Integrating Global Citizenship Education (GCED) in Biology Classroom Using Socio-scientific Issues

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Abstract: This study explores the integration of Global Citizenship Education (GCED) within biology lessons at the secondary level by leveraging Socio-scientific Issues (SSI). The study's objectives were to: (1) identify Socio-scientific Issue suitable themes and topics for GCED-enriched biology lessons; (2) develop biology lessons that integrate GCED with SSI on biology; (3) determine the teaching strategies utilized in the GCED integration. The study identifies key SSI topics such as environmental conservation, climate change, genetic engineering, public health, and biodiversity, and develops lesson plans that align educational objectives, instructional strategies, and assessment suggests. The study demonstrated that biology lessons can be effectively enriched with GCED by incorporating relevant global socio-scientific issues. A variety of teaching strategies congruent with active and inquiry-based learning were identified as effective for delivering GCED-enriched biology content. These strategies included case studies, problem-posing, collaborative learning projects, and the use of multimedia resources to enhance student global citizenship competency. The study recommends an approach to integrating GCED in biology classroom and suggests action options to promote its integration into instructional practices.

Keywords: Global Citizenship Education (GCED), Biology Education, Socio-scientific Issues, Inquiry-based Learning.

1. Introduction

Global Citizenship Education (GCED) is an educational approach aimed at developing learners into responsible and actively engaged global citizens (Amna Saleem et al., 2022; Yusof et al., 2019). It emphasizes values of justice, equality, diversity, tolerance, and solidarity at a global level and is closely linked to human rights (Education, 2015). GCED is not just about imparting knowledge; it is also about nurturing values and attitudes, with the goal of enabling learners to understand and address global issues such as inequality, human rights violations, and poverty, thereby contributing to sustainable development (Cinkaya & Aydin, 2018). Interestingly, while the concept of GCED is widely promoted, its integration into specific subjects such as Biology can reveal disparities in knowledge and values based on students' backgrounds, suggesting a need for tailored approaches that consider the diversity of learners (Kumari et al., 2018). Additionally, the challenge of implementing GCED in various educational systems highlights the importance of adapting international models to local contexts, ensuring that GCE is relevant and effective within the specific curriculum (Damiani, 2018).

Socio-scientific Issues (SSI) are complex, contentious issues that emerge at the intersection of science and society, often involving moral, ethical, and economic considerations as well as scientific understanding (Zangori et al., 2017). By employing SSI in the biology classroom, teachers can enhance students' engagement and comprehension of complex biological concepts while simultaneously developing their ability to apply scientific knowledge to societal issues (Arthamena et al., 2024; Kumari,

2015). Meanwhile, integrating global citizenship education (GCED) into a biology classroom involves adopting a curriculum that emphasizes the interconnectedness of global biological issues and the development of students' understanding of their roles as global citizens. The application of GCED in the Biology classroom can be approached by incorporating themes of biodiversity, environmental stewardship, and the ethical implications of biological research and technology (Jeehyun Bae, 2016; Wren, 2021).

This study aims to explore how to integrate Global Citizenship Education (GCED) into high school biology curriculum through Socio-scientific Issues (SSI), to promote students' understanding of scientific knowledge and cultivate their critical thinking, ethical judgment, and decision-making skills in the face of global challenges. Through this integration, students will not only learn biological knowledge but also understand the role of scientific knowledge in solving global problems, thereby laying the foundation for becoming global citizens.

The implementation of Global Citizenship Education (GCED) in science subjects, particularly biology, is a crucial aspect of promoting responsible global citizenship and sustainable development.

2. Research Background

Global Citizenship Education (GCED) is an educational framework that aims to equip learners with the knowledge, skills, attitudes, and values necessary to foster a sense of belonging to a global community and to act as responsible global citizens. The

objective of GCED is to empower individuals to engage and assume active roles, both locally and globally, to address and resolve global challenges and to become proactive contributors to a more peaceful, tolerant, inclusive, and secure world (Radjai, 2022).

While GCED is recognized as a critical element in achieving the Sustainable Development Goals (SDGs particularly target 4.7, its implementation varies significantly across different educational contexts. The implementation of Global Citizenship Education (GCED) varies significantly across different countries, reflecting diverse educational policies, cultural contexts, and pedagogical approaches. While GCED is recognized as a critical component of education systems worldwide, its integration into national curricula and educational practices is not uniform (De Poorter & Aguilar-Forero, 2019; Edwards, 2020; Kang & Shin, 2023; Yadava, 2023).

