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Research Article

Knowledge and Social Relevance: Analyzing Socio-scientific Nature of Learning Competencies and Standards in Grade 8 Science

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ABSTRACT

The Philippine education system is obscured of global competence by various challenges including developing skills and inclusive education (Diano, et. al, 2023). Since 2018, the Philippines has placed at the bottom, ranking last out of 78 participants, and barely improved in 2022 ranking 77th out of 81 countries participating (Education GPS & OECD, n.d.; OECD, 2022). A study revealed that essential competencies in the curriculum should highlight various concepts and contexts of problems in the community (Belmi & Mangali, 2020). Through a quantitative research design, this study analyzed 40 stratified samples of competencies and standards of the Grade 8 Science Curriculum Guide for its distribution and extent of socio-scientific issues (SSI) consideration and the underlying factors that could potentially hinder its effective implementation in the four (4) science disciplines. Findings revealed an unequal distribution of consideration in the curriculum guide for SSI in different science disciplines. Earth and Space with a mean of 4.26 appear to integrate SSI more effectively as compared to other science disciplines. On the other hand, varying factors such as limitations to various resources and socio-cultural contexts could largely hinder the implementation and integration of SSI in the curriculum guide. This study concludes that there is sufficient and acceptable frequency in the distribution of SSI in the curriculum guide of Science Grade 8 across four core disciplines, however, this study also acknowledges that there are present limitations that need to be considered.

Keywords: *Competencies, K-12 Curriculum, Science, Socio-scientific Issues, Standards*

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Introduction

Science has opened doors to knowledge upon inquiry and discovery of many things. The knowledge that has been transcribed provided society to evolve through space and time which empowered people's lives and significantly affected the way that decisions are made every day.

With the world becoming more modernized and digitalized, various social issues including socio-economic, political, environmental, and education arise. These problems can be identified and presented in aspects of climate change, environment conservation risks, global scale pollution, life threats, species endangerment, and some other factors which can be considered as socio-scientific issues (SSI) and can have a positive implication (Zeidler, et. al., 2019) when these are discussed, integrated, and learned from the curriculum to nurture and open awareness among children. SSIs are complex and controversial issues, uncertain, conflicting values, and incomplete scientific knowledge that involve science (Zeidler & Nichols, 2009) as a mechanism to be understood and have these explained and explored in conversations. By establishing connections between science and society, our education can foster future citizens to become more knowledgeable and accountable participants in a sustainable society (Li & Guo, 2021) responsive to local, national, or global aspects of the issues of the contemporary and future world.

Education, on the other hand, continuously provides an opportunity to learn science as a significant aspect of developing skills for the future of society with critical thinking, problem-solving, as well as attitude and values useful for the community (SEI-DOST & UP-NISMED, 2011). Science education is hoped to make sense of community issues and problems, phenomena, as well as political or economic relative importance (Fortus, Lin, &Sadler, 2022). Approaches to Science Education (Holbrook & Rannikmae, 2007) should be viewed and emphasize that science knowledge and skills such as intellectual and communication skills, positive attitudes, cooperation, and decision-making gained through the content must be taught to gain and enhance learning and skill development, in either social, moral, or ethical implications (Pinzino, 2012), which is necessary to understand and make ethical decisions in any of the socio-scientific issues.

Given the standing of the Philippines in the Programme for International Student Assessment (PISA) 2018, there has been a considerable gap between the K-12 curriculum and the international assessment framework. The published journal entitled Challenges of PISA: PNU Report, noted that "essential competencies should be highlighted in each grade level" that include various concepts and contexts of problems in the community (Belmi & Mangali, 2020) and "attention to environmentalism" (Aruta, 2023) which these points may be covered and regarded as relevant to socio-scientific issues. PNU report also pointed out that epistemic knowledge is not likely distributed across all grade levels.

