Citizenship Education through the Lens of Science: The Transformative Potential of Socio-Scientific Issues (SSI)

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1. Introduction to Socio-Scientific Issues (SSI)

Socio-scientific issues (SSI) refer to controversial, ill-structured, open-ended problems that relate to science and have significant societal implications. These topics often do not have one correct answer, which allows for discussion, debate, and exploration. They touch on various aspects of science, technology, and society, making them relevant to real-world concerns.

Examples of SSI:

- **E-cigarettes**: The increasing use of vaping among youth, raising health concerns and debates about regulation.
- **Sugary drinks**: Public health issues and societal pressures to regulate consumption.
- **Laughing gas as a party drug**: Exploring the ethics, health implications, and legalities of recreational drug use.
- **Nuclear energy**: Debates about whether nuclear energy is a sustainable and safe energy source in light of climate change.
- **Climate Change**: The ongoing global challenge of managing and mitigating the effects of climate change.
- **Covid-19 Vaccines**: Ethical and societal considerations regarding vaccine distribution, safety, and public health.

These SSI issues encourage students to engage deeply with scientific concepts through dialogue, discussions and debate, while considering their broader social, ethical, and political dimensions.

2. Importance of SSI in Education

The COVID-19 pandemic showed that these skills are more important than ever to deal with uncertain knowledge, controversial issues, develop a nuanced understanding, evaluate proposed solutions to make reasoned decisions

Scientific Literacy for All: In this complex and rapidly changing society, scientific litearcy is accepted ad a basic skill that all students need to have.

At the core of SSI-based education is the aim of promoting scientific literacy, which helps students understand the world around them, make informed decisions, and participate actively in societal issues.

Benefits for Students: Engaging with SSI allows students to:

- Develop critical thinking and problem-solving skills.
- Understand the complexity of real-world problems that often lack simple solutions.
- Cultivate ethical reasoning and informed decision-making.
- Improve their ability to communicate scientific ideas effectively and to engage in public debates.

Empowering Responsible Citizenship: SSI-based teaching emphasizes the development of responsible citizens who can analyze, discuss, and make decisions on significant societal issues. SSI-based teaching fosters students' ability to apply scientific knowledge to real-world problems. It also encourages studnets to consider multiple perspectives for making informed decisions

The goal is to encourage students to use their scientific knowledge not only for academic purposes but also for contributing positively to society.

3. The Role of Citizenship Education

- **Civic Engagement in Science Education:** One of the primary aims of integrating SSI into science education is to foster civic engagement. Classrooms are seen as spaces where students can explore complex societal issues and understand how scientific knowledge can inform solutions to these problems.
- **Core Goals of Citizenship Education:**
  - **Developing critical thinking skills:** Encouraging students to critically examine various viewpoints and assess the credibility of sources of information.
  - **Ethical decision-making:** Helping students understand the moral implications of their actions and decisions.
  - **Being open to diverse perspectives:** Encouraging dialogue and understanding of different viewpoints, cultures, and experiences.
  - **Exploring contemporary societal and sustainability issues:** Engaging with real-world problems like climate change, environmental sustainability, and ethical issues related to technology.
- **Key Concepts Addressed in Citizenship Education:**
  - **Sustainability Issues**: Understanding global challenges such as environmental degradation, climate change, and resource depletion.
  - **Ethical Reasoning**: Encouraging students to think critically about moral dilemmas and make decisions based on ethical principles.
  - **Critical Thinking**: Developing the ability to analyze, evaluate, and synthesize information from diverse sources.

4. Practical Approaches to SSI in the Classroom

- **Teaching SSI through Real-World Issues:** The presentation stressed the importance of introducing students to complex, real-world issues and providing them with the tools to analyze and discuss these issues in a scientific context.
  - **Classroom Examples:**

        - **E-cigarettes**: Students explore the health, legal, and ethical aspects of vaping. They are encouraged to critically examine the risks and benefits of vaping, drawing on scientific research and societal viewpoints.
        - **Text Neck Activity**: A practical activity where students investigate the physical forces involved in neck strain from using mobile phones. This activity links the science of forces to real-life problems that affect health, such as neck pain from prolonged screen time.
- **Interactive and Hands-On Learning:** Activities such as these encourage active student participation, where they take on roles such as scientists, ethicists, or policy makers, fostering a deeper understanding of the issues at hand.

