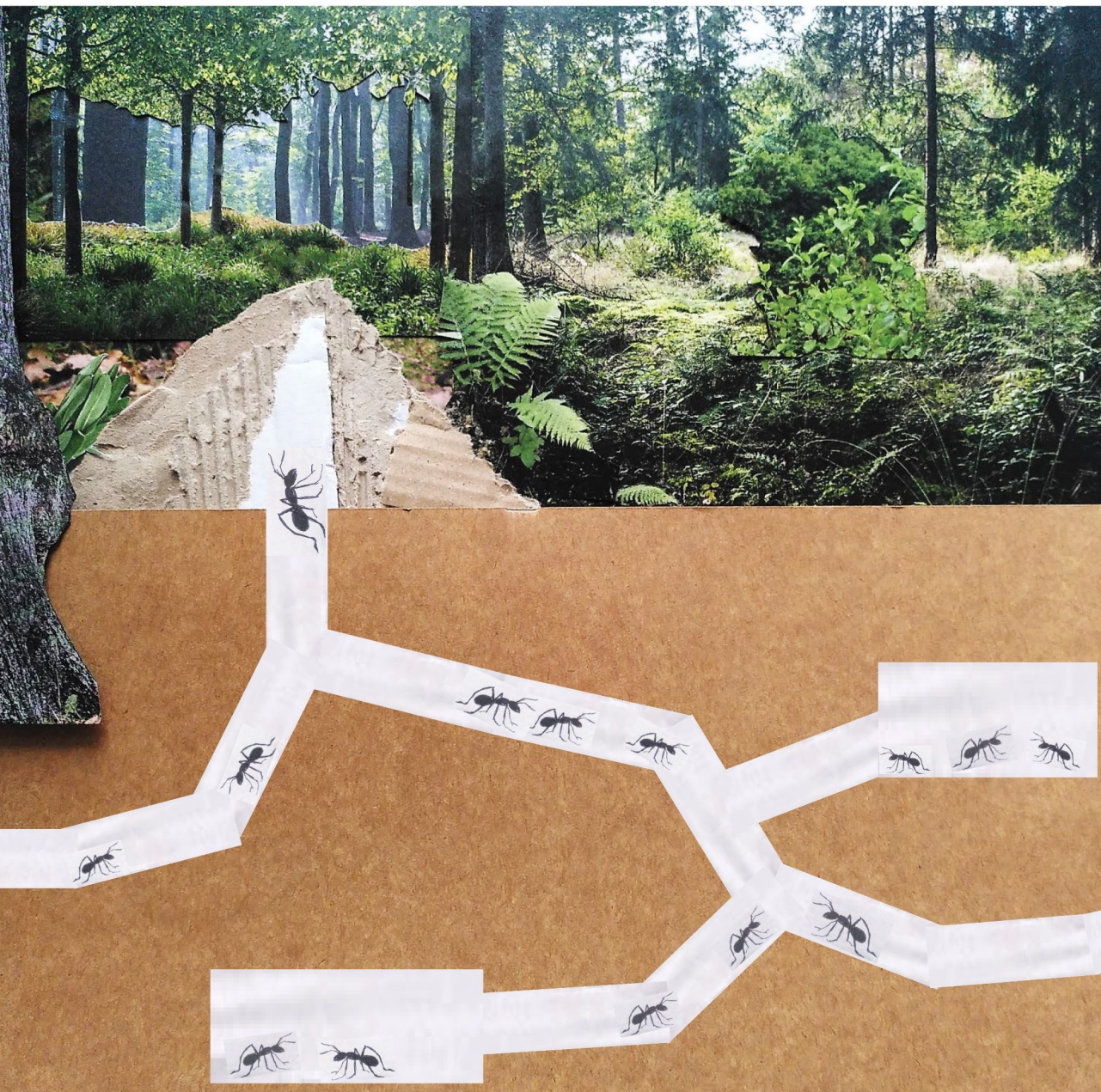
Ask, find out, and act

Fostering environmental citizenship through science education

Michiel van Harskamp



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Vraag, zoek uit en handel

Bevorderen van milieubewust burgerschap middels natuurwetenschappelijk onderwijs

(met een samenvatting in het Nederlands)

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A note on the cover

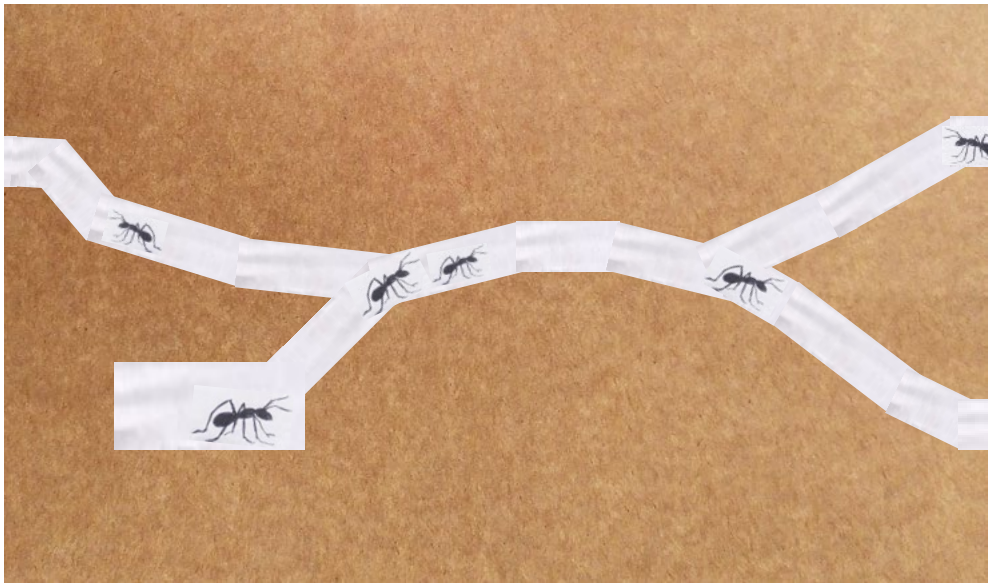
For the cover of this dissertation, Michiel took inspiration from an interview with Caspar Lapré, one of the science teachers who participated in several of the studies reported here. In an interview related to one of the studies, Caspar defined citizenship in the following way:

> Citizenship is how you, as an ant, behave in the colony at large. What I mean with this is, as a human, you are part of larger whole, and to make sure this whole keeps functioning, some things are expected of individuals. This happens on different levels: on a classroom level, on a family level, but also on a national or even a world level. You have to know what the task of the colony is. Then you consider in what communities you take part, and what tasks these communities have. After that you consider what you can add yourself.

Michiel used old nature conservation magazines, packaging materials, and other discarded paper and carton to create the cover.

1

General introduction



"Les progrès ne se font pas tous en une étape."
"Progress is not accomplished in one stage."
"Voor vooruitgang moet meer dan een stap worden gezet."
Victor Hugo – Les Misérables[1]

With *Les Misérables*, Victor Hugo paints a picture of a society in transition. Different groups of people work towards achieving different goals, each of them convinced they are doing the right thing. There is dispute about necessity of change, about which societal processes are no longer desirable, and about what the future should look like. In this sense, Hugo's work has not yet lost any of its relevance since it was first published in 1862. Our society, too, is in transition, and we see similar patterns arising. There is a growing consensus we need to replace unsustainable processes, some of which have been in place since before Hugo's time, with more sustainable alternatives. Yet stakeholders have different views about which processes are no longer desirable, what alternatives should look like, and what strategies we need to employ to reach these aims.

The opinion-forming and decision-making process regarding these sustainability issues is complex, yet its importance is increasingly acknowledged worldwide. Throughout all educational levels current curricula ask students to become fluent in sustainable action-taking. The United Nations for instance devoted an entire decade to placing sustainable development on the educational agenda worldwide (UNESCO, 2014). More recently, they formulated a set of learning goals that work towards achieving sustainable education for all (UNESCO, 2017). At a European level, the EU released the GreenComp framework, which describes the EU focus on promoting sustainability competences through all educational levels, even going beyond formal education (Bianchi et al., 2022). Sustainability is high on the Dutch national curriculum agenda too, for instance through its inclusion as 'green chemistry' for upper secondary level (CvTE, 2021) and as opinion-forming and decision-making skills at lower secondary level (SLO, 2016). Many of these curricula and educational initiatives feature aspects of Environmental Citizenship (EC): a form of citizenship revolving around opinion-forming, decision-making, and action-taking regarding sustainability issues (ENEC, 2018).

Despite this widespread inclusion of sustainability on the national and international education agenda, implementing it in science lessons remains challenging for science teachers. Most of this has to do with normative aspects and open-ended, controversial aspects of sustainability issues (Summers & Childs, 2007). Sustainability issues can be seen as Socio-Scientific Issues (SSI): they contain scientific and societal implications, are subject to controversy and uncertainty, concern many different stakeholders, and do not have clear-cut solutions (Ratcliffe

1 Part 3, Book 3, Chapter 6. French quote taken from the original (1862, Brussels, Librairie internationale A. Lacroix, Verboeckhoven, et Cie.); quote from English translation by Christine Donougher (2016, London, Penguin Classics); quote from Dutch translation by Tatjana Daan (2022, Breda, Papieren Tijger).

& Grace, 2003). Science teachers reported being challenged by these normative aspects (Borg et al., 2012; Taylor et al., 2019), by guiding dialogue and discussion (Corrigan et al., 2007; Day & Bryce, 2011), by a lack of suitable teaching approaches, inspiring examples, and assessment options (Boeve-de Pauw et al., 2015; Borg et al., 2012), and by the combination of ecological, economic, and social aspects that play a role in sustainability issues (Sinakou et al., 2019; Taylor et al., 2019). Yet, for all these experienced difficulties, it is important that specifically science teachers incorporate EC in their lessons. Sustainability issues contain a scientific side, which needs to be taken into account for informed decision-making regarding SSIs (Kolstø, 2001). Furthermore, incorporating real-world, controversial issues related to sustainability into science education can increase the experienced relevance of the topic for students (Sadler et al., 2016). A potential candidate for a teaching approach that is suitable for integrating EC into science teaching is SSIBL: Socio-Scientific Inquiry-Based Learning (Amos & Christodoulou, 2018; Ariza, Christodoulou, et al., 2021; Knippels & Van Harskamp, 2018). It could support teachers during development and implementation of EC based science education. Yet despite its promising potential, it has not yet been extensively tested in the classroom.

In this dissertation, SSIBL's potential to foster EC through science education will be tested at lower secondary level. We purposefully selected this particular age group of students for several reasons. First, in the Dutch educational system, at the end of lower secondary level students select which courses to follow at upper secondary level, and which courses they will drop. This means selecting lower secondary level as a focal point will yield heterogenous groups of students with broad interests (e.g., science, humanities, arts), whereas in upper secondary level, the student population is more homogenous. Since practicing in sustainable decision-making and action-taking is necessary for everyone, regardless of personal interest, focussing on fostering EC at lower secondary level is most desirable. Second, a dip in sustainability attitudes and behaviour has been identified for this age group in previous studies (Boeve-de Pauw et al., 2015; Olsson et al., 2019). Closely following this group of students during this turbulent time in their development would yield new insights which are valuable for science educators and researchers (Cincera et al., 2022). It would strengthen our understanding of what might drive these changes in student attitudes.

1.1 Main aim and research question

The aim of this dissertation is threefold. First, we aim to describe current EC practice, and views and experiences of science teachers and lower secondary students regarding EC. With this, we set the scene for the other studies. The second aim of this dissertation is to develop and validate an assessment instrument that focusses on EC opinion-forming, a previously uncovered area of assessment. Finally, the third aim of this dissertation is exploring the potential of SSIBL to foster EC through science education at lower secondary level. We can summarise these aims in the following research question:

How to foster environmental citizenship in lower secondary science education?

Sub-questions belonging to this main research question are:

- How can we characterise current Dutch teachers' and students' views on environmental citizenship?
- How can we validly and reliably assess environmental citizenship?
- What is the educational potential of Socio-Scientific Inquiry-Based Learning for fostering environmental citizenship?

In the following section we first provide an overview of the main theoretical work that is relevant to this dissertation. This section gives definitions of the most important concepts used in this dissertation and shows our position in the research field of education for EC. The final section describes the main chapters of this dissertation and gives an outline of their main goals and methodological approach.

1.2 Theoretical background and definitions

Sustainability is a central concept in this dissertation. Many definitions of sustainability exist, each with their own strengths and weaknesses. Perhaps the most influential and widespread has come to be known as the 'Brundtland definition'. It defines sustainable development as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (WCED, 1987, p. 41). It is usually associated with the three Ps of sustainable development: people, planet, and prosperity (Benninghaus et al., 2018). The Brundtland definition commonly receives criticism in its overly use-based, anthropocentric outlook on the relationship between humans and the rest of the natural world (Almeida & Vasconcelos, 2013; Beasy & Gonzalez, 2021; Summers & Childs, 2007). A more recent definition for sustainability was given by the EU, in their GreenComp framework. It shifts the focus from this anthropocentric view towards a more biocentric and ecocentric view on sustainability by defining it as "Sustainability means prioritising the needs of all life forms and of the planet by ensuring that human activity does not exceed planetary boundaries" (Bianchi et al., 2022, p. 12). This definition is not without its criticism either. It is for instance hard to select which boundaries are critical to sustain life on earth, it is hard to define where planetary boundaries lie, some boundaries are hard to quantify, and it is difficult to decide who is responsible for setting these boundaries (Biermann & Kim, 2020). Despite these difficulties, we consider a bio- or ecocentric view of sustainability to be more desirable than a purely anthropocentric one, since this leaves room for altruistic and biospheric value orientations (e.g., Jickling & Wals, 2008; Kopnina, 2014; Torkar & Bogner, 2019) in the decision-making process.