In South Korea, a proposed GCED model suggests incorporating virtual intercultural exchanges in high school education to foster global citizenship and intercultural competence (Kang & Shin, 2023). The International Baccalaureate (IB) Diploma Programme (DP), although international in scope, has been critiqued for not directly addressing GCED within its curriculum or assessment practices (Edwards, 2020). In Japan, the diffusion of GCED in higher education policies faces challenges due to the interplay between global SDG frameworks and local educational norms (Radjai, 2022). The Asia-Pacific region has identified a need for tools to monitor and evaluate GCED, particularly in the primary sector (Parker et al., 2023). In India, the National Education Policy 2020 emphasizes GCED across all stages of education, with

a focus on developing future educators who are equipped as global citizens (Yadava, 2023). In conclusion, while the importance of GCED is widely acknowledged, its implementation is influenced by national priorities, educational structures, and cultural values.

Interestingly, within the Chinese curriculum, there is no such concept as global citizenship education, but still many competencies involving global citizenship education have been put into the national curriculum standards, especially in science subjects. For example, in the High School Biology Curriculum Standard of China (MOE of PRC, 2020), "Social Responsibility specific to biology, refers to the responsibility and ability to participate in the discussion of personal and social affairs, to make rational explanations and judgements, and to solve the problems of production and life based on the understanding of biology." … "It is expected that students will be able to apply the knowledge and methods of biology in a way that benefits all human beings, with an attitude that is attentive to social issues, able to participate in discussions and provide rational explanations, and able to identify superstitions and pseudoscience; It is recommended that scientific practice be carried out with local resources in order to solve real-life problems. Furthermore, the concept of 'Lucid waters and lush mountains are invaluable assets (Pan & Pan, 2021) should be established and practiced, as well as participation in the practice of environmental protection."

Through it we can see, even with an education system that uses a completely different discourse than the GCED and SDG, China's core competencies for student

development like “encouraging address and discuss social issues”, “emphasizing ecological awareness”, “making rational explanations and judgments to solve real-life problems” are also included in UNESCO’s Conceptual Framework of Global Citizenship Education (Sun, 2020). So, it seems like different discourse systems simply reflect the specific ways and means by which countries express and address these issues, although China’s biology curriculum standards are different from the discourse of GCED and the SDGs, they still share common concerns about addressing global issues and raising environmental awareness, among other competencies of students.

In another aspect, Science subjects, such as biology, are suitable for Global Citizenship Education (GCED) because they inherently deal with topics that have global relevance and impact. Biology, for instance, encompasses the study of life and living organisms, including their structure, function, growth, origin, evolution, and distribution. These biological concepts are intrinsically linked to global issues such as public health, environmental sustainability, and biodiversity, which are central to the objectives of GCED and SDGs (Jenkins, 2021; Žegunienė, 2020).

While the suitability of biology for GCED is clear, there is a noted lack of awareness and integration of GCED in science education in some regions. For example, the need for improved global citizenship skills among graduates, including those from science disciplines, has been highlighted as a concern (J Paschal, 2022). Moreover, the perception of GCED among educators and parents may not always align with its broader objectives, sometimes reducing it to a narrower understanding related to travel

or cultural knowledge, rather than recognizing its relevance to scientific literacy and critical thinking about global issues (Çolak et al., 2019).

Socio-scientific issues (SSIs) contribute significantly to GCED in the biology by providing a context for students to engage with scientific concepts and their societal implications (Albe & Barrue, 2013; Kumari, 2015). SSIs, such as biotechnology, environmental issues, and sustainable development, are introduced in educational settings to foster scientific literacy and citizenship, enabling students to navigate and critically evaluate the controversies and ethical dimensions of science (Albe & Barrue, 2013; Stolz et al., 2013). Meanwhile, the integration of SSIs in science education not only promotes understanding of scientific concepts but also encourages the development of skills such as critical thinking, argumentation, and the ability to participate in public debates, this aligns with the broader goals of GCED, which include fostering social justice, diversity, and conflict resolution skills (Cinkaya & Aydin, 2018).