The major point posed is the inadequate inclusion of socio-scientific elements or issues that are relevant to discussion and consideration into the defined competencies and standards of the science curriculum. Several studies highlight some of the consequences of having no purpose of including socio-scientific issues in the science curriculum such as a limitation on students' critical thinking and decision-making skills (Sadler, 2011; Duplass & Zeidler, 2000), poor engagement and motivation (Hofstein, Eilks, & Bybee, 2010), and lack of citizenship readiness (Maass, Sorge, Romero-Ariza, Hesse, & Straser, (2021). These gaps make it difficult to create an all-encompassing educational framework that gives students functional scientific literacy, critical thinking abilities, and problem-solving skills they need to make sense of the natural world, and challenges and issues that arise.

With the recalibration of the new science curriculum in the Philippines through MATATAG agenda, it is aimed at emphasizing learners' understanding and skills which will be applicable in various contexts of scientific, environmental, technology, and engineering with its new features focusing on expanding literacy relating to real-world technological and engineering applications, learning complexity through key stages, and developmental se-

quence content (DepEd, 2023). The newly proposed science curriculum utilizes the Science, Technology, and Society (STS) approach focusing on the societal role of science and technology. Although there are some similarities between their goals in science in developing necessary skills and knowledge development, SSI still differs from the STS because it places more emphasis on the development of content knowledge, character, and virtue (Zeidler, Sadler, Simmons, & Howes, 2005), moral reasoning in scientific education (Zeidler & Keefer, 2003), and emphasis on psychological and epistemological growth of the child (Pedretti & Nazir, 2011). The SSI builds functional scientific literacy and real-world societal challenges to enhance students' retention of science knowledge and to foster critical thinking skills that emphasize affective and cognitive elements in science learning (Chowdhury, 2016). SSI is inherently socially created since it sits at the confluence of diverse human interests, values, and motives (Robottom, 2012).

By creating a more comprehensive science curriculum that not only improves science teaching but also develops students' functional scientific literacy (Zeidler & Kahn, 2014), closing this gap could have a substantial positive impact on science education. A generation that is better prepared to comprehend and tackle difficult socio-scientific concerns in a comprehensive and informed way can be produced by incorporating socio-scientific considerations into sustainable education methods or approaches directly into the science competencies and standards.

This study utilized a quantitative research method to evidently enquire about the socio-scientific considerations in the 2016 issue of the science curriculum guide for Grade 8 across all its disciplines (Biology, Physics, Earth and Space, and Chemistry).

This study is an important notion to make inferences about the science curriculum for Grade 8 in the Philippines and whether it connects to relevant and important discussions in the communities and real-world scenarios. By conducting this research, we can contribute to understanding how the curriculum, especially its competencies and standards, helps the learners to become responsible citizens, equipped with not just scientific knowledge but also skills that help them make a positive impact in society.

Methods

Research Method

The research design employed in this study is quantitative and involves content analysis of the Grade 8 K-12 Science Curriculum Guide. This specific research method is used to carefully examine these competencies and standards and see how SSI are integrated across different science disciplines. A stratified random sampling technique was employed to select a representative sample of learning competencies and standards from the Grade 8 science curriculum guide in each discipline. Moreover, this study also used a purposive sampling technique intended to target a cohort of science educators with specialized knowledge, experience, and professional background in the field of science from the High Schools in the Division of Masbate Province. These experts are considered to have a deep understanding of the curriculum landscape and pedagogical practices and are highly relevant to the exploration of socio-scientific considerations in science competencies and standards within the Grade 8 science curriculum.

In addition, the inference of relevant factors through a checklist was employed to identify which are more likely to challenge or hinder the consideration of SSI in the science learning content.

By understanding the current state of SSI integration in the Grade 8 science curriculum guide, this paper can identify areas for improvement and modification and ensure that future generations of students are not only skilled in knowledge but also equipped to navigate the complex world around them and participate in finding a solution to challenging issues.

Research Instrument

The research instrument utilized in the quantitative phase of this study is the Prevalence Indicator for Socio-scientific Issues (PI-SSI), where a set of criteria was adopted from Mark and Eilks (2009) for selecting issues and approaches to analyze each randomly sampled

science competency and standard and a checklist for factors that may challenge or hinder SSI considerations in the curriculum guide.