Sustainable decision-making and action-taking requires a certain set of competences. Wiek et al. (2011) reviewed higher education curricula, policy documents, and research articles, and synthesised the competences they found into a framework of *five key sustainability competences*

that are instrumental to of sustainability problem-solving (Figure 1.1). Sustainability issues are mapped using systems thinking competence, which concerns the current situation and processes that led to its occurrence. Strategic competence concerns developing strategies that facilitate the transition from the current, undesirable situation into more desirable futures. Anticipatory competence assists with painting images of possible future scenarios and assessing their likelihood. The final two competences are normative competence, which concerns desirability of current and future situations and leaving room for different points of view in the decision-making process, and interpersonal competence, which concerns social processes of collaboration and deliberation. Together, these five key competences for sustainability assist an individual in opinion-forming, decision-making and action-taking regarding complex sustainability issues.

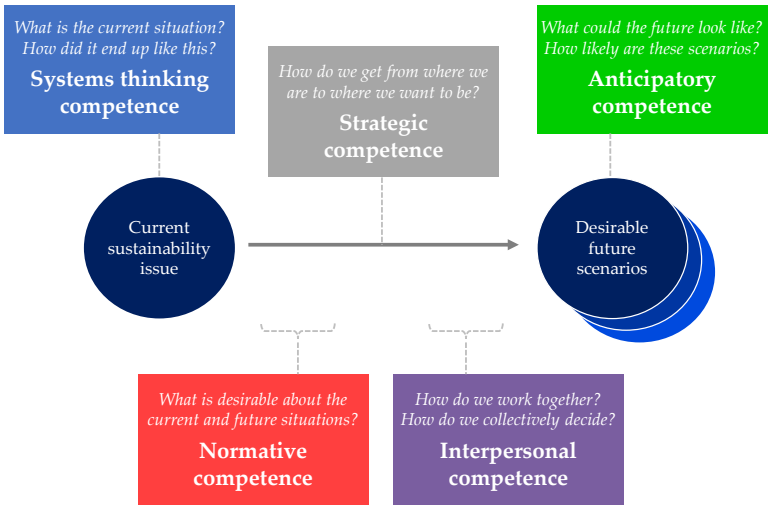


FIGURE 1.1 | The five key sustainability competences, adapted from Wiek et al. (2011).

The five key competences for sustainability therefore form one aspect of *Environmental Citizenship* (EC). The concept of EC encompasses those qualities that enable a person to make responsible decisions and take action with the aim to sustain life on earth. In the decision-making process, an Environmental Citizen considers dimensions such as time (past, present, and future), and place (local, regional, global), whilst taking into account ecological, economic, and social considerations, during individual, collective, private sphere and public sphere action-taking (ENEC, 2018). It builds on general citizenship literature, for instance on Westheimer's (2008) social-justice oriented citizenship, and shares commonalities with general citizenship competence (e.g., Ten Dam & Volman, 2007), for instance with its justice orientation and focus on critical thinking.

In order to provide opportunities to develop these aspects, it follows that education for EC benefits from being holistic, pluralistic, and action-oriented (Boeve-de Pauw et al., 2015).

Holism in this case entails taking into account the temporal, spatial, and ecological, economic, and social aspects of sustainability issues as one coherent whole (Öhman, 2008). Pluralism, on the other hand, deals with normative aspects, showing different points of view, and treating these with respect, regardless of whether they were rational or emotional in origin (Sund & Öhman, 2014). The action-orientation aspect of education for EC involves dealing with knowledge about causes and effects, about sustainability visions, and strategies for change (Jensen, 2002). With its focus on action-taking, education for EC aims to foster action competence. An action-competent individual has action knowledge, action skills, willingness to take action, and confidence in influencing possibilities and self-efficacy (Sass et al., 2020). The three concepts of holism, pluralism, and action-orientation are instrumental in fostering EC of learners in an educational setting, and therefore form the basis for education for EC.

Education for EC, Environmental Education (EE) and Education for Sustainable Development (ESD) are related concepts that differ in several ways. Whereas EE is mainly ecologically centred in its approach, education for EC adopts the more holistic outlook on sustainability that is central to ESD, also including the social and economic aspects. However, education for EC contains a stronger environmental focus than ESD, which, again, is more in-line with EE. A more extensive discussion of these concepts is beyond the scope of this dissertation, and can be found elsewhere (e.g., McKeown & Hopkins, 2003; Sinakou et al., 2019).

Despite their differences, two problems are inherently associated with EE and ESD: the democratic and the ethical problem (Sund & Öhman, 2014). First, the democratic problem concerns the paradox between free, autonomous education on the one hand, versus using education to transfer environmental values and dispositions as educational outcome. The ethical problem concerns "the existence of an external and eternal foundation to which we can anchor our moral beliefs." (Sund & Öhman, 2014, p. 642). In other words, these problems concern using education to teach desirable values, and whether an external foundation for defining these values exists. To mitigate these problems, it has been suggested to focus on competence development (often related to opinion-forming, decision-making, and action-taking) as opposed to value transmission in EE and ESD (Boeve-de Pauw et al., 2015; Garrecht et al., 2018; Jickling & Wals, 2008; Schild, 2016). It are precisely these aims of opinion-forming, decision-making, and action-taking which education for EC adopts as central learning outcomes.

The central teaching and learning approach that we employ in this dissertation is *Socio-Scientific Inquiry-Based Learning* (SSIBL). It combines SSI-driven inquiry aimed at taking action on controversial, real world issues in science education (Levinson, 2018). To this aim, it employs three phases (Figure 1.2). During the Ask-phase, personally relevant and authentic student questions are triggered by introduction of an SSI, which creates a need to know (Knippels & Van Harskamp, 2018). During the Find out-phase, students carry out inquiry towards finding answers to these questions. This can be done through scientific experiments, interviews,

surveys, literature research, or other means. The issue is mapped, for instance by a concept map, systems thinking, or a life-cycle analysis, and stakeholders and their views are identified. Finally, the Act-phase has students develop an appropriate action strategy and take action accordingly. Through SSIBL, students are able to explore opinions of themselves and of others regarding SSIs, creating opportunities for value orientation, value development, and value clarification. Since it was founded on principles of holism, pluralism, and action-orientation, SSIBL has potential to be an effective approach for science education aimed at fostering EC (Ariza, Christodoulou, et al., 2021). It creates opportunities to foster the four aspects of Socio-Scientific Reasoning as defined by Sadler et al. (2007): perspective taking, scepticism regarding information, appreciation for complexity of issues, and awareness of ongoing inquiry of issues.

FIGURE 1.2 | The three main SSIBL-phases of Ask, Find out, and Act, with connections to theoretical models from sustainability and EC literature.

Until now, SSIBL's theoretical potential to foster EC has not yet been extensively studied in the classroom. In order to study this, we used *Lesson Study* (LS) as a research approach in this dissertation. LS originated as a form of teacher professional development which revolves around codesign of lessons between teachers and researchers and collaborative classroom observation (Dudley, 2013). For this dissertation, the LS-team consisted of six science teachers (three biology and three chemistry teachers, among other subjects) and three science education researchers who went through several LS-cycles over the course of the project. Each LS-cycle consists of i) development sessions, during which lessons are collaboratively designed and case-students are selected for observation during the research lesson, ii) the first research lesson, during which one teacher teaches the lesson while the rest of the LS-team observe specifically selected case students, iii) a post-lesson discussion, during which observations and experiences of the teacher and observers are shared, iv) redesign of the lesson, based on experiences with the first research lesson, v) a second research lesson, during which another

class goes through the redesigned lesson while the rest of the LS-team observes, and, finally, vi) the final post-lesson discussion and overall evaluation of the LS-cycle (Goei et al., 2021).

During the school years of 2018-2019, 2019-2020, 2020-2021, and 2021-2022, the LS-team went through multiple LS-cycles, each focussed on EC development through SSIBL at lower secondary level. As a side-note, data collected during the school years which were most strongly affected by the COVID-19 pandemic (2019, 2020, and 2021) were excluded from data analysis. Data from these years were of insufficient quality and are therefore excluded from the main studies.

1.3 A guide to the five main chapters

This dissertation contains five main chapters which describe the empirical work that we did towards operationalizing EC through SSIBL in science education (Table 1.1). Each of these chapters explores a different aspect of education for EC. From science teachers' and students' experiences with EC, via developing an assessment instrument, to a practical application of SSIBL for EC in the classroom, these five chapters provide the empirical basis with which we answer the main research question of this dissertation.

TABLE 1.1 | Main studies in this dissertation, including their chapter number, their main goal, main method and the year(s) in which data collection took place.

Ch.	Goal	Method	Data collection
2	Mapping EC experience of science teachers in the Netherlands	Individual semi-structured interviews with 41 science teachers	Spring 2019
3	Mapping EC of lower secondary students in the Netherlands	Individual semi-structured interviews with 42 lower secondary students	Spring 2019
4	Developing a validated assessment instrument for EC at lower secondary level	Confirmatory Factor Analysis	2019-2022
5	Explore the potential of SSIBL during science education aimed at EC development	Lesson Study, including interviews, observations, post-lesson discussion, student materials	Summer 2019
6	Strengthen our understanding of SSIBL's potential to foster EC through science education	Lesson Study, including interviews, recordings of student group discussions, questionnaire	2021-2022

Chapter 2 explores the views of science teachers in the Netherlands regarding EC in education. It describes the findings of 41 individual science teacher interviews that aimed to describe Dutch science teachers' views of sustainability and citizenship education, their goals with this type of education, how they experienced its place in the national curriculum, what teaching and learning activities they employ for EC in the classroom, and what challenges and opportunities they see for EC in science education practice. This chapter forms an empirical foundation on which the Lesson Study chapters (5 and 6) build towards operationalising EC in science education.

Chapter 3 takes a similar approach, but then concerning views of the students. It describes a series of 42 individual lower secondary student interviews which were aimed at charting student definitions of sustainability, their affinity with the topic, whether they are concerned with the future of the planet, and their previous experiences with sustainability inside and outside of school. Like Chapter 2, this chapter forms the empirical basis used as a starting point for the Lesson Study chapters (5 and 6).

Chapter 4 describes the development of a validated assessment tool for EC. This tool encompasses areas of assessment that were previously uncovered by currently available validated instruments. These for instance concern opinion-forming as a main aspect of EC, and aspects of Socio-Scientific Reasoning. The work described in this chapter mainly entails Confirmatory Factor Analysis. The resulting assessment instrument will be used as a pre-post-test in Chapter 6 to track EC development of lower secondary students who participated in our Lesson Study. It can furthermore serve as a valuable instrument for other educational researchers and science teachers in monitoring these previously uncovered aspects of EC.

Chapter 5 revolves around the first block of Lesson Study cycles. It describes our first experiences with putting SSIBL to practice and exploring its potential for fostering EC through science education at lower secondary level. Data sources include classroom observations, post-lesson interviews with students and the post-lesson discussion of the observers and teacher. It forms an entry point for the more extensive Lesson Study described in Chapter 6.

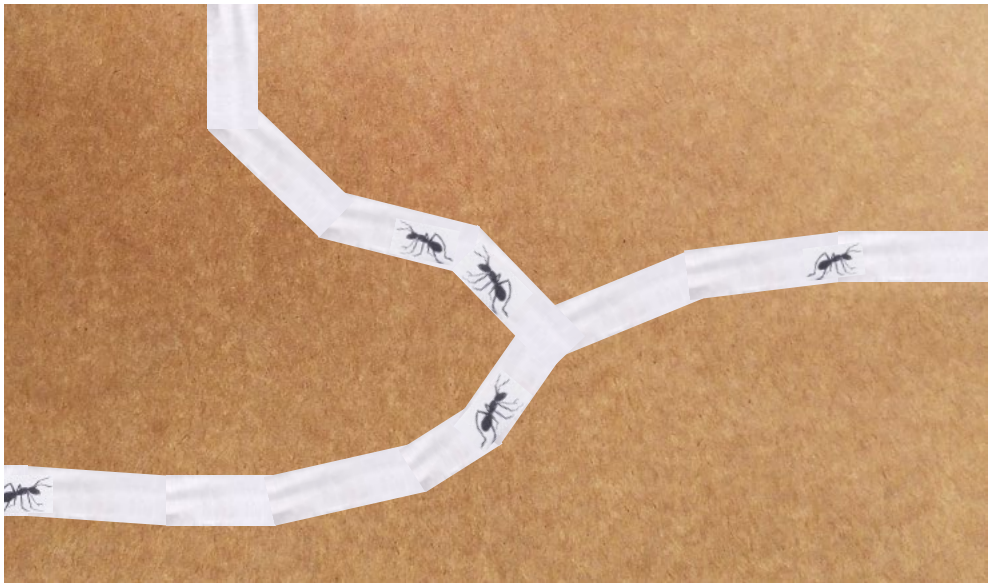
Chapter 6 concerns a second Lesson Study which again aimed to evaluate SSIBL's potential to foster EC through science education. It goes beyond the work done in Chapter 5 in several ways. First, there was a longer period of time set apart for the lessons we developed, meaning students spent more time going through the phases of SSIBL and practicing their EC competences. Second, data sources now mainly include classroom recordings of group discussions of students, shedding more light on student EC development in practice. Finally, students go through the phases of Ask and Act multiple times, offering them opportunities to practice with associated EC competences for these phases in different contexts.

The final chapter is the general discussion, which provides a bird's eye view of the main findings from the work described above. It furthermore gives an answer to the main research question of the dissertation. It also offers recommendations to science education practice and to science education researchers by means of potential avenues for further research.

Taken together, these seven chapters work towards operationalising EC for science education at lower secondary level. They therefore form a valuable knowledge base for science teachers and teacher educators who wish to incorporate EC in their teaching practice, for (science) education researchers with an interest in the workings of EC in educational practice, and for policy makers who want to adjust, update, fortify, or expand the current placement of EC on the educational agenda. This dissertation thereby aims to facilitate the process of teaching EC competences through science education at lower secondary level.

2

Secondary science teachers' views on environmental citizenship in the Netherlands



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Abstract

Environmental Citizenship (EC) is a promising aim for science education. EC enables people not only to responsibly make decisions on sustainability issues—such as use of renewable energy sources—but also to take action individually and collectively. However, studies show that education for EC is challenging. Because our understanding of EC practice remains limited, an in-depth, qualitative view would help us better understand how to support science teachers during EC education. This study aims to describe current EC education practices. What do secondary science teachers think sustainability and citizenship entail? What are their experiences (both positive and negative) with education for EC? A total of 41 Dutch science teachers were interviewed in an individual, face-to-face setting. Analysis of the coded transcripts shows that most teachers see the added value of EC but struggle to fully implement it in their teaching. They think the curriculum is unsuitable to reach EC, and they see activities such as guiding discussions and opinion-forming as challenging. Furthermore, science teachers' interpretation of citizenship education remains narrow, thus making it unlikely that their lessons are successful in fostering EC. Improving EC education therefore may be supported by explicit representation in the curriculum and teacher professional development directed at its implementation.