To integrated GCED through SSI into classroom, high school biology courses can adopt the following strategies: Incorporate global issues such as biodiversity and public health into the biology teaching content, the significance of integrating these topics is highlighted by the role of biology education in addressing global environmental challenges, including climate change and biodiversity loss (Akinwumi, 2023); engage students in scientific inquiry activities to actively explore and address biological issues related to global citizenship, Willcox & Lenz (2012) emphasizes the

value of issue-oriented science classrooms in engaging students with societal and global issues, fostering higher-order thinking skills essential for scientifically literate citizens. The integration of socio-scientific issues (SSI) into educational curricula is increasingly recognized to enrich student learning by combining content from various disciplines, including sociology and ethics, studies have shown that SSI-based education can enhance students' understanding of global issues by fostering higher order thinking skills and environmental awareness (Rahmawati et al., 2023).

3. Methodology

This study employs a literature review and curriculum design approach. By systematically reviewing and analyzing existing literature, the study explores effective strategies for integrating Global Citizenship Education (GCED) into biology classrooms and designs a biology curriculum based on socio-scientific issues (SSI). The study is grounded in social constructivism and inquiry-based learning theories, emphasizing the importance of deep learning and global citizenship awareness through engagement with real-world problems and collaborative learning.

In any kind of Project-based learning, before formalizing the project, the teacher first determines the project objectives, which are expectations of the results to be achieved, guide the teacher's teaching and students' learning, and direct the entire teaching and learning process.

3.1. SSI Topics Selection

Systematic review was employed in the present study as the research methodology to investigate research on implementations of nature of science in biology education. According to Bearman et al. (2012), systematic review is described as a specific approach to literature review that involves a rigorous and structured process of searching, selecting, and synthesizing the literature. A comprehensive search was conducted in online databases such as ERIC (Educational Resources Information Center), which is the largest education database in the world, containing millions of journal articles, research reports, conference papers, dissertations, and books (Wright & Pullen, 2007), to identify literature related to GCED, SSI, and biology education. Keywords utilized included “Global Citizenship Education”, “Socio-scientific Issues”, and “Biology Education”. When conducting a literature search in the field of education, we found an interesting phenomenon: when searching for studies containing the keywords “Global Citizenship Education”, “Socio-scientific Issues” and “Biology Education”, the number of results was very limited, with no more than five relevant documents in each database. Such several results were not statistically significant, meaning that we were unable to draw strong conclusions or conduct effective trend analysis from this data.

SSI teaching encompasses a broad spectrum of themes that touch on critical societal, environmental, health, and technological concerns. A systematic review highlights two central themes: Environment and Sustainable Development, and Health and Technology (Högström et al., 2024). Under the environmental umbrella, SSI teaching delves into Climate Change, examining the origins of greenhouse gases and

the shift toward renewable energy. It also addresses Biodiversity, highlighting the ecological imbalances and human-induced threats to species loss. Environmental Pollution is another key topic, discussing the hazards of introducing harmful compounds into the air, soil, and water, and the subsequent effects on health and ecology. Resource Management is also crucial, involving complex decisions about land and water use that are legally regulated and societally monitored.

In the realm of Health and Technology, SSI teaching confronts ethical dilemmas in Biotechnology and Medicine, particularly concerning human genetic engineering and medical treatments. The Food theme explores the impacts of specific food consumption, including the benefits and risks of genetically modified foods. Chemicals and Materials Engineering is another area of focus, looking at the harmful effects of product manufacturing on health and the environment, as well as air quality and pollution issues. Lastly, the theme of radiation explores the societal benefits and risks of technologies that emit various forms of radiation, such as nuclear energy and electromagnetic fields from electronic devices.

These themes are designed to encourage students to engage with and critically assess the pressing global challenges of today. By integrating scientific knowledge, students are equipped to better understand and make informed decisions on these complex issues, preparing them to contribute positively to society's ongoing dialogue and actions regarding these critical subjects. Sometimes, teachers complemented groupwork with other actives, such as role play, in which students were supposed to

address different perspectives and interests pertaining to the controversial issue. This approach helps students better understand the practical applications of scientific knowledge and improves their ability to solve real-world problems.