5. Global and Local Context of SSI in Education

Global Trends in Civic Education: International studies, such as the **International Civic and Citizenship Study (ICCS)**, have highlighted the varying levels of civic education across the globe. Dutch students score around the international average in their knowledge of political and societal issues, which underlines the importance of incorporating citizenship education into science curricula.

SSI in the Netherlands: In the context of Dutch education, the integration of SSI is seen as a way to address both global sustainability challenges and local societal concerns. National frameworks, such as the **De Staat van het Onderwijs 2025** report, emphasize the need for a more integrated approach to teaching about citizenship and sustainability.

According to **Leraar24, Burgerschap in de bètavakken:**

- Science subjects provide excellent opportunities to develop citizenship skills because students learn to **investigate, think critically**, and **analyse** societal dilemmas.
- Topics such as climate change, sustainability, energy, and vaccinations offer natural entry points for citizenship education in the sciences.
- Teachers can make citizenship meaningful by linking **scientific inquiry to real-world social issues.**

Citizenship Education in The Netherlands:

Primary & secondary schools: since **February 1st, 2006,** to promote active citizenship and social integration (Primary education act, article 8, paragraph 3).

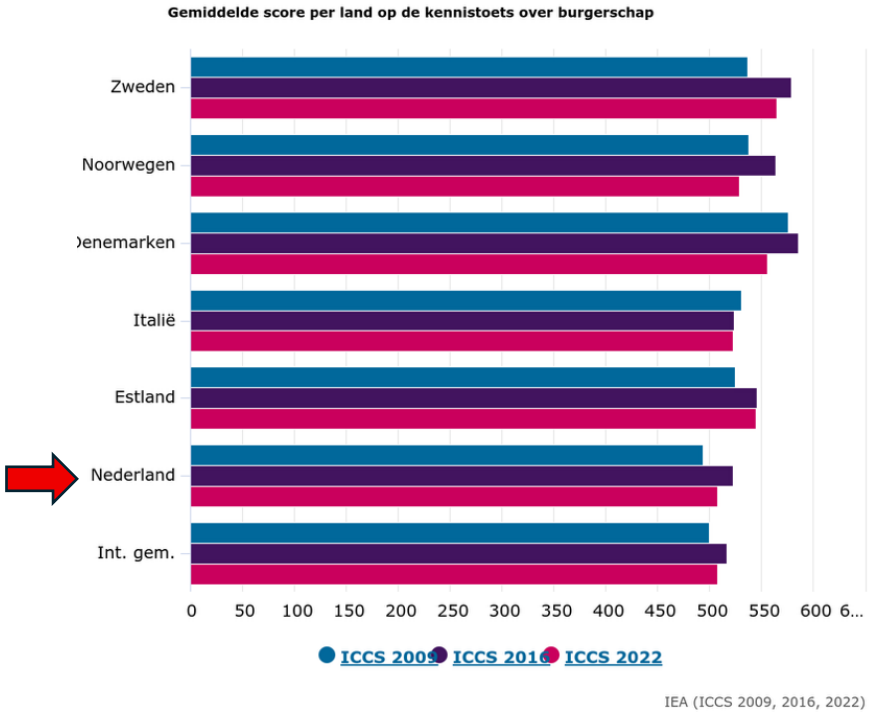
However, there were no concrete goals and guidelines

Since 2021, there is a new law promoting citizenship education. However, the main goals do not contain explicit goals for citizenship.