To quantify each criterion, a 5-point score on the Likert scale is utilized. Experts are asked to indicate the level of inclusiveness ranging from the highest point of 5 (strongly occurring), 4 (occurring), 3 (unsure), 2 (rarely occurring), and 1 (not occurring) for each science competency and standard in each criteria indicator. This scheme serves as a systematic tool to categorize and quantify instances, allowing subjective opinions or perspectives to be translated into numerical data points, of socio-scientific issues present within the Grade 8 science curriculum guide across various science disciplines.

Data Analysis

Analysis of Variance (ANOVA) was employed as a statistical tool to examine the occurrence and distribution of specific socio-scientific issues across different science disciplines within the Grade 8 K-12 Science Curriculum Guide. The distinct science disciplines within the Grade 8 Science Curriculum Guide were considered as separate groups for ANOVA analysis. The frequency or prevalence of identified socio-scientific issues within each science discipline, as assessed through a Likert scale across five criteria which include Authenticity, Relevance, Evaluation of Undetermined in a Socio-scientific respect, Allows for Open Discussion, and Deals with Question that is Answerable by Science, formed the quantitative variable for ANOVA analysis. This Likert scale provided a quantitative measurement for analyzing the presence of socio-scientific issues across the curriculum.

Once ANOVA results were obtained, a post-hoc Tukey's HSD test was applied when significant differences were detected. This ensured that the specific pairs of science disciplines with statistically significant differences in the occurrence of SSI were identified. By using this combination of ANOVA and post-hoc testing, the analysis was able to pinpoint not only whether differences existed but also where they occurred within the curriculum structure.

A predetermined significance level (α) of 0.05 was utilized. A p-value less than the chosen significance level would indicate statistically significant differences in the occurrence of socio-scientific issues among the science disciplines. Each criterion was rated using a Likert scale from 1 to 5, with higher scores indicating stronger alignment with the specific criterion such that the mean scores would statistically fit the ranges as follows: 4.21-5.00 is 'Strongly Occurring' to be an SSI, 3.41-4.20 is 'Occurring' to be an SSI, 2.61-3.40 is 'Unsure' to be an SSI, 1.81-2.60 is 'Rarely Occurring' to be an SSI, and 1.00-1.80 is 'Not Occurring' to be an SSI.

On the other hand, the frequency distribution of factors that may affect the consideration of SSI in the competencies and standards of Grade 8 science is utilized. These factors were analyzed to provide context and insight into the external or internal barriers that may influence the integration of SSI into the curriculum.

The combination of ANOVA and Likert scale analysis allowed for a comprehensive exploration of both the quantitative prevalence of socio-scientific issues and the qualitative assessment of these issues.

Ethical Considerations

Ethical considerations were observed during the conduct of data gathering. Proper communication and a signed letter of approval from the division superintendent were secured. Moreover, any information and data collected is emphasized to be regarded with utmost professionalism and confidentiality.

Result and Discussion

Consideration of SSI in the Competencies and Standards of Grade 8 Science

Twenty-four (24) individual respondents have shown varying interpretations of the criteria to justify the prevalence of competency or standard as a socio-scientific issue.

In Physics, there are three (3) Content Standards, two (2) Performance Standards, and eight (8) Learning Competencies that are focused on Force, Motion, & Energy. The resulting mean is equivalent to 3.99 which shows that all the competencies and standards are 'Occurring' to be considered as SSI. This means that the respondents regard the competencies and standards as fitting and with consistent recognition in the implementation of SSI. The

judgment of the respondents of "occurring" leans toward a positive acceptance of the competencies and standards to discuss relevant contexts and complex issues of society. The descriptor can also be an underlying opportunity to dig deeper into characterizing these competencies and standards into more relevant SSI.