SSI topics frequently discussed in the literature and appropriate for secondary students were selected. These included environmental conservation, climate change, genetic engineering, public health, and biodiversity. Teaching objectives were developed for each SSI topic, encompassing the knowledge, skills, and attitudes necessary for GCED. Effective teaching strategies identified in the literature, such as case studies, problem posing, collaborative learning projects, and multimedia resources, were incorporated into the curriculum design. A series of GCED-integrated biology lessons were designed, complete with detailed lesson plans, classroom activities, and assessment methods for each SSI topic. Specific teaching materials and resources, including instructional slides, activity guides, and assessment tools, were provided

3.2. The Develop of GCED Model for SSI teaching in Biology Classroom

To develop a teaching model, according to the revised Bloom's Taxonomy, there are four of the most important organizing questions (Anderson & Krathwohl, 2001, p. 6):

1. What is important for students to learn in the limited school and classroom time available? (the learning question)

In the context of GCED, students need to develop high-level thinking skills, including critical thinking, argumentation, and ethical reasoning, which will help them make informed decisions when faced with complex societal issues (Kumari et al., 2018). Students should learn scientific knowledge related to social issues that are necessary to solve social problems. In the area of environment and sustainable development, students are expected to focus on ecosystem issues, climate change, loss of biodiversity, environmental pollution and resource management, which are global challenges that require active student involvement; in the realm of Health and Technology, there are topics including biotechnology, medicine, food issues, and radiation, these topics involve ethical considerations and risk assessment and are closely related to human well-being (Högström et al., 2024). Above all, students need to learn more than just biology knowledge in the limited school and classroom time available to them; they need to learn how to apply that knowledge to solving real-world problems, developing high-level thinking skills, and the ability to participate in society as global citizens.

2. How does one plan and deliver instruction that will result in high levels of learning for large numbers of students? (the instruction question)

In order to plan and provide instruction that will result in high levels of learning for large numbers of students, the following key strategies are in place: ensure that instructional objectives are relevant to the development of high-level thinking skills, scientific content knowledge, argumentation skills, communication skills, and an understanding of the nature of science; and select topics related to, for example, the

environment and sustainability, health, and technology, that are closely related to current global challenges and that can stimulate students' critical thinking (Fu, 2022); through inquiry-based learning, students take responsibility for interpreting, reviewing, and evaluating information on their own in order to develop critical analytical skills, and to enable students to understand and practice the process of democratic participation and to enhance their civic engagement and competence (Chen & Xiao, 2021). Through these strategies, teachers can design and provide instruction that stimulates active participation, critical thinking, and deeper understanding, leading to high levels of learning outcomes.

3. How does one select or design assessment instruments and procedures that provide accurate information about how well students are learning? (the assessment question)

In the context of global citizenship education (GCED), the design and selection of assessment tools and procedures to accurately reflect student learning can include the following: combining self-assessment, peer assessment and teacher assessment to comprehensively capture students' progress and competence in different areas, e.g. encouraging students to express their understanding of their own learning process through journals, reflective essays or discussions to express their understanding of their learning process, which helps to assess students' self-awareness and self-regulation; assessing students' ability to apply scientific knowledge to real-world situations, e.g. through case studies or simulated decision-making situations (Alcaraz-Dominguez &

Barajas, 2021); assessing students' ability to engage in social practices and community services and the extent to which they apply their learning to real-world situations; and encouraging students to engage in self-assessment and peer-assessment that to enhance their self-directed learning and critical understanding of the work of others (Nuangchalerm & Kwuanthong, 2010). Through these methods, educators can more accurately assess the learning outcomes of students under globalized citizenship education and ensure that the assessment results fully reflect the development of students' knowledge, skills and attitudes.

4. How does one ensure that objectives, instruction, and assessment are consistent with one another? (the alignment question)

In the context of global citizenship education, it is crucial to ensure alignment between objectives, teaching and assessment, and according to pedagogical research: firstly, there is a need to define clear pedagogical objectives (Boulton-Lewis, 1995; Wilson, 2016), which should be consistent with the overall goals of global citizenship education, such as the development of higher-order thinking and scientific skills, democratic participation and awareness of social responsibility. skills, scientific literacy, democratic participation and awareness of social responsibility. Teaching and learning activities should be derived directly from the pedagogical objectives. This means that pedagogical content, methods and processes should be designed to achieve these objectives. Assessment tools should be able to accurately measure whether

students are meeting the instructional objectives. Assessment should cover all aspects of knowledge, skills and attitudes.

4. Result

According to the Methodology, this result of this research will give lesson plans of Integrating Global Citizenship Education (GCED) in Biology Classroom Using Socio-scientific Issue, which will be specifically on the Themes of Environment Sustainable Development and Health & Technology.

