (2020)              | Topic Specificity and Antecedents for Preservice Biology Teachers' Anticipated Enjoyment for Teaching About Socioscientific Issues: Investigating Universal Values and Psychological Distance | Frontier Psychology           | Q2 | 0,95  | (Büssing, 2018)., (Klosterman and Sadler, 2010)         |

In general, it can be said that the use of Socioscientific Issues (SSI) theory about the topic of climate change is very diverse. This is based on the fact that each expert uses a different theoretical approach in carrying out his research. There is only one theory that stands out and is used 2 times based on the results of the SLR analysis, namely (Herman et al., 2018). The theory states that SSI provides problems that are ill-structured problems and is an intersection between science and other aspects of social life. SSI problems tend to be controversial, and multi-faceted, involve many people, sometimes contradict the perspective of people in general, and are connected with various scientific concepts. From the explanation above, there are

several similarities between SSI and Problem-Based Learning (PBL) with SSI, which are both real-world problems and ill-structured. But the main difference is from the type of problem given. Problems given in SSI must be controversial, ambiguous, and must be based on existing scientific concepts. This is slightly different from PBL which does not require students to solve controversial problems and is always based on scientific concepts in problem solving. From these two points of view, it can be seen that SSI is a problem-solving solution with PBL breath and is more specific because it has to use science concepts in its solution. The following is a graphic representation of the SSI model in the learning process



**Figure 3. Graphic representation of SSI's Socioscientific Issues model in the learning process**  
(Herman et al., 2018; Presley et al., 2013)

Figure 3 explains that the SSI-based teaching model is very situational because it must be supported by three interrelated aspects, namely design elements, teacher attributes, and learning experiences. Design elements such as device planning, context, and learning models greatly affect the quality of SSI implementation. Teachers as learning resources must also have relevant experience related to SSI to make it easier to transfer and develop relevant and real information. Thus, students will easier to understand what is conveyed because it is experienced by the teacher. Related to teacher attributes and design elements, learner experience is also a driving factor for the success or failure of the SSI model. SSI should be given as early as possible to students to increase students' awareness of their environment (Herman et al., 2018). Student learning experiences must be provided by the real problems that exist in society. In addition, students must also be given interaction in the classroom, both teacher-student interaction and student-student interaction. A good quality of interaction will affect not only the development of student competencies but also a broader impact, namely changing the mindset and way of acting of the community.

Incorporating SSI into the curriculum is one of the answers to developing students' scientific method skills. Because based on the results of a systematic review of research publications, Socioscientific Issues (SSI) about the topic of climate change can develop argumentation skills, Nature of Science (NOS), Scientific explanation, teacher-student interaction, Students' Emotive Reasoning, Concept Map, personal epistemology, Enjoyment for Teaching, and student learning outcomes especially student understanding (Bossér & Lindahl, 2019; Büssing et al., 2020; Dawson & Carson, 2020; Eggert et al., 2017; Herman et al., 2019, 2020; Leung, 2020; Liu & Roehrig, 2019; Zeidler et al., 2019)

### **RQ2: The most relevant methodology used in Socioscientific Issues (SSI) with climate change materials**

The most relevant methodology used in Socioscientific Issues (SSI) with climate change materials is the model most often used by researchers. Based on the results of descriptive systematic review data, the percentage of each type of methodology is obtained, namely: Quantitative = 25%, Qualitative = 37.5%, and Mixed Methods = 37.5% (Table 4). This illustrates that the three types of research above are the types

of research that dominate in SSI research with Climate Change material in the

learning process. In full, the types of article methods used in this SLR are as follows.

**Table 4 The Most Relevant Methodology Used in Socioscientific Issues (Ssi) With Climate Change Materials**

| No.                   | Name                                    | Methods      |              |               |
|-----------------------|---|--------------|--------------|---------------|
|                       |   | Quantitative | Qualitative  | Mixed Methods |
| A1                    | Vaille Dawson & Katherine Carson (2020) |              |              | ✓             |
| A2                    | Ulrika Bossér & Mats Lindahl (2019)     |              | ✓            |               |
| A3                    | Herman et.al. (2019)                    |              |              | ✓             |
| A4                    | Herman et.al. (2020)                    |              | ✓            |               |
| A5                    | Jessica Shuk Ching Leung (2020)         |              |              | ✓             |
| A6                    | Eggert et. al. (2017)                   | ✓            |              |               |
| A7                    | Shiyu Liu& Gillian Roehrig (2019)       |              | ✓            |               |
| A8                    | Büssing et.al (2020)                    | ✓            |              |               |
| <b>Percentage (%)</b> |   | <b>25%</b>   | <b>37.5%</b> | <b>37.5%</b>  |