In Earth & Space, a 4.26 mean is demonstrated in its result scores. This discipline's particular competencies and standards that focus on understanding the formation of typhoons, and demonstration of and participation in mitigating activities for typhoons and earthquakes are considered 'Strongly Occurring' to be an SSI. On the other hand, some topics are considered 'Occurring' to be an SSI including the use of models in understanding faults, demonstrating how earthquakes generate tsunamis, able to explain the factors affecting typhoons, and understanding comets, meteors, and asteroids. The scores corresponding to the Earth and Space, of which half of these competencies and standards imply a strong and fitted connection with the real-world context and SSI that relates to individual citizens while other competencies and standards can rather inform a positive connection with SSI and real-world scenario but could still be subjected to in-depth and further understanding and scrutiny in the extent of consideration. The varying results in each competency or standard underlie differences in strategies or the depth of understanding to further improvise as relevant topics for SSI. Such competencies with the description of "occurring" may address further exploration of the topic for more coverage and relevance to SSI.

In Chemistry, there are two (2) Content Standards, one (1) Performance Standard, and two (2) Learning Competencies that are focused on Matter including its Particle Nature and the Elements of the Periodic Table. The experts considered these concepts to be "Occurring'as SSI with a mean of 3.97. While the scores gained can indicate a positive implication for SSI consideration, the competencies and standards in the Chemistry discipline could still be subjected to further study, refinement, and understanding of its content to gain an even stronger connection between science and society. More so that the Particle Nature of Matter and Elements of the Periodic Table provide essential scientific foundations, they might not naturally cause students to consider the larger societal significance of Chemistry, however, certain factors may contribute to the success of Chemistry in discussing connections in SSI. The presentation of the scientific content in Chemistry may considered on a case-to-case basis in terms of practice or approaches used to emphasize a strong connection to the social and ethical implications.

In Biology, there are three (3) Content standards, three (3) Performance Standards, and five (5) Learning Competencies that are focused on Living Things, specifically, the Digestive System, Roles of Organisms, Energy Flow in the Trophic Levels, Concept of Species, and Biodiversity. The result showed three (3) out of 11 are considered "strongly occurring" for SSI and that eight (8) out of 11 are considered "occurring". A resulting mean of 4.11 is observed. There are variations of scores in each competency and standard and it can be understood that a few naturally tend to discuss relevant real-world concerns while the majority of "occurring" as the extent to SSI consideration could need significant support for an in-depth understanding and study to better inform competencies and standards with relevant and important SSI. While some concepts have substantial connections to real-world issues, others could benefit from additional resources, appropriate approaches, and activities to encourage students to think critically about the social and ethical aspects of biological concepts.

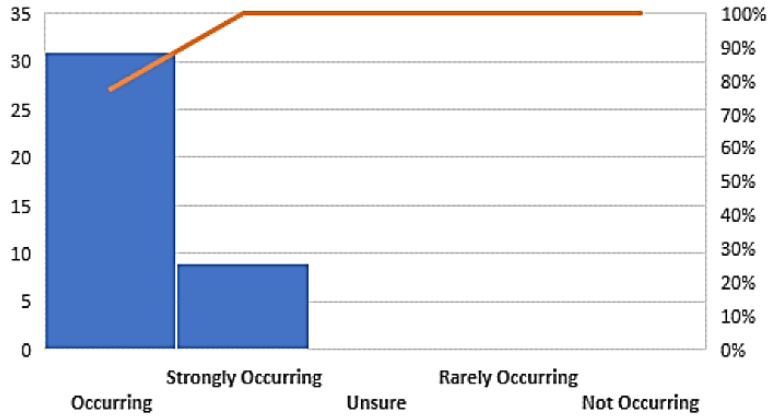

Figure 1. Frequency Distribution of Considerations of Science Competencies and Standards

Generally, the analysis of responses revealed that 90% of the identified competencies and standards fall within the ranges of 3.98-4.19 or categorically 'Occurring' to be considered as SSI, suggesting a notable confidence that the curriculum guide for grade 8 science has the means of discussing relevant and controversial aspects of SSI but could still indicate and demonstrate a considerable limitation on fully delving into the maximum potential of SSI. The frequency of responses also revealed that the competencies and standards are well-aligned to local, national, and global challenges that grade 8 students could relate to even with diverse backgrounds. The result also informs that the focus of the content adequately reflects the socio-scientific context and mostly encourages various methods of facilitating discussion of individual students' point-of-view while adequately exploring connections and implications between science and socio-scientific issues.