4.1. GCED Biology Lesson Design: Environment Sustainable Development

To design a biology curriculum focused on the Socio-scientific Issues (SSI) theme of "Environment Sustainable Development" while integrating Global Citizenship Education (GCED), it's essential to establish clear educational goals. These goals should encompass a comprehensive understanding of environmental sustainability concepts, such as the importance of biodiversity, ecosystem services, and the impact of human activities on the environment. Additionally, the curriculum should aim to develop students' critical thinking, problem-solving skills, intercultural understanding, and collaborative abilities. Fostering a sense of responsibility towards environmental issues and promoting a global citizenship identity are also key objectives (Wren, 2021). The Educational Goals Set can be as the form follows:

Educational Goals	Description
Understanding environmental sustainability	Concepts of environmental sustainability,
	The importance of biodiversity, ecosystem services,
	The impact of human activities on the environment

Competency of GCED	Develop students' critical thinking, problem-solving abilities, intercultural understanding, and collaboration skills
	Foster a sense of responsibility towards environmental issues, promote action-oriented attitudes, and nurture a global citizenship identity.

Form 1 Educational Goals of Environment Sustainable Development

The selection of suitable Environment Sustainable Development topics is of paramount importance for fostering meaningful discourse among students. From a systematic review, topics such as climate change, deforestation, pollution and biodiversity loss afford considerable scope for investigation (Högström et al., 2024). Providing students with comprehensive background information, including scientific data, social impacts, and relevant policies, establishes a robust foundation for learning. Such a knowledge base allows students to approach these issues in a critical and comprehensive manner.

Teaching Topic	**Description**
Climate change	Greenhouse gases, Global warming, Renewable energy
Biodiversity	Threats of ecological balance, Loss of biodiversity
Environmental pollution	Risks with man-made emissions to air, soil, or water
Resource management	Use of land or water to get materials or energy

Form 2 SSI teaching topics for the theme of environment and sustainable development.

The design of educational activities should encourage active learning and critical engagement (Hernández-Ramos et al., 2021). Case studies and discussions of real-world environmental challenges can prompt students to analyse scientific, social, and ethical dimensions of these issues. Project-based learning allows students to dive deeply into specific topics, developing solutions they can present through various formats, such as reports or presentations. Role-playing and debates are effective in

helping students understand different stakeholder perspectives, including governments, NGOs, and businesses, and the complexities of sustainable development. Interdisciplinary learning, incorporating knowledge from sociology, economics, and geography, further enriches their understanding of environmental issues.

Finally, promoting global perspectives and cultural understanding is vital in GCED (Herbjørnsrud, 2021). Introducing international case studies provides students with a broader view of environmental challenges and solutions from various cultural contexts (Jenkins, 2021). Facilitating collaboration and exchange opportunities with students from other schools or regions can enhance intercultural understanding and the sharing of best practices in environmental stewardship. These approaches collectively contribute to developing informed, responsible global citizens committed to sustainable development.

4.2. GCED Biology Lesson Design: Health & Technology

To design a biology curriculum that integrates the Socio-scientific Issues (SSI) theme of "Health & Technology" with Global Citizenship Education (GCED), it's important to establish clear educational goals, too. These goals should include an understanding of key concepts related to health and technology, such as advancements in medical technology, ethical issues in biotechnology, and global disparities in healthcare access. The lessons should also aim to develop students' analytical skills, ethical reasoning, and the ability to assess the societal impacts of technological advancements in health. Furthermore, fostering a responsible and ethical mindset

regarding the use of technology in health and promoting a sense of global citizenship is crucial, particularly in emphasizing equity in healthcare access. The Educational Goals Set can be as the form follows:

Educational Goals	Description
Understanding Health & Technology	Advancements in medical technology
	ethical issues in biotechnology
	the global disparities in healthcare access
Competency of GCED	Develop students' analytical skills, ethical reasoning, and the ability to assess the societal impacts of technological advancements in health
	Encourage a responsible and ethical mindset regarding the use of technology in health, and promote a sense of global citizenship, emphasizing equity in healthcare access

Form 3 Educational Goals for the theme of Health & Technology

Choosing appropriate SSI topics is essential for engaging students in meaningful discussions. From a systematic review Relevant themes include the ethics of genetic engineering, the impact of telemedicine, the role of artificial intelligence in healthcare, and global health disparities (Hernández-Ramos et al., 2021). Providing comprehensive background information on these topics, including scientific principles, ethical considerations, and global case studies, sets the foundation for a well-rounded understanding.