March 2024: SLO published the draft core objectives for citizenship

July 2025: SLO published the finalized (draft) core objectives for citizenship

According to the International Civic & Citizenship Study, Dutch students score around the international average in their knowledge of political and societal issues (a score of 508)



According to the 'De Staat van het Onderwijs 2025 – Expertisepunt Burgerschap', in many schools, citizenship education is still not sufficiently goal-oriented, coherent or structurally embedded. Schools often lack a shared vision on what citizenship entails and how it should be implemented across the curriculum. The inspectorate highlights the need for cross-curricular approaches, where citizenship goals are integrated into regular subject teaching.

Core Goals for Dutch Students:

- **Lower secondary education:** Encouraging students to explore societal issues and think about actions they can take to address these issues.
- **Recognizing Multiple Perspectives:** Encouraging students to recognize and understand different viewpoints, which is crucial for informed decision-making.

Citizenship education: promotes the broad development of students, enabling them to grow into **responsible and critically thinking citizens.** It provides **knowledge, skills**, and **experiences** that help students discover how they can contribute to a democratic and diverse society and help shape it.

Goal: to make students **aware of their role** and **opportunities** to actively contribute to this society and a democratic culture, together with others.

Bèta Burgerschap is defined as (Guérin, 2018; Tolkamp et al., 2019):

- Actively participating in discussions about socio-scientific/technological issues.

- Encouraging students to actively engage with scientific topics and understand their implications for society.
- Empowering students to be informed and responsible citizens who can contribute thoughtfully to discussions about science and technology.
- It's not just about learning facts; it's about understanding how science intersects with ethical, environmental, and societal issues.
- Developing students' skills (argumentation, critical thinking, informed decision-making, etc.).

How can we incorporate SSI in science lessons to promote responsible citizneship:

1. Through Research and EU pojects
    a. Ready to use lesson materials
    b. (OER, editable; (e.g. ENGAGE materials)
    c. Tools

    Local & global SSI, can be linked to the textbook

At ESoE (Eindhoven School of Education) we have a common assignment in the courses Pedagogy of Physics and pedagogy of Chemistry. In this assignment, students choose one SSI (local or global) connected to the topics of chemistry or physics in the secondary school curricula.

Another example, is the Hackathon that we organized which included all colleagues at the depatrment. In this one-day event we worked in groups. Groups competed each other by providing solutions/ideas to implement citizneship education into our teacher education programme.

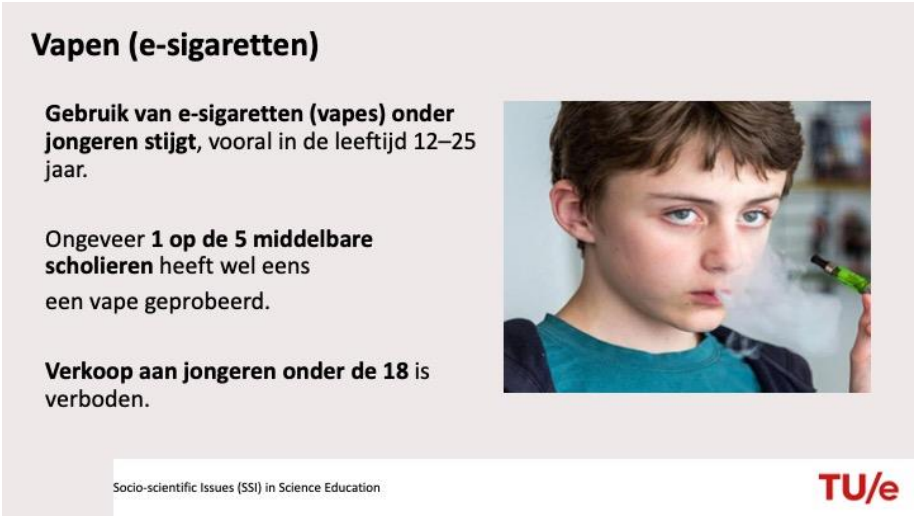
Other example is the **ENGAGE Project**: This European Union-funded project aims to develop ready-to-use lesson materials for teaching SSI. The project provides a platform for educators to access a variety of resources that can be integrated into science curricula to address societal issues.