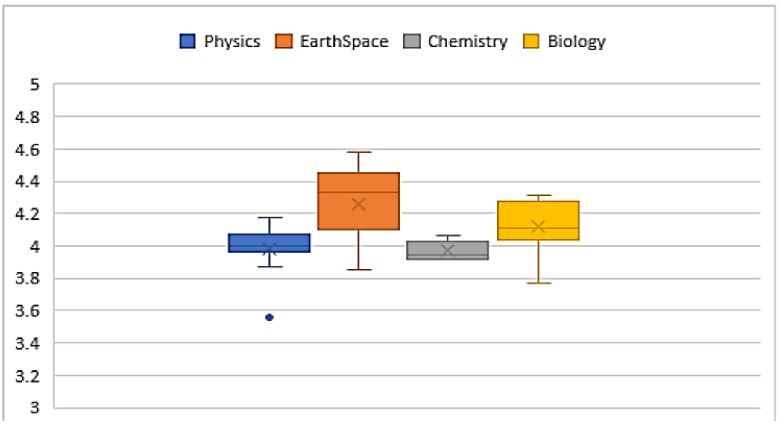

Figure 2. Calculated Means of Each Discipline for Socio-scientific Considerations

The significant result was determined by 0.00217 p-value which is less than compared to the significance p-value of 0.05. This means that there is a significant difference between the means of one or more pairs of treatments among the groups (Physics, Earth and Space, Chemistry, and Biology). This unequal distribution shows that some science fields may be neglecting opportunities to educate students on the social and ethical aspects of scientific principles. Earth & Space, with the highest average score (4.26), appears to integrate SSIs more effectively, possibly because of the underlying connection between these themes and real-world challenges such as the occurrence of a natural phenomenon or climate change. Physics and Chemistry, with lower average scores, might require a more intentional curriculum design to establish SSIs in the scientific concepts.

Table 1. Descriptive Summary and Analysis of Variance (ANOVA) Between Individual Groups of Science Discipline

SUMMARY

Groups	*Count*	*Sum*	*Average*	*Variance*
Physics	13	51.81459	3.985738	0.022171
Earth and Space	11	46.86667	4.260606	0.05421
Chemistry	5	19.84167	3.968333	0.003868
Biology	11	45.28333	4.116667	0.027611

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	0.54226	3	0.180753	5.917016	0.00217	2.866266
Within Groups	1.099731	36	0.030548			
Total	1.641991	39				

A post-hoc Tukey's HSD test was employed to provide a pairwise comparison of each group to pinpoint which of them exhibited statistically significant differences. Tukey's HSD test has a significant effect in the comparison of treatments A and B, and B and C, which means it is unlikely due to chances. While treatments (A=Physics; B=Earth&Space; C=Chemistry; and D=Biology) A and C, A and D, B and D, and C and D are more likely to be a random chance there is no confidence in the effects presented.

The result showed a significant value from pairs between A and B of 0.002 and between B and C of 0.019 which is less than a significance level of 0.01 and 0.05, respectively. While the other remaining pairs were consequently treated to be insignificant.

A subsequent variation between significant results of p-value and Post-hoc Tukey's HSD test only underscores a certain degree of potential limitation and complexity in the interpretation upon gathering the data. Such findings could be affected by certain factors such, but not limited to, varying interpretation of the competency and standards, availability of sample size, or inadequate background to the context of the study.

Factors Challenging the Competencies and Standards for SSI

Teaching science guided by the science curriculum has varying factors that may affect the overall performance of students and the delivery of the competencies and standards stipulated in the curriculum guide, so much so in the implementation of relevant socio-scientific contexts and issues.