Keywords: environmental citizenship; lower secondary level; science education; science teachers; education for environmental citizenship

2.1 Introduction

Societies are dealing with complex environmental issues such as climate change, energy crises, and degradation of natural areas. These issues create a need for citizens who are analytic, who can make decisions based on personal, social, and scientific considerations, and who are able to put these into practice. In other words, these issues raise the need for Environmental Citizenship (EC). The importance of EC is shown by educational programs of large international organizations across the globe. For example, the Lifelong Learning Competences of the EU explicitly feature sustainability elements in their description of citizenship competence (European Commission, 2019). Another example is the Sustainable Development Goals, set by the UN, in order to globally align policies and development plans with the sustainability agenda (United Nations, 2019). Finally, the UN organised the Decade of Education for Sustainable Development, which lasted from 2005–2014, and aimed to push the sustainability agenda on schools worldwide (UNESCO, 2014).

However, this focus on EC in educational policy does not necessarily result in more EC being implemented in the classroom. In education, much depends on the choices of the teacher. When science teachers do not see the value of EC, chances are slim for their students to develop EC on their own. Previous large scale, quantitative studies have shown that many science teachers feel unprepared and unsure when teaching about sustainability and its related SSIs (Borg et al., 2012; Olsson et al., 2020). However, because most of these studies adopted a quantitative approach, there is a need for in-depth interview study to provide a qualitative view on science teacher's perceptions on and experience with teaching sustainability at the secondary level (Borg et al., 2012). If we would better understand what teachers are struggling with and what possibilities they foresee, we would be better equipped to support teachers during EC teaching. Hereby, we would improve chances of fostering EC.

In this paper, we aim to describe the current situation of education for EC in the Netherlands at the lower secondary level by answering the following questions: What do Dutch science teachers think sustainability and citizenship entail? What are their experiences (both positive and negative) with education for EC in classroom practice? Describing this current state is a first step in better understanding what challenges exist, and where the research community could support science teachers in education for EC.

Definitions of EC and related concepts

The last decades of research on sustainability education have resulted in insights in teacher experiences with EC in science education. Results from these, mostly quantitative, studies will be discussed in this section, but not before making a statement as to the interpretation of EC and its relation to sustainability, sustainable development, and educational approaches towards these topics.

Although many definitions of sustainability exist, one of the most widely used is the Brundtland definition, from the famous Our Common Future report. This report defines sustainable development as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (WCED, 1987, p. 41). To make this sustainable future into a reality, citizens need a specific set of knowledge, attitudes, and behaviour that enables them to deal with sustainability issues in their daily lives. This form of citizenship consists of diverse competences such as systems thinking, normative competences, future thinking, and strategic thinking. An Environmental Citizen performs these actions individually and in groups, both in private and public spheres, and on local, national, and global scales (A. C. Hadjichambis & Paraskeva-Hadjichambi, 2020a). In doing so, environmental citizens aim to solve contemporary issues, prevent new ones, and achieve sustainability through this, among others. EC thereby encompasses elements of all three types of citizen as defined by Westheimer and Kahne (Westheimer & Kahne, 2004): (i) the personally responsible citizen, who acts responsibly, is law abiding, and honest; (ii) the participatory citizen, who actively participates and takes leadership positions in existing systems; (iii) and the social-justice oriented citizen, who questions, debates, and changes these existing systems.

Two common teaching approaches that can foster EC are Environmental Education (EE) and Education for Sustainable Development (ESD). Despite sharing certain aspects, they differ considerably in their ideological focus (McKeown & Hopkins, 2003). EE explores humanity's relationship with nature and aims to preserve natural areas. It focuses strongly on scientific content knowledge. ESD, on the other hand, adopts a broader view which also considers social, economic and cultural elements. A common theme in ESD is the triple bottom line of sustainability, which consists of people, planet and prosperity (Hammond, 2006). This broader focus of ESD, and especially its supposed overemphasis of economic aspects of sustainability issues, has received criticism from scholars. They argue that by moving away from EE towards ESD, the inherent value of nature no longer has a place in the science classroom (Kopnina, 2014). Other researchers see EE and ESD next to each other, both with their own niche and focus (McKeown & Hopkins, 2003). A third form exists, which combines elements of EE and ESD, in such a way as to address "knowledge, skills, values and affective issues for a changing future without losing sight of the imperative for understanding and valuing conservation of the biophysical world" (Taylor et al., 2019, p. 104). This form is called Education for Sustainability (EfS). A synthesis of the concepts EE and EfS, with a special focus on citizenship, is Education for Environmental Citizenship (EEC), which aims to empower students to become responsible environmental citizens (A. C. Hadjichambis & Paraskeva-Hadjichambi, 2020a).

Teachers' conceptual understanding of sustainability and citizenship

There have been several quantitative studies looking into teachers' conceptual understanding of sustainability (i.e., Borg et al., 2012; Hasslöf et al., 2016; Sinakou et al., 2019; Summers et al., 2005). Judging by these, sustainability is a difficult concept for teachers to define. In a large

questionnaire study with over 3000 Swedish teachers, many different teacher interpretations of sustainability were found, and many teachers reported they were uncertain of its meaning (Borg et al., 2012). Most teachers saw sustainability issues solely as knowledge problems, often altogether disregarding the social, ethical, personal, and economical aspects of sustainability. In doing so, they almost exclusively focused on the scientific facts and models behind sustainability issues.

In other studies, this omission of the citizen aspects of sustainability teaching has been found as well (Summers et al., 2005). Traditionally, science education focused on the environmental aspects of sustainability (i.e., processes of climate change, toxicity of compounds, energy efficiency of different fuels). Only 15% of the 123 pre-service teachers that filled in a questionnaire on sustainable development used a combination of the people, planet and prosperity elements, whereas three quarters of the participants named planet aspects to be central to sustainability. This oversimplified understanding of sustainability is widespread, with a holistic view of sustainability often being absent (Sinakou et al., 2019). Findings like these prompt researchers to call for a broader focus on multiple perspectives, critical thinking, added complexity, and socialization or repoliticising sustainability issues in the classroom, of course combined with rational and scientific ways of thinking (Hasslöf et al., 2016).

Recently, a review study has been carried out looking into pre- and in-service-teachers' perceptions of EC (Georgiou et al., 2021). From these mostly quantitative studies, the researchers concluded that teachers adopt relatively narrow definitions of EC, focusing on local scale issues, the individual dimension of EC and remaining in the private sphere. The researchers conclude that these perceptions influence educational practice, and are thus worth looking into.

These studies are all based on quantitative data. A qualitative view on science teachers' understanding of sustainability is desirable. With this, we could better describe their rationale behind their interpretation of the complex and multifaceted concepts of sustainability and EC. This could provide a stronger foundation from which to support science teachers during teaching EC.

Current EC teaching practice

Several themes can be identified about current EC classroom practice. In recent years, a shift from EE towards ESD has been observed in science education policy documents (Bagoly-Simó, 2014; Sinakou et al., 2019). Some researchers criticize this shift in focus, expecting this to be counterproductive for the transition towards a sustainable society (Kopnina, 2014). However, despite this shift in policy focus, classroom practice seems as of now unaffected. While EE focuses strongly on ecocentrism, ESD introduces anthropocentric tendencies. Findings from a large, international comparison study show that science teachers in developing countries mostly adopt anthropocentric views, whereas ecocentric views still prevail among teachers in developed countries (Borg et al., 2012; Clément & Caravita, 2014).

Zooming in on the Netherlands, the Dutch curriculum for lower secondary science education (*Kerndoelen 'Mens en natuur'*, core aims 'Humanity and nature') does not explicitly mention EC or citizenship (SLO, 2016). It does, however, refer to citizenship aspects such as making informed decisions and behaving in a sustainable manner. Perhaps this relative underrepresented role of citizenship in the Dutch curriculum has led to relatively poor results for the country in international comparison studies such as the International Civic and Citizenship Education Study (Schulz et al., 2018).

Concerning sustainability, ESD, EE, and EfS, the Dutch lower secondary curriculum aims contain many examples, such as, for instance, "The student learns that people, animals and plants are in connection with each other and their surroundings (environment), and that technological and scientific applications affect the sustainable quality of these surroundings in both positive and negative ways" (SLO, 2016, p. 11, core aim 30). In the Netherlands, the lower secondary curriculum aims form a set of guidelines; it is not an obligatory rulebook. This means that in the end, the teachers are the ones who decide what curriculum aims are pursued. From previous studies it became clear that not all science teachers think ESD is important (Borg et al., 2012). Furthermore, teachers from different subjects show different willingness to teach ESD (Borg et al., 2012). Therefore, to better understand the current state of EC teaching in the Netherlands, it is necessary to look into the choices teachers make and their rationale behind those decisions.

Next to the national curriculum, teachers formulate their own learning aims for students. In ESD, three different approaches to learning aims have been defined by Kelly (1986): (i) a focus on science theory, discarding emotional aspects entirely to prevent indoctrinating students with their own opinions; (ii) raising awareness of environmental issues; and (iii) showing the complexity and controversial nature of sustainability issues with the aim to promote responsible decision-making. Reasons for picking the first strategy commonly include the focus of national exams on theory, a focus that creates the risk of painting too narrow a picture of sustainability issues (Hasslöf et al., 2016). Neglecting or glossing over negative emotions in sustainability debates has been deemed a common and undesirable trait of current science education practice (Ojala, 2020). Exploring teacher-initiated learning aims related to sustainability could further improve our understanding of current EC practice.

Challenges of teaching EC

Previous studies have found a diverse range of challenges with teaching EC at the lower secondary level. A review study on teaching EfS shows that secondary teachers generally feel they lack skills to effectively integrate it into their regular classroom practice (Taylor et al., 2019). Teachers say they are used to teaching scientific facts, whereas they are uncertain with teaching ethical and social issues in the science classroom (Day & Bryce, 2011). Because sustainability issues are often controversial in nature, they benefit strongly from teaching methods that involve discussion and dialogue, yet science teachers feel less secure in applying these activities (Summers et al., 2005).

Another main issue for science teachers is the multidisciplinary character of sustainability issues. This complicates teaching because many teachers come from highly specialised backgrounds. Interdisciplinary teaching would enable students to develop EC competences, whereas focusing on individual topics is counterproductive to reach EC (Sinakou et al., 2019). Teaching about sustainability in a holistic manner, thus showing interconnectedness of topics, makes EfS difficult (Dutta & Chandrasekharan, 2017). Next to holism, pluralism is important when teaching about sustainability issues. In a pluralistic classroom, multiple perspectives on issues are considered. Pluralism, like holism, has been found to be hard for science teachers (Boeve-de Pauw et al., 2015).

Other, more practical, complicating factors for teaching sustainability were found in the previously mentioned study by Borg et al. (2012). In this study, teachers reported that teaching sustainability issues was made difficult by a lack of time and space in the curriculum, a lack of inspiring examples, a lack of time to adapt existing teaching activities to make them more suitable, and a lack of perception of learning aims for sustainability education. Similar conclusions are drawn in other studies (e.g., Taylor et al., 2019).

As can be seen from many of these data sources, most of what we know about current-day science teachers and their views towards sustainability, their current EC teaching practice, and the challenges they experience with teaching EC stems from quantitative studies. A qualitative, in-depth view would improve our understanding of what support science teachers need when teaching these topics.

2.2 Method

For this study, 41 science teachers were interviewed in a face-to-face setting. The interviews lasted for 31 min on average.

Participants

Teachers were approached from the researchers' network. Participants were selected to ensure a representative topographical spread, gender ratio, and subjects taught. Table 2.1 shows background data of the participants. The final sample slightly overrepresented rural areas when considering the urbanization ratio of The Netherlands, which lies at 91.5%, with 15% of the interviewed teachers being from rural areas (United Nations, 2018).

Instruments and data collection

A semi-structured interview approach was used to gather the data (for interview scheme see Appendix 2.1: interview scheme). The interview scheme was constructed to cover a broad range of teacher activities, including their conceptual understanding of sustainability and citizenship, whether they think it is important for their teaching practice, learning aims, lesson

design, and carrying out EC lessons in the classroom. Furthermore, to explore their aims and teaching approaches with EC, we asked them in what way they recognised EC concepts in the national curriculum aims. After this, we asked them about challenges they experience with applying EC in the classroom, and their levels of confidence when teaching EC. To fortify our understanding of their confidence with teaching EC, the interview ended with questions regarding incorporation of other Socio-Scientific Issues in their lessons, and three self-efficacy questions. The self-efficacy questions were based on the three self-efficacy themes defined by Tschannen-Moran and Woolfolk Hoy (2001): (i) classroom management, (ii) ability to motivate students, and (iii) availability of teaching and learning activities, all seen from an EC angle.

TABLE 2.1 | Background data of the interviewed teachers, showing age, gender, teaching experience, current subjects taught, and type of school (rural or urban).

Category	Background data
Age	Average: 44.2 Minimum: 25 Maximum: 64 20–29: 9 30–39: 7 40–49: 8 50–59: 11 60 and above: 6
Teaching experience (years)	Average: 11.9 Minimum: 1 Maximum: 40 0–9: 19 10–19: 18 20–29: 1 30 and above: 3
Gender	Female: 19 Male: 22
Current subjects taught (number of teachers)	Biology: 26 NASK[1]: 16 Science[2]: 6 Other[3]: 19
Urbanisation level of school area (number of teachers)[4]	Rural: 6 Urban: 35

1. Abbreviation of *Natuur-scheikunde* (Physics and chemistry), a subject that some schools teach at the lower secondary level. 2. Some schools teach this subject, which focuses on scientific inquiry through problem-based learning and question-oriented learning. 3. Other subjects include mathematics, home economics, IT, and research-based subjects. 4. Based on number of addresses per 500m^{2}.