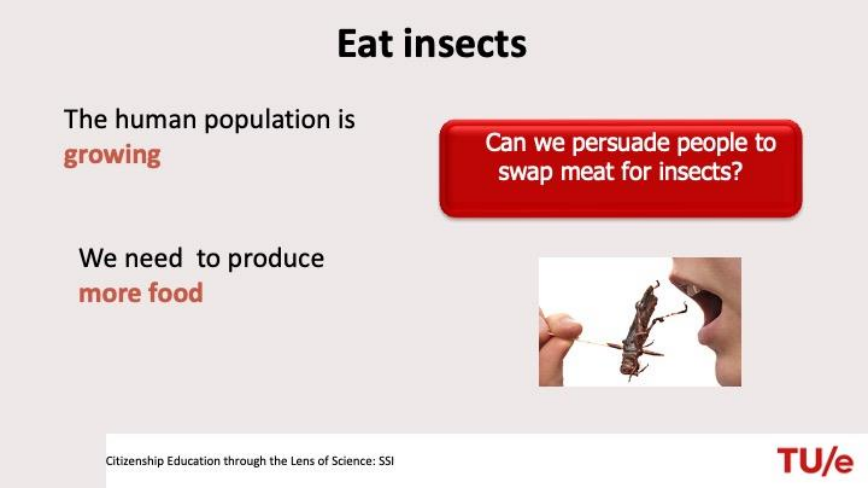
- **Research and Pedagogical Tools:** The presentation highlighted several projects and tools that help educators implement SSI in the classroom. These include:
    - **OER (Open Educational Resources)**: Editable materials that teachers can modify according to the levels of the students.

7. Instructional Models for SSI Education

- **The 5E Learning Cycle:** A widely-used instructional model for Inquiry-Based Science Education (IBSE), the **5E Learning Cycle** includes five phases: Engage, Explore, Explain, Elaborate, and Evaluate. This model helps guide students through the process of inquiry and critical thinking, providing opportunities for hands-on learning and reflection (Bybee, Powell, & Towbridge, 2007).

Example lessons:





These ENGAGE SSI-lessons can be downloaded by using the links and the QR codes below. You can modify and use them:

ENGAGE materials-1 lesson: https://padlet.com/durutue/engage-ssi-materials-1-lesson-2xmi5js97aqqdwg8

ENGAGE materials- lesson series: https://padlet.com/durutue/engage-ssi-lesson-series-ejn4j3qvb715yxy

Case Studies and Dilemmas: The presentation provided examples of real-world dilemmas used in the classroom to prompt students to make decisions based on scientific and ethical reasoning:

- **Action A: Nuclear Energy**: A case study where students evaluate the pros and cons of using nuclear energy as a sustainable energy source.
- **Action B: Veganism**: Students analyze the ethical, environmental, and health implications of a plant-based diet.

    - **Action C: Banning Cars**: A debate on the impact of car use on the environment and whether banning cars could contribute to solving climate change.

8. Tools for Citizenship Education

- **Student Sheets and Decision-Making Guides:** These tools help students collect data, evaluate risks and benefits, and make informed decisions. Students are encouraged to use critical thinking to assess the validity of sources and the potential impact of different actions.
- **Ethical Thinking Guides:** The **Rights and Duties** framework helps students navigate moral dilemmas, encouraging them to base their decisions on ethical principles. For example, students must decide whether it is right for a man to steal medicine to help his sick wife.
- **KWHL Grid**: This tool helps students organize their knowledge, questions, and learning objectives in relation to a specific SSI topic, promoting active learning and reflection.

9. Conclusion and Final Thoughts

- **Empowering Students as Informed Citizens:** The overarching goal of SSI-based education is to prepare students to be active, informed, and responsible citizens. By engaging with real-world scientific issues, students develop the skills needed to analyze complex problems, make informed decisions, and contribute meaningfully to society.
- **The Role of Teachers:** Teachers are crucial in facilitating this process by creating a classroom environment where students feel empowered to discuss, debate, and explore the science behind contemporary societal issues.