In the quantitative research group, it can be concluded that methodologically the two types of research articles, namely A6 and A8, use a very large sample (Büssing et al., 2020; Eggert et al., 2017). his very large sample reflects the excellent quality of quantitative research. Besides, when compared in terms of data analysis techniques, the research in article A6 has a good data analysis technique, namely by using One Way Anova with Post Hoc Games-Howell related to Computer-Based Concept Mapping Scaffolds. In terms of methodology, this research is very creative because it compares three types of mind mapping, namely concept-provided, non-concept, and line-provided conditions for each material, namely Issue of Climate Change, Climate Engineering Strategies, and Factual Knowledge on Climate Change (Eggert et al., 2017). On the other hand, article A8 has a high level of analysis and novelty because it uses confirmatory factor analysis (CFA) techniques to determine the

relationship between Investigating Universal Values and Psychological Distance variables on Anticipated Enjoyment for Teaching by Preservice Biology Teachers (Büssing et al., 2020).

In the qualitative group, namely A2, A4, and A7, they have similarities in the implementation of their research because they use transcripts of interview data (Bossér & Lindahl, 2019; Herman et al., 2019; Liu & Roehrig, 2019). However, in terms of the novelty of analytical tools and techniques, A7 is less superior in consistency for research coding because it uses Nvivo software.

Meanwhile, the mixed method groups A1, A3, and A5 showed that there was equality in the data analysis technique because it used inferential statistical analysis and coding techniques in the qualitative research section (Dawson & Carson, 2020; Herman et al., 2019; Leung, 2020).

**RQ3: Synthesis Conclusions and suggestions for future Socioscientific Issues (SSI) research based on climate change problems.**

The synthesis of conclusions and suggestions is displayed in Table 5.

**Table 5 Conclusions and Suggestions for Future Socioscientific Issues (SSI) Research Based on Climate Change Problems**

| No. | Conclusion  | Suggestion  |
|-----|---|---|
| A1  | Students' understanding of climate change has improved significantly and the effect is large. The number of categories given in written arguments on climate change issues has also increased significantly. The data results of qualitative analysis of reasoning ability also follow  | -   |
| A2  | Students are positioned as affected by the issue but as spectators of the public negotiation of the issue   | To support student positioning and the anticipated educational outcomes of learning, it appears that it is critical for dialogue classroom practice to comprehend how teacher-student interaction positions pupils. |
| A3  | The results of this study show that place-based SSI learning makes students' interpretation of the nutritional cascade more precise and complex, and contains more ecological causal mechanisms. After the location-based SSI course, significant and moderate to moderate correlations were also found between the accuracy and contextualization of students' NOS views and the complexity of their interpretation of the nutritional cascade   | NOS should be prominently displayed in conjunction with the science information found in curriculum requirements and through instruction that emphasizes authentic, pertinent, place-based science education.       |
| A4  | A more thorough investigation showed that when students engaged in environmental SSI, they displayed modest concern for people and the environment in diverse ways by expressing their helplessness, transferring responsibility, and making value judgments. The students also displayed four types of empathic dissonance toward people and the environment that are impacted by SSI: deep compassion for those who are struggling with SSI, guilt for not finishing SSI, rage towards those who are thought to be the cause of SSI and natural anger when the moral precepts of justice and fairness are broken as a result of the effects of SSI. | Pedagogical implications include how to instruct SSI in an authentic place-based setting that encourages the emotive reasoning necessary for environmental SSI engagement.  |
| A5  | A statistical comparison of pre-and post-course performance reveals a considerable shift in the application of NOS understanding, particularly about the social dimensions of information sources. These changes are explained by the availability of explicit instructions for comprehending NOS and   | These results support changes in the practice of science learning and provide empirical support for calling for changes from students   |