Data analysis

All interviews were audio recorded and transcribed verbatim, omitting vocalised pauses to enhance readability of the transcripts. Common themes were sought in the transcripts based on the constant comparative method (Glaser, 1965). This method consists of several cycles of coding all the transcripts, with each cycle further specifying and tightening the coding scheme. During the first cycle of coding, the data are coded in as many categories as necessary. Notes about emerging themes were made, which informed subsequent cycles. During these following cycles, the coding scheme was narrowed down, ultimately leading to a tight, cohesive set of codes that shows common themes in the data (see Appendix 2.2: coding scheme for the final list of categories and their descriptions). A second researcher coded 12% (five interviews) of the data using the developed coding scheme, and after discussing the two analyses, 98% of agreement was reached. This indicates nearly perfect agreement (O'Connor & Joffe, 2020). Percentage of agreement is an applicable intercoder reliability measure in this case because in the current study, each code can be given only once to each teacher (O'Connor & Joffe, 2020). Based on the discussion, the coding scheme was finalised and the whole dataset was coded accordingly.

2.3 Results

The following common themes were found after analysis of the science teacher interviews.

Science teacher definitions of sustainability and citizenship

When teachers described their definition of sustainability, planet aspects were by far the most common of the triple bottom line, with about half of the teachers' answers falling in that category (19/41, Figure 2.1). In contrast, prosperity aspects were mentioned by less than one tenth of the teachers (3/41). One teacher summarizes:

> "Well, kind of, reuse of resources. Good for the environment, little CO_2 emissions. Yes, something like that? It is kind of a vague concept, isn't it? Students think so too, by the way." (Teacher 11)

A few teachers give a definition of sustainability that fits closely to the Brundtland definition (7/41). Most teachers focus on sustainable processes and recycling when defining sustainability instead (24). About half of the teacher definitions of sustainability included references to the environment (22/41) and prolonged use of products and materials (18/41). Another common theme is effects on next generations (12/41). As the following quote illustrates, 13 teachers mentioned sustainability is a container concept:

> "Sustainability concerns, it is a very broad concept, a container concept that contains a great many things. Sustainability is about for instance sustainable energy. It is about all kinds of resources that nature offers us, and using these in a sustainable manner. So using

them in such a way that we can use them again. Kind of. It is about leaving a sort of Earth that can be used again. On which you do not exhaust all kinds of resources, but with which you, where you can use them but use them in such a way that next generations can use them too. Kind of a vague story, but. And then you can talk about solar energy, well, apart from the materials where that is made out of, what do you do with that?" (Teacher 23)

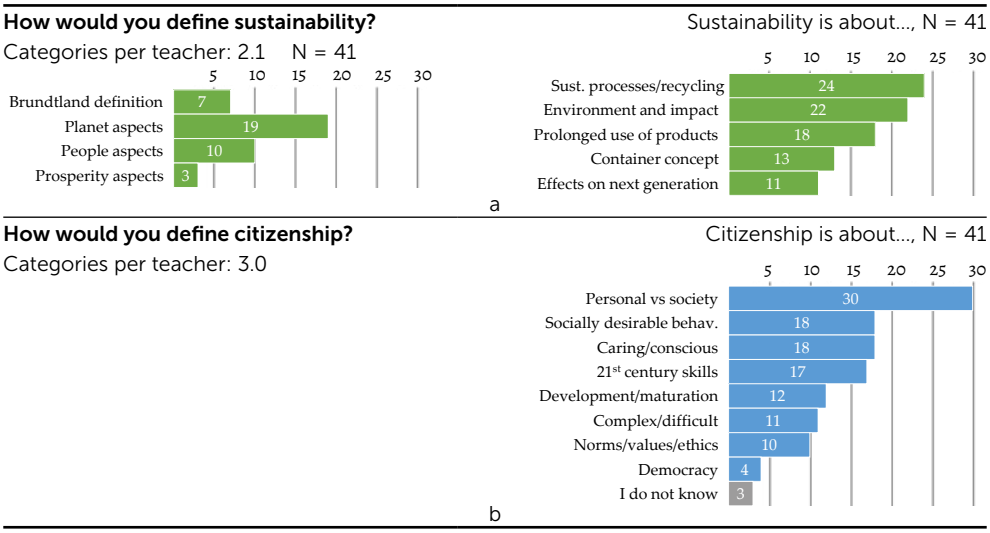

FIGURE 2.1 | Definitions of: (a) sustainability, including categorization on Brundtland and triple bottom line of sustainability (people, planet, prosperity); and (b) citizenship, according to the 41 interviewed teachers. Numbers in the bar graphs represent total number of teachers whose answers fell in the respective categories.

Concerning citizenship, three quarters of the teachers define it using terms that describe the relationship between the personal, the individual, with society (30/41). According to half of the teachers, citizenship deals with socially desirable behaviour (18/41), caring for your surroundings, being involved and conscious about your place in society (18/41). One teacher says:

> "I find that a very difficult question, but yeah, I see that as learning from each other, how you find your way in this society and, how you develop, in such a way that you add something to society and your surroundings and people around you, and that can be very broad but it can also be very small, in a smaller circle. Yes, summarizing, adding something to your surroundings." (Teacher 39)

Citizenship is seen as being part of 21st century skills by seventeen teachers. A quarter of the teachers says it has to do with the development or maturation of the students (12/41) and with norms, values and ethics (10/41). A total of 11 teachers think citizenship is a complex and difficult concept, with three other teachers going further by claiming they do not know how to define it at all.

Curriculum and classroom practice

Twenty-five teachers think there is a lack of sustainability in the national curriculum (Figure 2.2). They think the curriculum overemphasizes the theoretical side of sustainability (12/41) and that sustainability is incorrectly represented in the current curriculum (9/41). Describing this, one teacher says:

> "The disadvantage of school is you have a program, [...] with physics lessons, sustainability isn't at all an item there. But as soon as we discuss solar panels and solar energy, then suddenly it is. So I think it is an important theme, but I could do a lot more about it. [...] Because learning is not only for your test or the exams, it is also life-learning. [...] You don't always have the time for that, [...] not the societal part, and that is a pity, it only is the technical aspect [...] Look, that whole discussion now, about, we have a climate treaty [...] And then the question immediately presents itself: how are we going to make that workable? What can we do with it? That whole kind of thinking, look, students know very little about that." (Teacher 34)

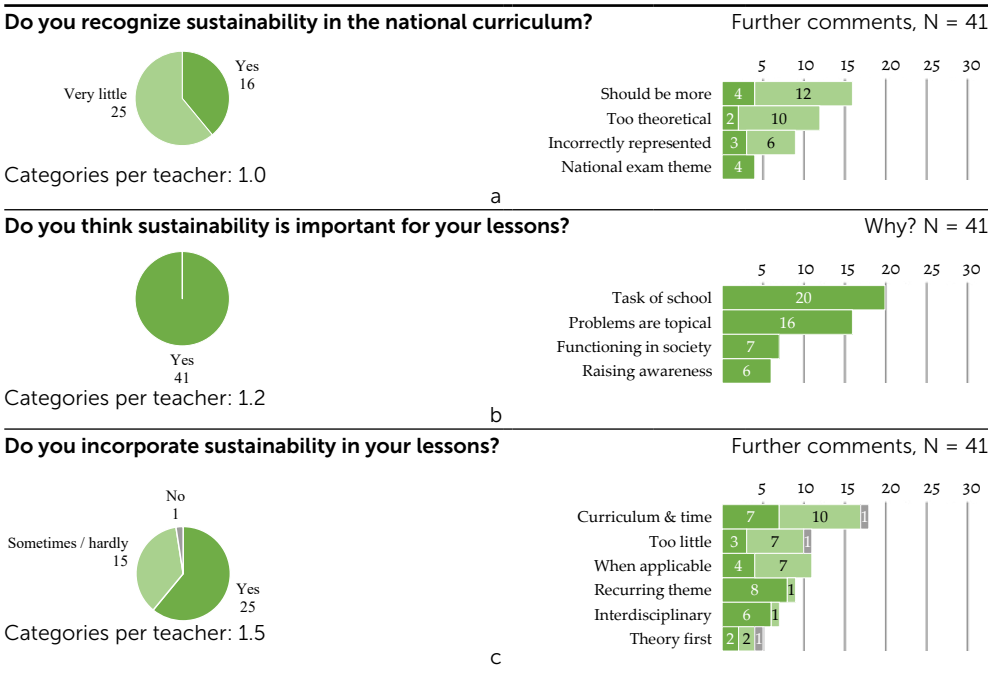

FIGURE 2.2 | Teacher perceived (a) curriculum presence, (b) importance in the classroom, and (c) teaching occurrence of sustainability, as described by the 41 interviewed teachers. Numbers in the bar graph represent total number of teachers whose answers fell in the respective categories. Colours in the pie and bar graphs correspond.

Despite this general lack of sustainability in the curriculum, all interviewed teachers think sustainability is important for their lessons. Twenty teachers feel that it is a task of the school

to teach about sustainability. Sustainability issues are typified as urgent and topical (16/41), so they should be taught at school. Seven teachers think that students need to know about sustainability to function in society. One teacher explains:

> "I think it is a very important theme, because you see it a lot around you of course. […] You see it everywhere, this is sustainable, that is sustainable, on fashion brands, or sustainable wood, you know, on these stickers and labels, you find them all the time. I think it is important that we pay attention to this during biology lessons, because it kind of is a term that is used regardless of whether it is appropriate or not, even though it is kind of a difficult concept. What actually is that, sustainable? […] Where does the sustainability come from then? I think it is a subject, certainly for biology and mainly in lower secondary level, […] that everyone should learn something about." (Teacher 13)

Despite the criticism on the curriculum, over half of the teachers (25/41) incorporates sustainability in their lessons. Nine teachers claim it is a recurring theme for them. Reasons for only occasionally incorporating sustainability in their teaching include a lack of time and a full curriculum (11/41), and a focus on theoretical subject knowledge first for the lower secondary level, before more complex topics such as sustainability can be taught in the higher secondary level (4/41). This is illustrated by one of the teachers, saying:

> "Currently on my schedule is sustainable energy. We discuss energy use, gas and electricity, energy at home, energy transport, […] and at a certain moment you discuss how do you produce electricity? Yeah, you don't just discuss coal plants then, but you also have to explain wind turbines and discuss the energy transition and explain that. I think this belongs in the curriculum. Next to that, you hope that children learn more than what is written in the textbook, but that they become kind of critical citizens of the world, in a way, and that, that is kind of a side effect that I hope to achieve in my lessons, but it is not part of the program. And I try to stimulate them and because I like this subject I talk about it sometimes, but I do not always receive the response that I like. Then I think yeah we have subjects such as philosophy and big thinkers, let them discuss these themes there as well. And I think that this belongs there more, and in chemistry, I think, yeah you should discuss plastics and recycling and such, the actual content belongs here, but the moral stuff belongs on a higher level." (Teacher 12)

Only one teacher says they never teach about sustainability, with reasons for this including the curriculum and this focus on theory first.

In contrast, about half of the teachers do not recognize any citizenship in the national curriculum (18/41, Figure 2.3), with a further quarter of them only seeing very little citizenship in the curriculum (12/41). Elements of citizenship that are there are connected to sustainability (10/41) or related to opinion-forming (10/41). Eight teachers feel there should be more citizenship in the science curriculum, and seven teachers feel citizenship is mainly connected to other subjects or should be mainly taught at the school level. One teacher says:

"I think there is nothing about it [citizenship] in there [the curriculum]. I cannot remember at least. I should have a look at that, if there is something in the chemistry curriculum about citizenship. But I cannot remember it being there. [...] Actually, I would be surprised if it is there, very honestly. But in a way I would think it is good if it is there, because I think chemistry plays a role in that too. [...] But I think it is kind of limited, because it actually only fits with sustainability, because all other subjects [...] I could not think of another subject that could fit with it [...] polymers perhaps, plastics, but those again connect to sustainability. So all of it is sustainability related then." (Teacher 8)

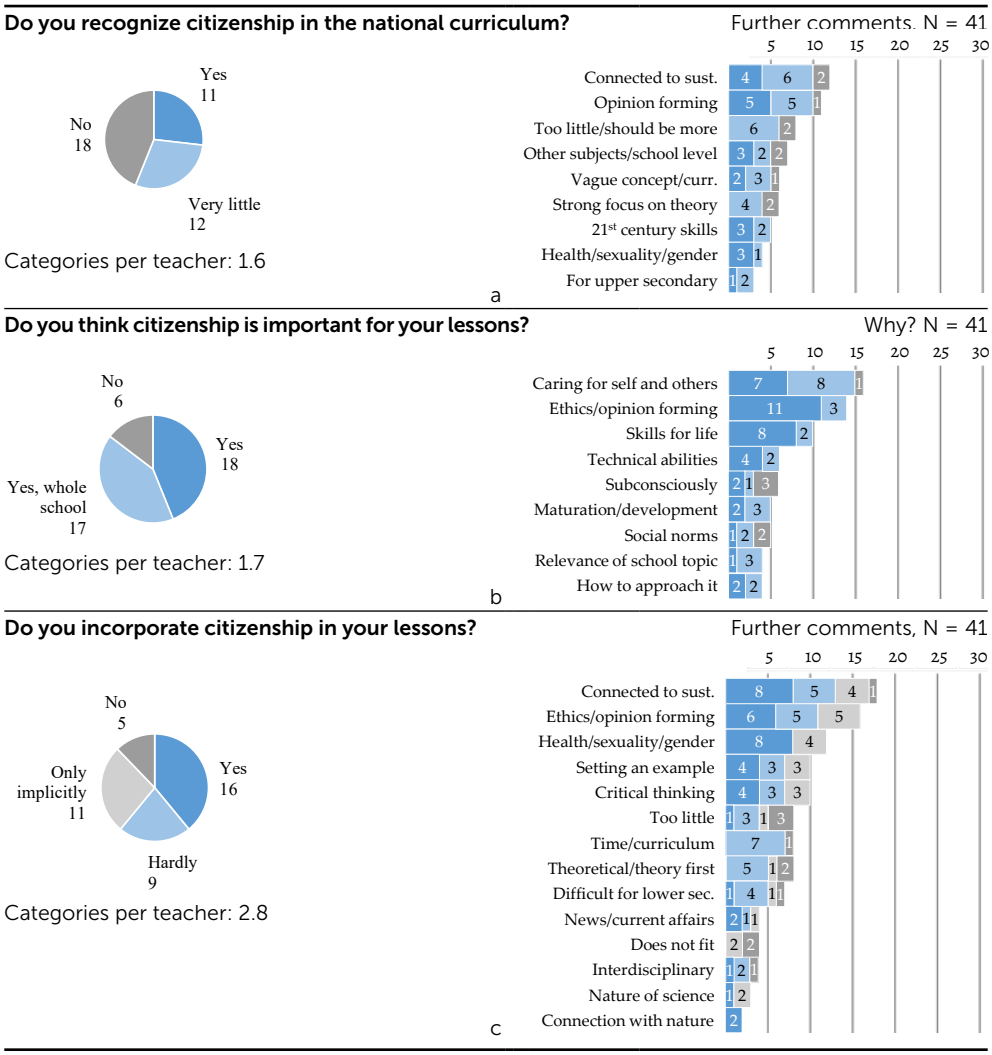

FIGURE 2.3 | Teacher-perceived (a) curriculum presence, (b) importance in the classroom, and (c) teaching occurrence of citizenship, as described by the 41 interviewed teachers. Numbers in the bar graph represent total number of teachers whose answers fell in the respective categories. Colours in the pie and bar graphs correspond.