Teaching Topic	Description
Biotechnology and medicine	Genetic engineering, Medical treatment, Diseases
Food	Impacts, benefits or risks from consumption of specific food Use of genetically modified food
Chemicals and materials engineering	Manufacturing and/or use of harmful products Man-made contribution to air pollution
Radiation	Risks associated to radiation from technical solutions in society

Form 4 Form 3 SSI teaching topics for the theme of Health & Technology

Case studies and discussions using real-world scenarios, such as CRISPR gene editing, digital health records, and telemedicine in rural areas, can help students explore the scientific, ethical, and societal dimensions of these issues (Arthamena et al., 2024; Kumari, 2015). Project-based learning allows students to delve into specific health technologies, assessing their benefits and risks and considering their impact on different populations. These projects can culminate in presentations or reports. Organizing debates on controversial topics (Hernández-Ramos et al., 2021), such as the use of AI in diagnosing diseases or the implications of genetic modification, helps students develop ethical reasoning by considering multiple perspectives. Integrating knowledge from technology, ethics, and social studies provides a holistic view of these complex issues.

Cultivating critical thinking and reflection is a key aspect of GCED. Students can maintain reflection journals to document their learning experiences, ethical considerations, and personal views on the impact of technology in healthcare (Bailin, 2002). Using diverse assessment methods, including essays, project presentations, and participation in debates, ensures a comprehensive evaluation of students' understanding and critical thinking skills. Promoting global perspectives and cultural understanding is also important. Including case studies from various countries highlights how health technologies are used in different cultural and socioeconomic contexts. Facilitating exchanges with students or experts from other regions can offer insights into global health challenges and innovations, fostering a broader understanding of these issues.

Finally, focusing on the ethical and social implications of health technologies is crucial (Burr & Morley, 2019). Conducting ethics workshops can help students think critically about the responsibilities that come with technological advancements. Discussions about healthcare policies and the role of government and international organizations in regulating health technologies can provide students with a deeper understanding of the broader context in which these technologies operate.

5. Discussion

Global Citizenship Education is increasingly recognized as an important component of curriculum development across various disciplines, while there is a consensus on the value of GCE, there are also challenges and contradictions in its implementation. For instance, the perception of GCE among parents and teachers can be limited, often associating it with international travel or knowledge of other cultures rather than a comprehensive educational approach (Žegunienė, 2020). Additionally, there is a need for more research on effective GCED training and certification for teachers and educators on discipline specific curriculum applications (Saperstein, 2020), as well as the development of instructional strategies on GCED can enhance students' social responsibility competencies (Wren, 2021).

This research on the integration of Global Citizenship Education (GCED) within the biology curriculum through Socio-scientific Issues (SSI) presents a multifaceted approach to enhancing students' understanding of complex global

challenges and their roles as active global citizens. This study has identified several key strategies and themes that are crucial for effective GCED implementation, such as the focus on biodiversity, environmental stewardship, and the ethical implications of biological research and technology.

The literature review conducted revealed a limited yet significant body of literature about biology curriculum, indicating the need for further research and development in this area. The identified SSI themes—environmentally sustainable development, health and technology—serve as a foundation for fostering scientific literacy and citizenship among students. These themes resonate with the broader goals of GCED, which include nurturing critical thinking, ethical judgment, and decision-making skills.

The study's findings, based on the two lesson designs for the theme of environmentally sustainable development; health and technology, underscored the importance of aligning educational objectives, instructional strategies, and assessment methods to ensure a cohesive learning experience when integrating Global Citizenship Education within the biology curriculum through Socio-scientific Issues (Figure 1 showed the common workflow for the lesson designs). The use of diverse teaching methods, such as case studies, problem posing, and collaborative learning projects, has been shown to enrich student learning and engagement with global issues (Hernández-Ramos et al., 2021; Högström et al., 2024). Moreover, the incorporation of multimedia resources and role-playing

activities facilitates a deeper understanding of the practical applications of scientific knowledge in real-world contexts (Burr & Morley, 2019).