Physics, on the contrary, is treated to be one of the hardest aspects of science considering that these contents are complex and abstract. The study on Filipino Physics Teachers (Diate & Mordeno, 2021) found challenges experienced by science teachers including appropriate approaches and strategies to make Physics to be relatable for the students. Quoted from one of the responses of the teacher-respondent in this study is that Physics is "too abstract and contains too much idealization or assumption which is not the case in an actual situation". However, in some cases observed from experienced and expert teachers, they can actualize the connection between the concept of Physics and what is of real-world scenarios. The curriculum guide may be implicitly designed and still depends on the interpretation and approaches of every individual teacher.

The competencies and standards in Earth and Space align with the mitigation practices and learning which made sure that recognition of the importance of understanding these concepts and relevance to the experience of students. Especially since the Philippines experiences most typhoons. With this content in the science curriculum, learners can engage with the learning perspectives that allow them on how they could prepare and become resilient (Kitagawa, 2021).

In learning Chemistry concepts, learners prefer learning experience that stresses their relevance through a problem-based learning

approach (Juuti, et. al., 2010). This approach when used in SSI topics and concepts can be deemed effective and improve critical thinking skills (Fita, et. al., 2021).

In the recommendation of a study (Santos & Rogayan, 2021) regarding their investigation into identifying the least learned competencies in Biology concepts, they suggested that one of the best strategies to use is a visual simulation like a gallery walk to explain the significance of meiosis in maintaining the number of chromosomes.

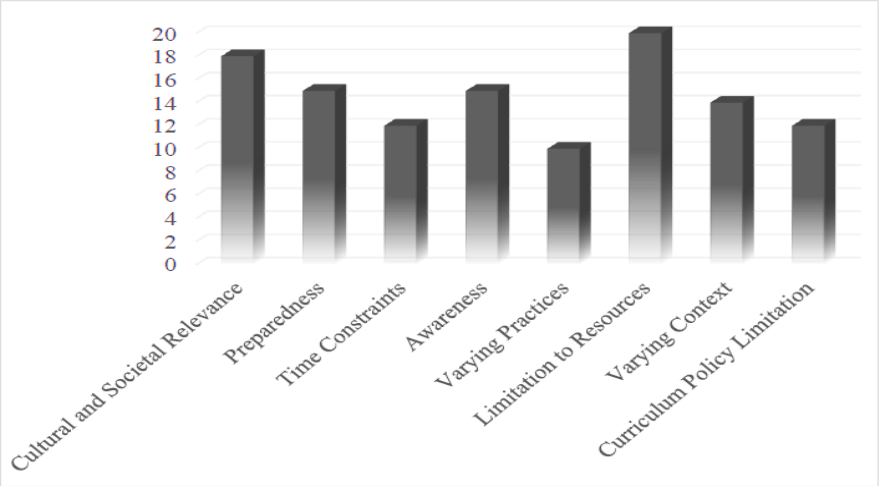

Figure 2. Frequency Distribution of Factors that may Affect the Implementation of SSI in the Science Curriculum

Awareness, Preparedness/ Readiness, Time Constraints, and Teaching Practices can be categorically aligned to be 'teacher factors'. Awareness involves the perceived need for SSI in education and well-informed differentiation between genders (Badeo, et. al., 2024; Kolong, et. al., 2023) and the extent of knowledge and ability to recognize timely SSI context in the lesson (Gutierez, 2015). The study of assessing SSI-approach in teaching science (Badeo, et. al. 2024) noted that readiness is a factor in the effective implementation of SSI including the difference in science specialization of the teacher and the process could take long (Talens, 2016), therefore limiting the momentum of preparation and discussion. Varying levels of knowledge (Gutierez, 2015; Aligaen & Capaciete, 2016) and different teaching (Talens, 2016; Ho & Seow, 2017; Van Der Leij, et. al., 2022) are problems that can be determined among teaching practices in the implementation of SSI.