As can be seen from Figure 2.3, some teachers say citizenship is a vague concept. Again, teachers describe the theoretical focus of the science curriculum, leaving little room for topics such as citizenship. Three teachers think that citizenship is more suitable for the upper secondary level.

Many teachers think citizenship is important for their lessons (18/41), while other teachers do agree with this, adding that it is important for all subjects (17/41). Fourteen teachers think it is important because it is about care for oneself and for others. Other reasons include ethics and opinion-forming being important (14/41) and citizenship being a necessary skill for life (10/41). Describing this in further detail, one teacher says:

> "Yes I think indeed, students at school, they do not necessarily, do not see the use of lessons very often. Even though I think that when you show the use to yourself and of the world around you, without that, we cannot live. […] I think we have an important societal role or responsibility as biology teachers. But […] I think that citizenship should be more prominent in that." (Teacher 32)

Just under half of the teachers actually incorporate citizenship in their lessons (16/41), with a further nine claiming to do so hardly ever, and eleven others only doing so implicitly. Five teachers never teach citizenship at all. Time or room in the curriculum is seen as a limiting factor (8/41). Teachers want to focus on theory first (8/41) and feel citizenship is too difficult for lower secondary level students (7/41). Four teachers think it does not fit with their subject at all. In answering whether they incorporated elements of citizenship education in their lessons, one teacher says:

> "No, not that much. Concerning this, chemistry is a very technical subject. You learn several things and you learn how you can deal with certain conditions but you do not learn how to prevent issues. And you learn how you can potentially solve issues, but critical thinking, would you do this or that, yeah, much, much less. Chemistry is a subject that is very much anchored in protocols and rules. You have the twelve principles of green chemistry, that concerns how you can use chemistry in a green manner, […] so, chemistry that is as sustainable as possible, that does lead to as little waste as possible. These are rules and formulas and you can in a way calculate […] how green something is, how sustainable something is. With this, a critical view, that isn't at all a thing. You just do what is written down. You follow the recipe. Totally at the end, you could incorporate a critical view on, you have two processes, a and b, and the end result is this and that. Compare the two and which one is the greenest? But yeah, is that critical? I don't think so. Because critical thinking means you make your own judgement, and think about it yourself, and reason about stuff, and that happens very little, […] yeah that isn't a thing at all." (Teacher 10)

Reasons given for incorporating citizenship in science education include its connection to sustainability (17/41), or to ethics and opinion-forming (16/41) and because citizenship connects

to many issues about health, sexuality and gender (12/41). Ten teachers aim to set an example for their students and stimulate critical thinking, both of which are perceived to be elements of citizenship in their classroom practice.

Teaching and learning activities and learning aims

Teaching and learning activities that teachers deem suitable for sustainability issues vary greatly (Figure 2.4). About two fifths of the teachers use discussion, research, and videos or documentaries during teaching about sustainability. With these activities, over half of the teachers aim to raise awareness (24/41). Many teachers aim to show the impact of our behaviour or to show the bigger picture (15/41). For a third of the teachers, opinion-forming and decision-making is an aim, so are teaching theory and 21st century skills. One teacher says:

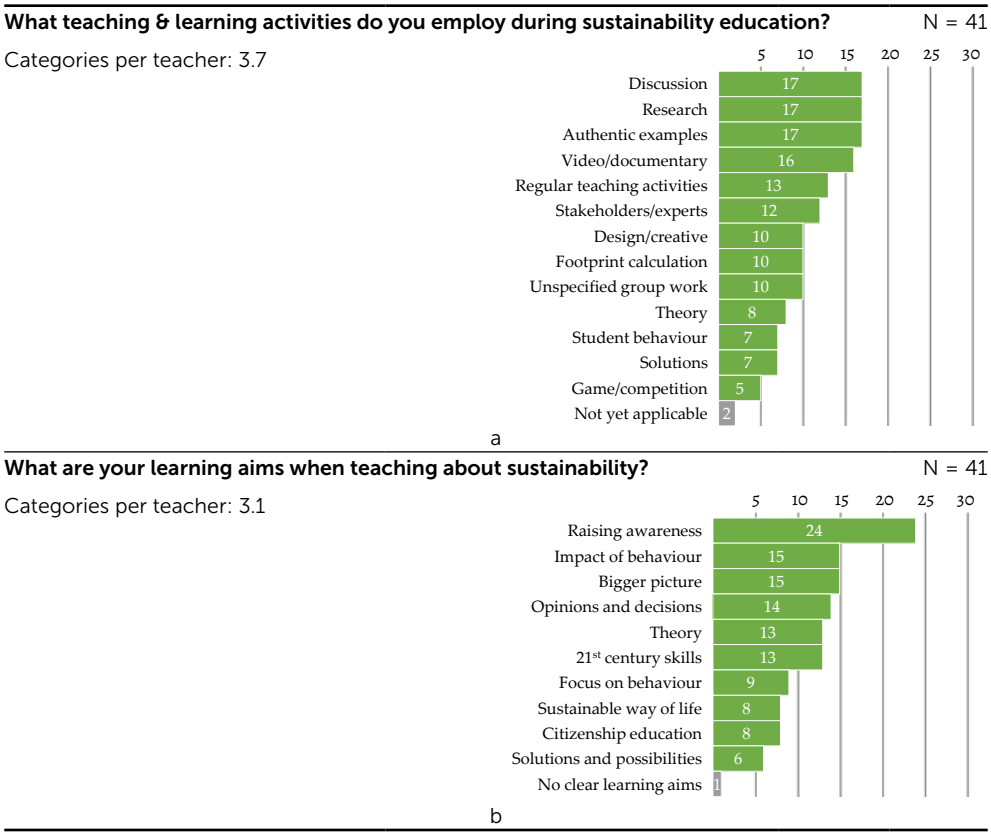

FIGURE 2.4 | Sustainability (a) teaching and learning activities and (b) learning aims, employed by the 41 interviewed teachers. Numbers in the bar graph represent total number of teachers whose answers fell in the respective categories.

"You also want that, sometimes, that they can see there is a problem they cannot solve. That in itself is a very important learning aim, [...], that they have to choose between

multiple solutions none of which are the perfect solution. Well, such a soft learning aim, [...] that they see that this is an interdisciplinary problem, that you have to deal with many people, with different parties, yeah, and you can, depending on the topic or where you are in the curriculum, there are also sustainability concepts that you can have as learning aims, but I feel that, why I think it is important, that is because of the softer learning aims." (Teacher 36)

Teaching and learning activities during citizenship education often feature discussion (13/42, Figure 2.5) and resemble regular teaching and learning activities (13/41). Ten teachers do not teach citizenship at all. Half of the teachers mention learning aims dealing with 21st century skills and opinion-forming or decision-making. One teacher explains:

"Especially the development of an educational approach [...] in secondary education that is very underdeveloped. That I think is challenging [...], I just mentioned complexity, there are a few competences that belong with that, right, [...] such as systems thinking, but also future thinking, painting scenarios from the future. And, paying more attention to the moral aspects of issues, because, it isn't like something is right, something is wrong, desirable or undesirable, but by whom, etc., and what do you do with that? So I think developing a moral compass on that front is very important." (Teacher 37)

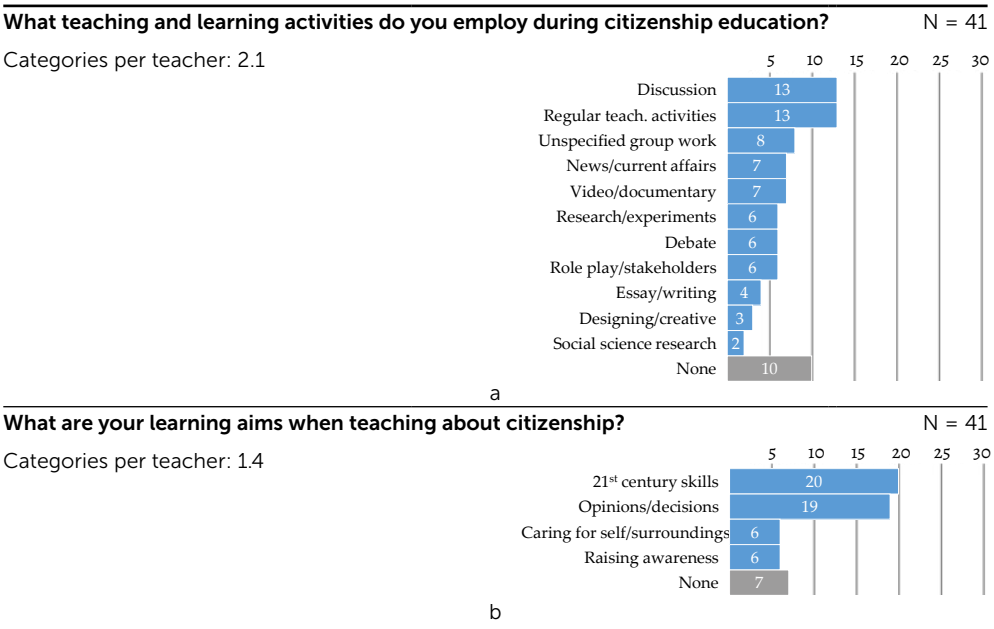

FIGURE 2.5. Citizenship (a) teaching and learning activities and (b) learning aims, employed by the 41 interviewed teachers. Numbers in the bar graph represent total number of teachers whose answers fell in the respective categories.

Challenges and confidence with sustainability and citizenship in science education

Fourteen teachers feel less confident about teaching sustainability than other topics (Figure 2.6). The most common reason for this is the different opinions that exist on the topic (10/41). The other teachers do feel confident with teaching sustainability, with the most common reason being their inherent interest in the topic. Teachers are also able to come up with real life examples, often from their own surroundings.

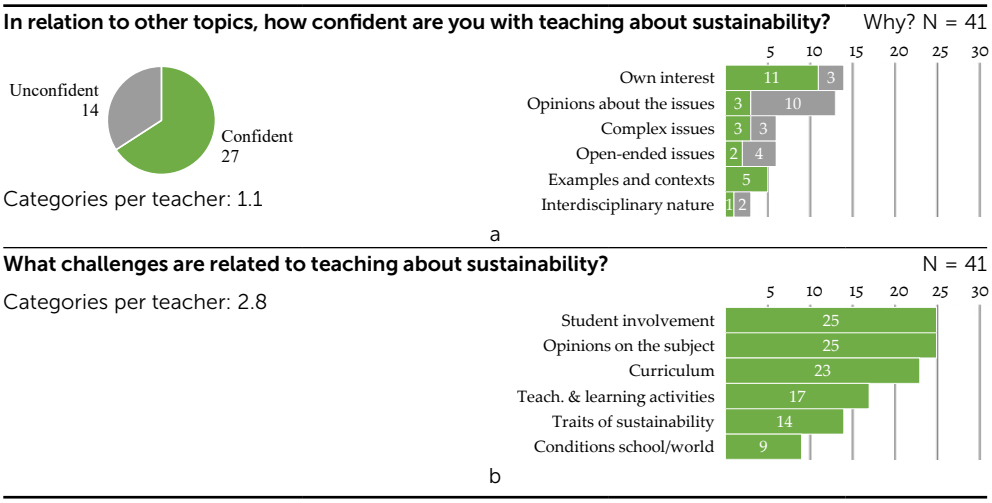

FIGURE 2.6 Teacher (a) confidence with and (b) challenges when teaching sustainability. Numbers in the bar graph represent total number of teachers whose answers fell in the respective categories. Colours in the pie and bar graphs correspond.

When asked to name the biggest challenges with teaching about sustainability, more than half of the teachers mention three main issues. The first one is difficulties with student involvement. Teachers think students are not interested in sustainability, or perceive it as something that is far off for the students, as this teacher describes:

> "Maybe, when I think about it now, when I teach about these topics [sustainability], I experience an enormous distance between the world of the students, who do not at all look at it this globally, they only see their daily lives. I would almost say, they do not even look further than their own table, [...] they do not see anything. And this is a global look on things, where you look at how do they do this for society at large [...], and that distance is really big. And that way, I can only very difficultly connect with the world of the students. [...] That truly is a field with opposing powers. That means I have to work really hard to accomplish something here." (Teacher 16)

Equally as challenging are the many different opinions that exist among the students regarding sustainability. These opinions can sometimes be experienced as very harsh or strong, involving

strong emotional responses. The third biggest challenge according to these teachers was the curriculum. It pays too little attention to sustainability, and it takes a too theoretical approach. Less common reasons include difficulty with finding suitable teaching and learning activities, and specific traits of sustainability issues making it less easy to implement, for instance, because issues are abstract and play on such a large scale. Nine teachers felt that conditions in the world or at school, for instance, dealing with colleagues who did not think sustainability was important, made teaching about sustainability challenging.