| No. | Conclusion   | Suggestion   |
|-----|--|--|
|     | its applications, practical exercises in all circumstances, peer interaction, and a focus on non-professional viewpoints.  | who only understand NOS to actively apply their understanding of NOS.  |
| A6  | According to the findings of the first concept map on climate change, it is best to encourage students' linked concepts. Pupils who work under this processing setting achieve the highest levels of built-in proposition knowledge, map complexity, and TPA scores. When using the presented concepts, students can concentrate on how ideas like biodiversity, greenhouse gasses, climate policy, etc. are related to one another. Boost students' performance on the post-tests for each of the four processing circumstances. Thus, all students gain from similar educational interventions in terms of knowledge growth. | Further research is needed, especially on the impact of additional metacognitive cues in the process of student concept mapping  |
| A7  | Building evidence-based arguments for viewpoints different than their own is a harder task for educators. Furthermore, while these educators have key epistemological similarities regarding climate science, they diverge in other areas, such as the validity of scientific findings and the skill of scientists.  | The findings also demonstrate that, as demonstrated by their reasoning, the individual teachers' epistemologies of general science and climate science differ from one another. It serves as a springboard for encouraging critical thinking and reasoning on climate education and has substantial implications for how future continuing education initiatives will be developed.  |
| A8  | <p>The benign socially-oriented universal value predicts the expected enjoyment of preimplantation diagnostic teaching, and the basic value of universalism's environmental orientation predicts the expected happiness of wolf return teaching for the pioneers of other specialized themes.</p> <p>The psychological distance can predict the predicted pleasure of teaching in any subject, even though this is in line with the intricacy of this particular social science problem.</p>   | Future studies can look into the effects of other elements that have been identified as the core of teaching emotions, such as student behaviour responses, which have been described in earlier research (for instance, this research has given rise to such new studies and supplements significant insights about the theme's understanding of the particularity of the theme and the pioneers of a specific theme, the expected fun of teaching, and teacher training and professional development). |

Based on the conclusion data from Table 5, it can be synthesized 2 types of conclusions in SSI learning with climate change material, namely research conclusions that lead to the improvement and training of students' argumentation skills both in the classroom and in the community, because generally students already understand and know the problems and solutions. SSI did well but failed when explaining or implementing it in the community because it acted as a watcher (Bossér & Lindahl, 2019; Dawson & Carson, 2020; Herman et al., 2020; Methley et al., 2014). a good teacher role is needed in the process of sharing personal epistemology related to climate change material. The second conclusion leads to how teachers can improve student learning interactions with relevant media (mind mapping) to increase students' understanding of NOS (nature of science) (Büssing et al., 2020; Eggert et al., 2017; Herman et al., 2019; Leung, 2020).

The results of the SSI suggestion synthesis related to future climate change materials can be classified into three types or categories. First, SSI with climate change material supports the improvement of student competence, both in terms of metacognitive thinking skills and student learning outcomes (Bossér & Lindahl, 2019; Dawson & Carson, 2020; Leung, 2020). Research on metacognitive abilities related to SSI in the learning process is innovative research, especially in the context of climate change because there are not enough references related to SSI research in the context of environmental change material on students' metacognitive abilities. Second, NOS has a very strategic and important role to be integrated into the curriculum because it can support SSI learning as one of the placed-based

instruction models (Herman et al., 2019, 2020; Leung, 2020). Third, the teacher is one of the components of SSI so its Professional Development must also be considered properly. In the future research on SSI needs to develop the professional development of its teachers (Büssing et al., 2020; Liu & Roehrig, 2019).

The results of the synthesis of the conclusions and suggestions of the Systematic Review led to SSI as a place-based instruction capable of developing various types of student competencies beyond their pedagogical competencies so that further research recommendations focus more on developing teacher professionalism, students' metacognitive abilities, and designing learning to apply students' understanding of SSI and Nature of Science (NOS).

## **CLOSING**

### **Conclusion**

The most widely used SSI theory in research related to SSI, especially with climate change material is theory (Herman et al., 2018), while the most relevant methodologies used in research are quantitative, mixed methods, and qualitative methods. The results of the synthesis of the conclusions and suggestions of the Systematic Review led to SSI as a place-based instruction capable of developing various types of student competencies beyond their pedagogical competencies so that further research recommendations focus more on developing teacher professionalism, students' metacognitive abilities, and designing learning to apply students' understanding of SSI and Nature of Science (NOS).

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