Respondents of the study are likely to be affected by these factors for certain reasons as mentioned thus constraints the seamless implementation and consideration of SSI in the competencies and standards of science 8. One, Master Teachers were given administrative tasks such as Assistant to the Principal when they were already taken out of teaching duties and some of them were not directly teaching science 8 thus their expertise of focus and varying knowledge are beyond or away from the level and content-focus required thereby specialization is not attained. Two, Head Teachers and Principal or School heads are years practicing administrative tasks such as managing teachers or implementing school and department's policies thereby not ensuring the knowledge and specialization of teaching and SSI consideration.

Students' backgrounds leading to varying contexts and societal and cultural relevance could also become a constraining factor in the implementation because students who lack experience or cultural appropriation aspect could make a greater effort to establish SSI in the lesson and content focus.

The heterogeneity of students' backgrounds that sums all up their experiences, individual's natural environment and social influences, and socio-economic contexts, presents both opportunities and challenges in the implementation of socio-scientific issues within the

curriculum. Taking advantage of this diversity can encourage classroom discussions and broaden students' understanding of complex and relevant societal issues, it can also give rise to significant challenges, particularly in establishing the relevance and appropriateness of SSI within the lesson and content focus.

Inadequate resources including instructional or content-based approaches and professional development programs (Gutierez, 2015) and adequate opportunities to elaborate awareness and learning (Canlas & Karpudewan, 2023) can be tracked down to the efficiency of the curriculum in the implementation of SSI. In addition, alignment of the SSI content and implementation could also be a limiting factor, thereby redirecting relevance (Talens, 2016).

In general, curriculum encompasses all these factors thereby shaping both teacher and student in effectively implementing SSI. A poorly designed curriculum could lead to all the aforementioned factors and largely affect its implementation limiting the scope and skills that need to be inculcated among the students.

Conclusion

Considering all that this study has revealed with important aspects and information of research through examining the extent and factors of the socio-scientific considerations in the Grade 8 Science competencies and standards and the PI-SSI Tool and the statistical tools have helped to uncover notable insights of the study.

There is a sufficient and commendable distribution and consideration of the SSI concept and context in the competencies and standards of the science curriculum guide across four different disciplines. The curriculum guide of Grade 8 science provides wide acceptance and the presence of SSI consideration. This emphasizes the importance of SSI content and approaches in the science curriculum to address challenges in the community and society effectively.

There are underlying factors that need to be looked for, emerging as hindrances to a rather with no apparent gap between implementation and integration. Such challenges, but not limited to, may include the abstract nature of the content, awareness of the context and social significance of the SSI, and appropriate strategies and interventions.

The curriculum emphasis on SSI and adjustment tailored across different science disciplines is necessary.

While integrating SSI in a way that reflects both global challenges and local cultural contexts can foster more relevant and engaging learning experiences, Prof. Lam (2021) noted that collaboration and inclusivity efforts are required to preserve the connection of both important aspects of society. Empowering local communities and involvement (Hiswara, A., et.al., 2023) while promoting education is a critical effort in recognizing cross-cultural understanding while supporting and adhering to a progressive society. Empowering the local communities and promoting education are integral parts of cross-cultural understanding. Students are more likely to understand and relate to global scientific issues, such as climate change or biotechnology, when these topics are linked to their cultural realities and local environmental concerns.

In addition, students, policymakers, and industry professionals can provide valuable new perspectives in future research aimed at establishing socio-scientific considerations (SSI) in the science curriculum. Policymakers can contribute by aligning socio-scientific considerations with broader educational goals, standards, and policies. Industry professionals bring practical, real-world expertise to the conversation ensuring that SSI is in the science curriculum while also addressing ethical, environmental, and social considerations that arise in professional practice. Engaging these diverse groups will enhance the development of a science curriculum that is not only academically sound but also socially relevant, culturally sensitive, and adaptable to the needs of future generations.

Furthermore, addressing the existing gaps and challenges, amidst the positive outlook of the curriculum guide in its competencies and standards, is crucial to effectively incorporate SSI content and context into the curriculum and increase its learning impact. Thus, allows learners to engage with complex societal issues and

contribute meaningfully to their communities and the world at large.

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