Science teachers seem to feel less confident about teaching citizenship, with half of them feeling confident (21/41), two fifths feeling less confident (14/41) and six saying they never implement citizenship at all (Figure 2.7). Teachers feel most unconfident about guiding discussions, followed by less common answers such as lack of prior knowledge, inexperience, and the necessity of preparation before teaching these lessons. One teacher explains:

> "Maybe I feel more confident with other topics, because those are of course mainly theoretical. When you tell how to name a molecule. Yeah, there is little discussion possible about that. But when you talk about sustainability, then… I think I am also a little less trained for that. So, yes, I think I am a little bit more unconfident the moment I talk about sustainability, also because more discussion can arise then, you can never exactly know what might happen." (Teacher 8)

Eleven teachers are confident because they are interested in citizenship aspects of their subject.

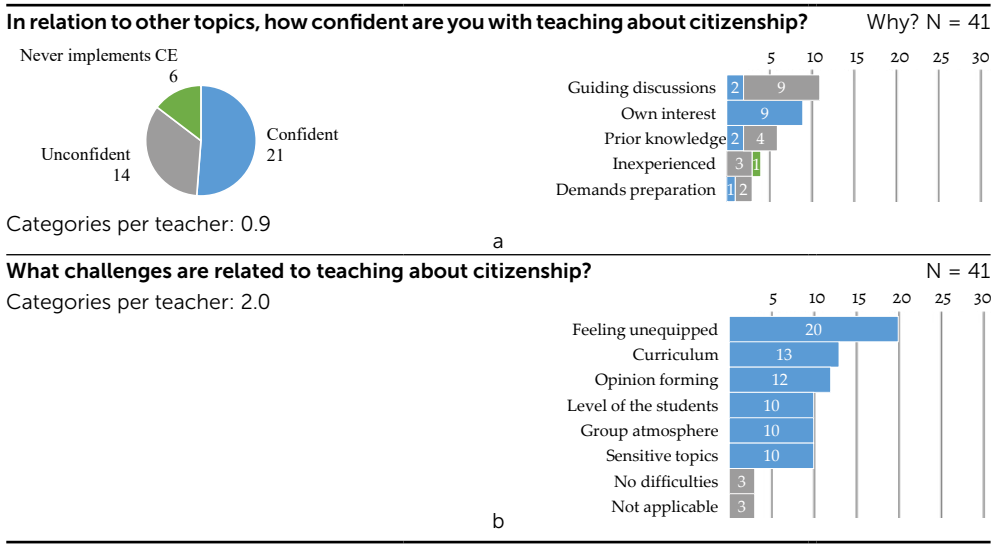

FIGURE 2.7 | Teacher (a) confidence with and (b) challenges when teaching citizenship. Numbers in the bar graph represent total number of teachers whose answers fell in the respective categories. Colours in the pie and bar graphs correspond.

The most common challenge for science teachers with integrating citizenship education in their lessons is that they feel unequipped to teach citizenship (20/41)—for instance, because of difficulty with guiding discussions and being unsure about assessment and evaluation of citizenship. One teacher says:

> "I think it is difficult for instance to guide a discussion. […] That is not something I am trained to do, and I know that other teachers are way better at this, so I try to avoid it a little bit. And that does make me feel a little insecure. […] And I think it is difficult to gain insight in student opinions. Because it usually are the same students who quickly form an opinion. […] To make them say what they feel, their opinion, that is pretty difficult. […] And the fact alone that I do not really know what citizenship education means, that tells you something about how confident I am about this. […] It is a very vague concept. […] And I also do not know when it is good enough or something. With sustainability you can just show some examples, but with citizenship, I just don't know when I have sufficiently reached these students. […] It is way easier to set learning aims for sustainability than for citizenship education." (Teacher 7)

Other common themes that create challenges are the curriculum, difficulty with external influences on opinion-forming, such as parents or politicians. Finally, teachers say an experienced lack of cognitive level of the students is challenging, as well as creating the right atmosphere in the group, and difficulties with sensitivity of citizenship topics. Three teachers do not experience any difficulties whatsoever with citizenship.

Sustainability and citizenship and other socio-scientific issues in science education

All science teachers agree that the combination of sustainability and citizenship is logical (Figure 2.8). Reasons for this include both of these topics concern decision-making and involving social and societal aspects.

A total of 31 teachers incorporate societal issues other than those related to sustainability in their teaching. The most common issues relate to sex, sexuality and gender (18/41), the relationship between technology and society, for instance with genetic modification or radioactive energy (15/41), and medical issues, for instance related to genetic screening (12/41). All ten teachers who did not incorporate societal issues besides those dealing with sustainability were chemistry teachers. No biology teachers or teachers who taught both biology and chemistry fell in this category. Reasons for not teaching about issues other than sustainability related ones include no such issues being present in the curriculum (5/41) and the subject being heavily focused on theory (4/41). Only one of the teachers mentioned evolution as a societal issue about which they teach that is unrelated to sustainability (Teacher 29).

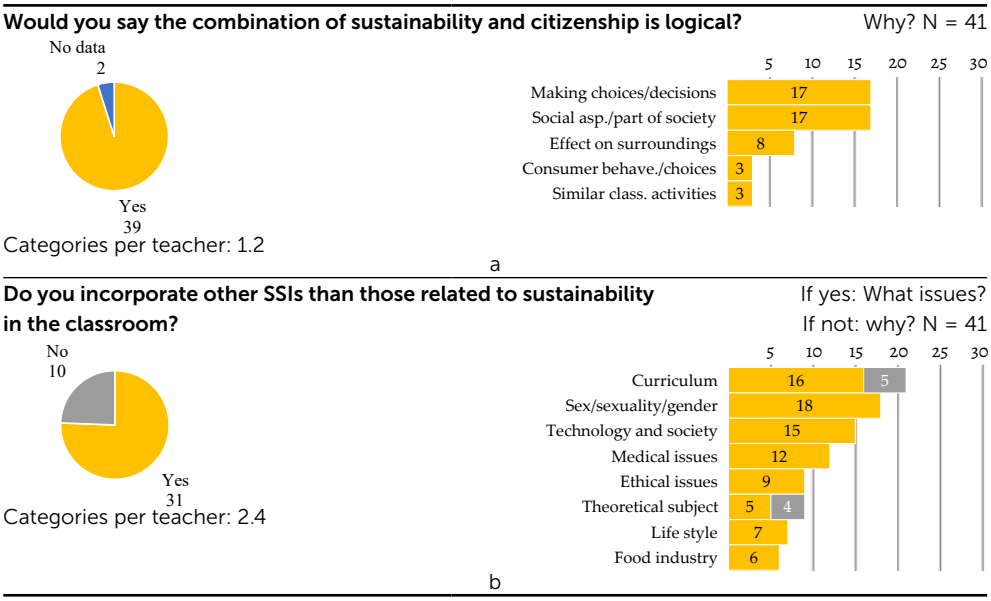

FIGURE 2.8 | Comments on (a) the combination of sustainability and citizenship, and (b) use of non-sustainability related Socio-Scientific Issues in the classroom, according to the 41 interviewed teachers. Numbers in the bar graph represent total number of teachers whose answers fell in the respective categories. Colours in the pie and bar graphs correspond.

Self-efficacy: classroom management, student motivation, and availability of teaching and learning aims

Teacher self-efficacy aspects related to EC varied. A total of 27 teachers think classroom management is at least a little harder when teaching about sustainability and citizenship education then other subjects (Figure 2.9). Reasons for this are that discussion and opinions are difficult to manage (19/41), and that creating a safe classroom atmosphere costs effort (11/41). Five teachers think that classroom management is easier for these topics. This is mainly caused by the teachers' own interest in these fields, innovative teaching activities, and energetic students. The nine teachers that did not see any difference in classroom management mainly said that learning activities are innovative, but this was something they liked.

According to nineteen teachers it is not easy to say whether students are more easily motivated during sustainability or citizenship education compared to other topics, whereas twelve teachers think it is easier to motivate them. Eight teachers think motivating students for sustainability is a challenge. Inhibitors for student motivation are students being focused on themselves at this age (8/41), and students being tired of sustainability because they hear it everywhere (8/41). One teacher says:

"That differs strongly per topic, because I see that these kind of teaching and learning activities, sometimes they work brilliantly, but I think that depends strongly on the topic and not on the activity. For instance with sustainability, that is really trending right now, and if you discuss that now, depending on how you do it by the way, because when you only talk about theory that they already know than they don't care at all, but because it is a very trendy topic they want to talk about it for sure, but for instance, at a certain point things such as bioindustry they have hear about this so many times, they don't want to hear about it anymore." (Teacher 5)

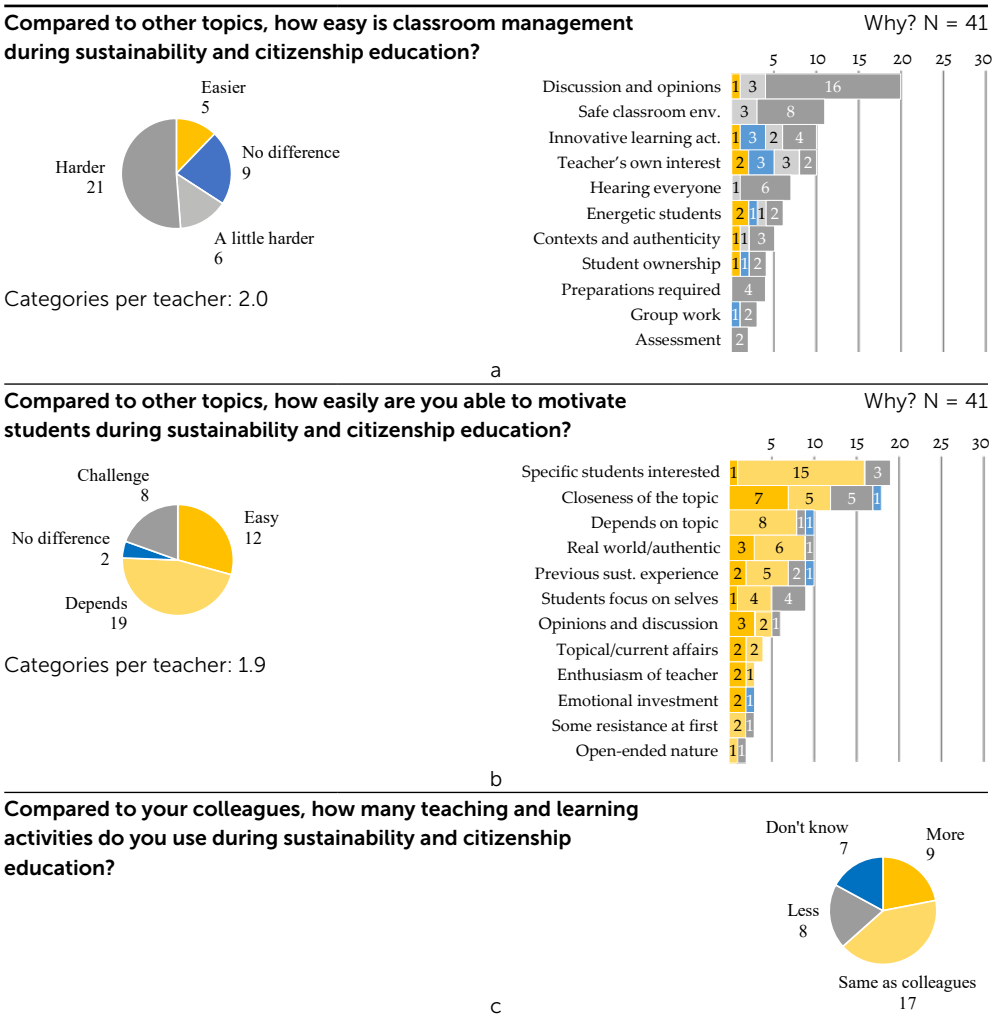

FIGURE 2.9 | Self-efficacy elements: (a) classroom management, (b) student involvement, and (c) number of available teaching and learning activities related to EC education, according to the 41 interviewed teachers. Numbers in the bar graph represent total number of teachers whose answers fell in the respective categories. Colours in the pie and bar graphs correspond.

Motivation strongly depends on the type of student, with specific students being more interested in these topics (19/41), and on the sustainability issue or citizenship aspect that is discussed (10/41). Teachers do not agree whether sustainability and citizenship issues are topics that are close to the student world, with about equal quantities claiming these issues to be close (7/41) and far removed from the student's world (5/41). The twelve teachers who think students are easily motivated for sustainability and citizenship teaching think this is caused by the opinion-forming activities (3/41) and the authentic nature of the issues (3/41), among others.

A total of 26 teachers felt they had at least equally as many teaching and learning activities at their disposal for teaching about sustainability and citizenship as their direct colleagues. Eight teachers thought they could incorporate less teaching and learning activities than their colleagues for this type of teaching, and a further seven were unable to judge this.

2.4 Discussion

In order to better support science teachers when teaching EC, we need a better understanding of current EC practice, and teacher interpretations of EC. Based on the findings from this study, current EC practice among the interviewed teachers seems as diverse as the concept itself.

Definitions

Teacher definitions of sustainability most commonly revolve around planet aspects. These teachers mostly focus on the environmental side, with only seven teachers using a full sustainability view, based on the Brundtland definition. This finding corresponds with previously reported findings in the literature (Georgiou et al., 2021; Summers & Childs, 2007). It thus seems that Kopnina's (2014) criticism regarding the shift from EE to ESD does not yet manifest itself in Dutch science teachers with highly economic or societal ideas about sustainability. Most teachers still seem to use an environmental approach (Georgiou et al., 2021). This is further cemented by the most popular connotations of sustainability being impact on the environment, using products for prolonged times and sustainable processes regarding energy use and production efficiency in general. As a side note, many teachers believe sustainability is a container concept, so they might hint at it being broader than a purely environmentalist view.

According to the teachers, citizenship relates to the relationship between a person and society, with socially desirable behaviour, and being active and caring for your surroundings. To many teachers, citizenship can be seen as a 21st century skill. These definitions most strongly show aspects of Westheimer and Kahne's (2008) personally responsible citizenship, with some occasional signs of participatory citizenship. Personally responsible citizenship, while important, is not the only ingredient for a more socially just and sustainable world (Westheimer,

2008). Aspects from social-justice-oriented citizenship, which most strongly relates to EC, are not seen in these teacher definitions of citizenship.