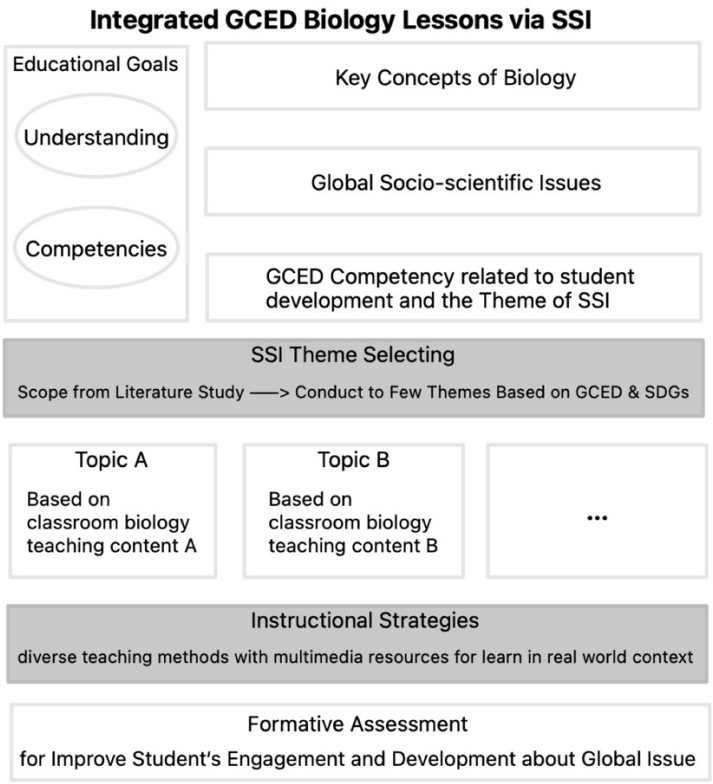

Figure 1 Integrated GCED Biology Lesson Design Model via SSI

One of the significant challenges in implementing GCED biology lesson is the variation in educational policies and cultural contexts across different countries. The study highlights the need for adapting international models to local contexts, ensuring that GCED is both relevant and effective within the specific curriculum (Cinkaya & Aydin, 2018; Herbjørnsrud, 2021). This adaptability is crucial for addressing the disparities in knowledge and values among students from diverse backgrounds.

6. Conclusion

6.1. Contribution and Limitations

The integration of GCED in biology education holds profound implications for both theory and practice. Theoretically, it extends the understanding of how global issues can be seamlessly woven into science education, challenging the traditional boundaries of subject-specific learning (Ampatzidis & Ergazaki, 2023; Kumari, 2015). Practically, it impacts the way educators approach teaching, emphasizing the need for a more holistic and interconnected approach to learning. The findings suggest that by engaging students with real-world problems, educators can enhance their global citizenship competencies, preparing them to contribute to sustainable development and social justice. This study also underscores the importance of aligning educational objectives, instructional strategies, and assessment methods to ensure a cohesive learning experience.

This study has made significant strides in integrating Global Citizenship Education (GCED) into biology classrooms through the lens of Socio-scientific Issues (SSI). The primary objective was to identify suitable SSI topics, develop biology lessons that integrate GCED, and determine effective teaching strategies. Key findings include the identification of pressing SSI topics such as environmental conservation, climate change, genetic engineering, public health, and biodiversity. The study demonstrated that biology lessons can be effectively enriched with GCED by incorporating these global socio-scientific issues, aligning with the educational goals of fostering critical thinking, ethical judgment, and decision-making skills.

While the study provides valuable insights, it is not without limitations. The research was primarily based on a literature review and curriculum design approach, which may limit the generalizability of the findings, the study may not fully represent the diverse educational contexts and student backgrounds in pratice. These limitations should be considered when interpreting the results and when applying the findings in different educational settings.

6.2. Suggestions for Future Research

The study suggests several directions for future research. There is a need for empirical studies that validate the effectiveness of the proposed GCED-enriched biology lessons in diverse educational contexts. Further research should also explore the impact of GCED on students' long-term attitudes and behaviors related to global citizenship in the K12 Curriculum contexts. Investigating the role of technology in facilitating GCED integration and assessing the effectiveness of different teaching strategies in various cultural and educational settings would also be beneficial. Moreover, research into teacher training and professional development in the context of GCED is crucial, as it can inform the development of more effective instructional practices.

In conclusion, this study contributes to the growing body of research on GCED by demonstrating the potential of integrating global socio-scientific issues into biology education. It highlights the importance of a comprehensive approach to education that prepares students to engage with global challenges and to act as

responsible global citizens. The findings of this study serve as a lesson design model for further exploration and development in the integrating GCED in biology or other disciplines teaching and learning, encouraging educators and policymakers to consider the broader implications of their teaching and learning practices. By fostering a global perspective in biology education, we can empower the next generation to address the interconnected issues of our world with empathy, understanding, and a commitment to sustainable development.

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