Based on these teacher definitions, it would be overly optimistic to assume that EC is effectively incorporated in science lessons of these teachers. Many teachers use a strong focus on recycling and small, at-home behaviours in their explanation of sustainability, which leads to an oversimplified view on how to solve sustainability issues in the long run. For this, a broader approach that also includes governmental or other collective actions is pivotal (Estellés & Fischman, 2021). Teachers who do not include public-sphere behaviour and the global aspects of EC that are necessary to reach a sustainable future in their EC teaching is a common theme in literature (Almeida & Vasconcelos, 2013). Our study adds to this knowledge base.

Curriculum presence, importance and classroom occurrence

Whereas all interviewed teachers think sustainability is important, only just over half of them clearly state they incorporate it in their teaching. The national curriculum seems a limiting factor here, as previously found in the literature (Taylor et al., 2019), because teachers hardly recognize sustainability in the curriculum, and they are critical towards its overly theoretical representation. Citizenship education is even less common, with only one quarter of the teachers recognizing more than a little citizenship in the science curriculum. Just like with sustainability, a majority of teachers think citizenship is important, but this does not translate to classroom practice, with just under half of them clearly stating they incorporate it in their teaching. For these two concepts, it becomes clear that teachers are unable to put their views into practice.

The interviewed teachers' learning aims for EC mostly fall in the second and third categories of Kelly's (1986) framework, these being raising awareness and promoting responsible decision-making. Only a quarter of the teachers mention learning aims dealing with theory behind sustainability, which would fall into Kelly's first category. The general lack of this learning aim contrasts with the strong theoretical bias that teachers experience with sustainability in the curriculum. It thus seems there is a mismatch between the theoretical approach of the Dutch curriculum and the learning aims of the teachers when sustainability issues are concerned.

Just like with the teacher definitions, the citizenship learning aims further strengthen the idea that Dutch science teachers adopt Westheimer and Kahne's (2004) personally responsible and participatory views on citizenship, while largely ignoring the social-justice oriented citizenship which is necessary for true EC. This social-justice-oriented citizenship correlates strongly with EC's aim of public sphere, collective action-taking, which could lead to fundamental changes in existing unsustainable structures and processes. Judging by their learning aims for EC, changing these existing structures seems to be beyond the scope of what science teachers in the Netherlands want to reach with their EC education at the lower secondary level.

Confidence and challenges

Teacher confidence with, and challenges during, EC education found in this study add to the existing research base. The teachers most commonly identify opinion-forming activities and guiding dialogue as challenging. These results are in line with previous studies which showed that science teachers generally struggle with implementing humanities-based teaching activities (Day & Bryce, 2011). Finding a way to deal with student opinions during EC is the third most common element that lowers confidence of the interviewed teachers. They identified strong emotional responses of the students as challenging during sustainability and citizenship education. Previous studies link this to the value-laden character of EfS (Taylor et al., 2019). Many science teachers feel unequipped to teach citizenship in their science lessons, which mirrors findings from a large qualitative study with Swedish teachers (Borg et al., 2012). Interestingly, the commonly reported difficulties with examination of EC (Taylor et al., 2019) are only sporadically mentioned by the interviewed teachers.

Another common challenge for successful implementation of EC is the national curriculum. Teachers feel there is too little time for EC education in everyday practice. Furthermore, the curriculum is believed to misinterpret sustainability because it focuses too strongly on theory. Previous studies show that the curriculum is one of the biggest hurdles for teaching about sustainability issues (Borg et al., 2012; Taylor et al., 2019), and socio-scientific-based education (Knippels & Van Harskamp, 2018).

Common with sustainability thinking is a general feeling of hopelessness on the one hand, caused by the idea that it already is too late to turn the tide (Ojala, 2020). On the other hand, people might underestimate sustainability issues because effects of sustainability issues are often not felt close to home, which results in feelings of apathy and resignation (Dutta & Chandrasekharan, 2017). Dealing with this emotional duality is difficult for teachers (Ojala, 2020). They feel that some of their students are unmotivated towards sustainability because students at the lower secondary level are focused strongly on their own developments and do not think about the world outside of their immediate surroundings. This shows in the data too, with about equal numbers of teachers thinking students can be easily motivated for sustainability, and teachers thinking that motivating students for these issues is a challenge.

Next to these challenges and uncertainties, a substantial group of the interviewed teachers is inherently interested in sustainability and citizenship. These teachers thus feel confident about teaching EC. Illustrating this, three quarters of the teachers incorporate other societal issues than those related to sustainability in their science lessons. All ten teachers who do not implement other societal issues in their lessons are chemistry teachers. It seems that biology teachers are more used to teaching about societal issues than their chemistry colleagues. However, such an indication needs to be subject to further research.

Limitations

When looking at the total science teacher population in the Netherlands, or, indeed, worldwide, this study only used a relatively small group of teachers. This should be taken into account when interpreting the results. Differences exist between countries, depending, for instance, on the curriculum or school system in general, so these data might only reflect the Dutch situation. Additionally, a general lack of teachers with more than twenty years of experience is seen among the participants. Finally, the participants slightly overrepresent teachers from rural area schools, with urban schools being marginally underrepresented. However, despite these limitations, this study still adds valuable qualitative data to the knowledge base about teaching EC at the lower secondary level, and it provides an in-depth sketch of the Dutch EC landscape.

Conclusions

When looking at EC education in the Netherlands, there seems to be a mismatch between the curriculum on the one hand, and the aims, ideas, and wishes of science teachers on the other. Despite a relatively narrow definition of sustainability and citizenship, Dutch science teachers aim to promote different aspects of EC through their teaching. Complicating this wish, teachers interpret the curriculum as being focused too strongly on theoretical aspects of EC, largely ignoring those areas that they wish to include. Furthermore, science teachers struggle with the social aspects of EC teaching, including dialogue, discussing emotions, and guiding opinion-forming and decision-making. Their understanding of EC does not yet involve many aspects of social-justice-oriented citizenship, and some teachers do not really see a place for citizenship education in science lessons at the lower secondary level at all. Additionally, teachers' views remain limited to the private sphere and to individual actions. However, what does become clear is that the majority of the interviewed teachers are passionate and motivated about helping their students deal with EC issues that riddle our daily lives. A supportive rather than limiting national educational strategy, that focuses on the broad concept of EC, would give them the room to implement EC more successfully. With a more suitable curriculum that includes opinion-forming, ethics and other normative aspects of sustainability, a stronger focus on the competences needed for EC, and more opportunities to train their citizenship education skills, science teachers will have a higher chance of fostering EC with their lessons.

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Appendix 2.1 | Interview scheme

Questions concerning sustainability

1. How would you define sustainability?
2. Do you think sustainability is an important theme for your lessons?
3. Do you teach about sustainability in your lessons? Which teaching and learning activities do you use? How are these different from other topics? Which learning aims do you set?
4. How would you couple sustainability to the curriculum? To what extent do you recognise it in the formal (national) and informal (school book) curriculum?
5. Do you feel confident when teaching about sustainability?
6. Where would you say challenges lie when teaching about sustainability?

Questions concerning citizenship

7. How would you define citizenship?
8. Do you think citizenship is an important theme for your lessons?
9. Do you teach about citizenship in your lessons? Which teaching and learning activities do you use? How are these different from other topics? Which learning aims do you set?
10. How would you couple citizenship to the curriculum? To what extent do you recognise it in the formal (national) and informal (school book) curriculum?
11. Do you feel confident when teaching about citizenship?
12. Where would you say challenges lie when teaching about citizenship?

General questions

13. Do you think a combination of sustainability and citizenship is logical?
14. Do you teach societal issues other than those concerning sustainability in your lessons?

Self-efficacy questions

15. How would you consider your classroom management to be during teaching sustainability and citizenship?
16. How involved are your students during teaching about sustainability and citizenship?
17. Compared to your colleagues, do you use many teaching and learning activities during teaching about sustainability and citizenship?

Appendix 2.2 | Coding scheme

Questions concerning sustainability

1. Definition	
Code Brundtland OR a combination of People, Planet, Prosperity	
Brundtland	Brundtland-like definition, including needs of current and future generations
People	People-related, social, fairness
Planet	Ecology-related, planet, nature conservation, environment
Prosperity	Prosperity-related, economy, money, costs
Subsequently code as many as necessary (but one of each per teacher, max) of the following	
Sustainable processes/recycling	Sustainable processes, production, efficient, energy, raw materials, recycling, renewable, circular
Environment and impact	Environment, ecosystems, low impact on the environment, do not pollute, deforestation, animal welfare
Prolonged use of products	Be frugal, consume consciously, persevere for a long time, use products for a long time
Container concept	Container concept/very broad/vague concept
Effects on next generation	Effect on subsequent generations
2. Importance	
Code one of the following two	
Yes	
No	
Subsequently code as many as necessary (but one of each per teacher, max) of the following	
Task of school	Task of the school, also for other subjects, students do not learn about this at home, good moment in their development
Problems are topical	Current/certainly now, urgent problems, opposition to populism
Functioning in society	Skills important for functioning in society
Raising awareness	Awareness, showing alternatives, ethical aspects
3a. Incorporation in lessons	
Code one of the following three	
Yes	
Sometimes/hardly	
No	
Subsequently code as many as necessary (but one of each per teacher, max) of the following	
Curriculum & time	It is part of the curriculum, it costs too much time
Too little	Wants to do more about it
When applicable	Where logical, when current, less-suitable for lower secondary
Recurring theme	Recurring theme in their lessons
Interdisciplinary	Interdisciplinary, cross-curricular, in collaboration with other colleagues (not if teacher only mentions that sustainability is important for all subjects)
Theory first	Theoretical basis first, then sustainability; too theoretical

3b. Teaching and learning approaches	
Code as many as necessary (but one of each per teacher, max) of the following	
Discussion	Discussion, conversation, often with whole class
Research	Research, short research projects, presentations about findings
Authentic examples	Authentic, teacher context, concrete example, current events, where the ownership lies with the student
Video/documentary	Showing video/documentary with questions
Regular teaching activities	Normal teaching activities, most often whole-classroom discussion
Stakeholders/experts	Stakeholders/role play, expert visit, show multiple opinions
Design/creative	Creative activity where students make/develop something
Footprint calculation	Calculating (carbon) footprint, sometimes also water/ecological
Unspecified group work	Unspecified group work, without further explanation
Theory	Focus on content specific theory, chemistry, biology concepts
Student behaviour	Focus on the student's own actions
Solutions	Finding solutions of local issues, improving school
Game/competition	Activities that form a game, competition element
Not yet applicable	Does not teach about it yet, starting teacher, expects to do so later
3c. Learning aims	
Code as many as necessary (but one of each per teacher, max) of the following	
Raising awareness	Create awareness, make students more aware
Impact of behaviour	Clarifying/showing the impact of student behaviour/choices on the environment
Bigger picture	Show big picture; subject influence on the world, relation subject and the world
Opinions and decisions	Opinion-forming and decision-making
Theory	Focus on content specific theory, chemistry, biology concepts
21st century skills	Reliability sources; critical attitude; media literacy; skills for life; academic thinking
Focus on behaviour	Action, focuses on student action
Sustainable way of life	Promoting sustainable lifestyles; responsible for other species
Citizenship education	Citizenship aspects such as working together, place in society
Solutions and possibilities	Thinking about solutions; show possibilities
No clear learning aims	Teacher does not have clear learning aims
4. Curriculum	
Code one of the following three	
Yes	
Very little	
No	
Subsequently code as many as necessary (but one of each per teacher, max) of the following	
Should be more	Should be incorporated for more topics/more extensive/in-depth
Too theoretical	Mostly fact-based/fact-driven/too theoretical, not enough skills
Incorrectly represented	Detached from actual issues/placed too much in contexts; too little focus on skills; lags behind current events
National exam theme	Always included in the national exam
5. Confidence	
Code one of the following two	
Confident	
Unconfident	

Subsequently code as many as necessary (but one of each per teacher, max) of the following	
Own interest	Topic concerns the own interest of teacher
Opinions about issues	Opinions from students' home but also opinion-formation process
Complex issues	Complex subject, prior knowledge of students is tangled/wrong
Open-ended issues	Not hard truth, it concerns open issues, unsolvable so teacher feels they can say 'don't know' to difficult student questions
Examples and contexts	Offers narrative, stories, many topical examples
Interdisciplinary nature	Interdisciplinary, cross-curricular, can always refer

6. Challenges

Code as many as necessary (but one of each per teacher, max) of the following

Student involvement	Doom thinking, hopelessness, boring for students, stimulating students is difficult, far-from-their-bed show, prior knowledge is missing, students are tired of sustainability/have nothing to do with it
Opinions on the subject	Own opinions of teachers, of parents, of students; extremism, politics; ethics; feelings; opinion-forming
Curriculum	Lack of time, overcrowded curriculum, wrong emphasis of curriculum and exam and assessment, very interdisciplinary, few guidelines, vague theme
Teaching & learning activities	Discussion, few practical working methods, no suitable teaching material, changing behaviour or taking action difficult
Traits of sustainability	Large-scale problem, difficult concept, abstract, fast developments, unsolvable/open ended
Conditions school/world	Colleagues are not involved, many poor sources of information, it is difficult to create safe atmosphere

Questions concerning citizenship

7: Definition

Code as many as necessary (but one of each per teacher, max) of the following

Personal vs society	Place of people/students in society
Socially desirable behaviour	About socially desirable behaviour
Caring/conscious	Taking care of the world, actively participating in the world, taking care of yourself, awareness of the impact you have
21st century skills	21st century skills, critical thinking, opinion-forming, media literacy
Development/maturation	Personal development, formation, 'bildung', being yourself
Complex/difficult	Complex/difficult concept
Norms/values/ethics	About norms, values, ethics, social norms
Democracy	Democracy, democratic processes
I do not know	Teacher does not know what citizenship means

8: Importance

Code one of the following three

Yes
Yes, whole school
No

Subsequently code as many as necessary (but one of each per teacher, max) of the following

Caring for self and others	Taking care of the world, actively participating in the world, taking care of yourself, awareness of the impact you have
Ethics/opinion-forming	For ethics/opinion-forming aspects of subject
Skills for life	Life-skills, life-learning

Technical abilities	Technical skills/scientific thinking are part of citizenship
Subconsciously	Subconsciously implements it, not explicitly involved
Maturation/development	Personal development, formation, 'bildung', being yourself
Social norms	Standards of decency/manners
Relevance of school topic	Subject-'real-world' connection/improves student interest in subject
How to approach it	Teacher does not know how to apply it in their teaching

9a. Incorporation in lessons

Code one of the following four

Yes
Hardly
Only implicitly
No

Subsequently code as many as necessary (but one of each per teacher, max) of the following

Connected to sustainability	Citizenship in relation to sustainability
Ethics/opinion-forming	During ethical issues, for forming opinions
Health/sexuality/gender	For health topics/own body, sexuality, taking care of own body
Setting an example	The teacher sets good example/has an exemplary role/is a role model
Critical thinking	Stimulate critical thinking, think through, remain critical
Too little	Applies too little, would like to do more about it
Time/curriculum	Overcrowded curriculum, spending a lot of time on other themes, is not part of the curriculum
Theoretical/theory first	First lay theoretical foundation, subject too theoretical for citizenship
Difficult for lower secondary	Too difficult for lower secondary, does not belong in lower secondary, only upper secondary
News/current affairs	Current affairs, responding to news, dealing with social themes if they are urgent
Does not fit	Does not fit with the scientific subjects, belongs somewhere else
Interdisciplinary	Interdisciplinary, cross-curricular, not only in scientific subjects
Nature of science	Nature of science, clarify properties of the scientific method
Connection with nature	Promoting a connection with nature

9b. Teaching and learning approaches

Code as many as necessary (but one of each per teacher, max) of the following

Discussion	Discussion, general group discussion, reasoning
Regular teaching activities	Standard teaching methods, class discussion, examples, assignments from book
Unspecified group work	Group work, not specified
News/current affairs	Current affairs, news, recent developments that are discussed
Video/documentary	Video, documentary, Zondag Met Lubach (popular show, '*Sunday with Lubach*')
Research/experiments	Research, scientific experiments
Debate	Debates, statements
Role play/stakeholders	Role-playing, empathizing with stakeholders
Essay/writing	Writing an essay, assignment, unspecified reporting
Design/creative	Students design products, make something, creative assignment
Social science research	Social science methods such as interview, survey
None	Does not have teaching activities for citizenship

9c. Learning aims	
Code as many as necessary (but one of each per teacher, max) of the following	
21st century skills	Collaboration, communication, critical thinking, information search, media literacy, scientific thinking
Opinions/decisions	Opinion-forming and decision-making, showing different sides/ opinions
Caring for self/surroundings	Take care of your body and your environment
Raising awareness	Awareness about the effect of actions; effects elsewhere; effects around you
None	None, not applicable
10. Curriculum	
Code one of the following three	
Yes	
Very little	
No	
Subsequently code as many as necessary (but one of each per teacher, max) of the following	
Connected to sustainability	With sustainability, only with sustainability, if it is linked to sustainability
Opinion-forming	Opinion-forming, often on ethics/ethical issues
Too little/should be more	Teacher wants or has to do more, does too little/brief, very superficial
Other subjects/school level	At school level, for other subjects, not for own subject, school-wide
Vague concept/curriculum	Curriculum is vague, core objectives are loosely described, the concept of citizenship is vague/unclear
Strong focus on theory	Curriculum focusses on theory, subject is theoretical in nature, theory is more important
21st century skills	21st century skills such as assessing sources for reliability, critical thinking, media literacy, scientific literacy, research skills
Health/sexuality/gender	Taking care of body, discussing sexuality, orientation
For upper secondary	Mainly suitable for the upper secondary, less suitable/not for lower secondary
11. Confidence	
Code one of the following three	
Confident	
Unconfident	
Never implements CE	
Subsequently code as many as necessary (but one of each per teacher, max) of the following	
Guiding discussions	Guiding discussion/dialogue/opinion-forming conversations
Own interest	Does or does not have an interest in the subject of citizenship education
Prior knowledge	Did or did not cover citizenship during teacher training
Inexperienced	Never deals with it, hardly implements it, has little prior knowledge/previous experience
Demands preparation	Does not teach this without preparation, needs professional development/training

12. Challenges	
Code as many as necessary (but one of each per teacher, max) of the following	
Feeling unequipped	Reluctant to act, difficulty supervising discussions, assessment is difficult, how do you implement this, what does it actually mean, little experience with citizenship
Curriculum	Curriculum is full, no time for it, issues are scattered/broken to pieces to fit in separate subjects (i.e., biology, chemistry, economics)
Opinion-forming	The teacher also has an opinion, is not neutral, the opinion of colleagues/the school, students echo others, parents have opinions
Level of the students	Too difficult for lower secondary, students are not engaged in it, not involved
Group atmosphere	Atmosphere in the group must be good, there must be room for all opinions in the class, depends on the class
Sensitive topics	Subjects are sensitive, have to do with politics, religion, cultural differences
No difficulties	Does not see any difficulties with it
Not applicable	Does not cover citizenship in class

General questions

13. Combination	
Code one of the following two	
Yes	
No	
Subsequently code as many as necessary (but one of each per teacher, max) of the following	
Making choices/decisions	It is about making choices/decisions
Social aspect/part of society	How do you stand in society, what choices do you make as a group/individual
Effect on surroundings	It has to do with the effects students have on the environment (both nature and society)
Consumer behaviour/choices	It is about consumer decisions/behaviour, which choices you make as a consumer
Similar classroom activities	Teaching and learning activities are similar for both subjects
14. Other SSIs	
Code one of the following two	
Yes	
No	
Subsequently code as many as necessary (but one of each per teacher, max) of the following	
Curriculum	It literally is part of the curriculum/it is not part of the curriculum
Sex/sexuality/gender	Safe sex/sexuality/gender
Technology and society	Technology & society (gene technology, radioactivity, cloning)
Medical issues	Healthcare/organ donation/vaccination
Ethical issues	Ethics in general
Theoretical subject	Subject mainly focuses on theory
Life style	Alcohol, drugs, smoking, obesity, nutrition
Food industry	Agriculture/food problem/food production/antibiotics

Self-efficacy questions

15. Classroom management	
Code one of the following four	
Easier	
No difference	
A little harder	
Harder	
Subsequently code as many as necessary (but one of each per teacher, max) of the following	
Discussion and opinions	Guiding discussion, learning outcome of discussion, motivation of students for discussion
Safe classroom environment	Creating a safe classroom climate, good relationship with class, atmosphere must be good
Innovative learning activities	More innovative activities, different from before, many types of activities
Teacher's own interest	Own interest of teacher in sustainability and/or citizenship
Hearing everyone	Ensuring everyone can have a say/has a say
Energetic students	Energetic/busy/overactive students
Contexts and authenticity	Real world contexts, authentic, rapid development in area
Student ownership	Student-driven, student is taken seriously, responsibility of student, self-motivation, teacher is supportive
Preparations required	Prepare first, not just go in and see what happens
Group work	Collaborative activities/group work/student collaboration
Assessment	Assessment is difficult/how do you do that
Easy	
Depends	
No difference	
Challenge	
Subsequently code as many as necessary (but one of each per teacher, max) of the following	
Specific students interested	Certain students like it, lower grades more than upper grades, some students get it from home, differs per class
Closeness of the topic	Subject is near/far, far-from-your-bed show, recognisable in daily life, students' own future, many have an opinion
Depends on topic	Depends on the subject, some subjects are inherently interesting, others are boring
Real world/authentic	Authenticity, sincere, not from the book, students feel taken seriously
Previous sustainability experience	Tired of sustainability, boring image, students think they already know everything, a lot of prior knowledge
Students focus on selves	Pupils are in their own world, are mainly concerned with themselves, puberty
Opinions and discussions	Pupils like to give an opinion, do have an opinion about it, do want to discuss it
Topical/current affairs	Current subject, environmental strike, especially now a lot of interest, more interest than before
Enthusiasm of teacher	The teacher is enthusiastic about this subject and can draw a lot from his own enthusiasm
Emotional investment	Pupils have an emotional bond, are hopeless/doomsayers

Some resistance at first	First needs to go over a bump, then this is doable
Open-ended nature	Many options (examples, contexts) for the teacher to use/apply/ deploy
17. Teaching & learning activities	
Code one of the following four	
More	
Same as colleagues	
Less	
Don't know	

3

Dutch lower secondary students' environmental citizenship

Abstract

To enable students to make informed decisions and take appropriate action regarding sustainability issues, science education needs to provide tools to navigate sustainability related issues, thus fostering Environmental Citizenship (EC). However, this remains challenging for science teachers, for instance because of emotional reactions and multidimensionality. This study provides a qualitative view on the current Dutch lower secondary students' EC, thereby providing potential support for science teachers. The research question is: how can Dutch lower secondary students' EC be characterised? We conducted semi-structured interviews with 42 students (F: 25, M: 17; average age 13.3) with questions relating to their sustainability knowledge, attitudes, behaviour, and reflection, which together forms their EC competence. Common trends in the data are worry for the future of the planet, experienced distance from sustainability issues, and interest in possible solutions that students can implement themselves. Students do not discuss sustainability with friends. They often adopt a form of EC that can be typified as personally responsible citizenship. Our data provide qualifiers and reasons behind conclusions drawn from quantitative studies that previously dominated our understanding of student EC.

Keywords: environmental citizenship, lower secondary education, sustainability knowledge, sustainability attitudes, sustainability behaviour, sustainability reflection

3.1 Introduction

Sustainability issues are among the most pressing challenges of the 21st century, as recognised by institutions such as the UN (United Nations, 2019) and the EU (European Commission, 2016). Since sustainability issues operate on a scientific and societal level, and they typically involve different groups of stakeholders and do not have clear cut answers or solutions (Wiek et al., 2011), they are Socio-Scientific Issues (SSIs). Next to scientific thinking, informed decision-making regarding these issues requires socio-political, value-based, place-based, and emotional thinking (Wals et al., 2014).

Despite schools not being the only places where citizenship competences can, or should, be taught (Biesta, 2007), they are suitable places where young people can practice their citizen skills and become competent in decision-making regarding sustainability issues. To do so, science education needs to provide students with the tools to navigate sustainability related SSIs in their daily lives, thus aiming to foster Environmental Citizenship (EC)(Taylor et al., 2019). An Environmental Citizen focusses on both individual and collective decision-making and action-taking regarding sustainability issues. These issues often affect areas from multiple disciplines. A transdisciplinary or interdisciplinary approach might seem obvious. Yet, sustainability and citizenship aspects such as reasoning and informed decision-making are science curricular aims across the globe. For instance, the Dutch national science curriculum requires students to be able to evaluate situations in nature and technological applications, using scientific arguments, normative considerations, and personal opinions (curricular aim A9; College Voor Toetsen en Examens vwo, havo, 2019). Hence, science education offers an opportunity where students can practice their citizenship skills regarding sustainability issues in a constructive environment.

However, science teachers experience difficulties with teaching sustainability related SSIs, mentioning strong emotional student responses and a sense of disempowerment among students as the most challenging aspects (Taylor et al., 2019; Van Harskamp et al., 2021). To effectively foster EC through (science) education, we must first understand the learners' relationship with the environment (Payne, 2001). Thus, it would be useful to provide a starting point from which to develop teaching strategies and educational materials by describing current student EC at secondary level.

Looking at certain aspects of EC from a large-scale, qualitative perspective, the International Association for the Evaluation of Educational Achievement (IEA) compared levels of citizenship among countries with their International Civic and Citizenship Education Study (ICCS). The ICCS contained items that looked into environmental concerns of lower secondary level students across the world. In doing so, they found that Dutch students score significantly lower on perceiving threats to the world's future (Schulz et al., 2018). For instance, on the topics of risks of pollution (international average: 76%; Dutch students average: 63%) and perceived

risks of climate change (international average: 55%; Dutch students: 48%) Dutch students score more than 10 percentage points below the international average. Furthermore, most Dutch students do not view responsibility to protect natural resources as part of good citizenship (22% as opposed to 49% for the international average).

These data show some aspects of EC of lower secondary students in The Netherlands, but they do not paint a complete picture yet. A more in-depth, multifaceted and qualitative description of EC of Dutch lower secondary students is desirable. This would help us understand what science teachers currently are dealing with in the classroom, as well as suggest possible ways to support them in fostering EC through education. A qualitative, more intricate view on EC of students is desirable, since a thorough understanding of the intricacies behind secondary students' EC is as of yet missing (Blatt, 2014). Such a view might provide insight in reasons behind the current trends that are described in the quantitative studies performed so far. It could give students a chance to explain why the sustainable behaviour subscale had relatively low mean scores in a study with Swedish adolescents (Gericke et al., 2018). It furthermore could explain the reason for the low EC values and attitudes found in a study with Cypriote students (A. C. Hadjichambis & Paraskeva-Hadjichambi, 2020b) and with Spanish, Flemish, and Swedish students (Ariza, Boeve-de Pauw, et al., 2021). This study aims to provide such an in-depth and qualitative view on current Dutch lower secondary (age 11-15) students' EC. Therefore, the research question is:

How can Dutch lower secondary students' environmental citizenship be characterised?

In order to describe EC of lower secondary students, semi-structured interviews were carried out. Interview transcripts were analysed to find common themes of EC among the participants.

3.2 Theoretical background

Sustainability and environmental citizenship

Sustainability has proven to be an elusive construct. The most widely used definition of sustainability is derived from Our Common Future, more generally known as 'the Brundtland Report', which describes sustainable development as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (WCED, 1987, p. 41). Furthermore, a growing consensus exists in literature which stresses the importance of three aspects being in balance for sustainable development to occur (Summers & Childs, 2007). These three aspects, economic and social development combined with environmental protection, are more commonly dubbed 'the triple bottom line' of people, planet and prosperity (Benninghaus et al., 2018).

In an educational context, sustainability issues prove challenging. As Wals (2010, p. 144) puts it in a special issue on sustainability education:

> "It seems that […] we do not and cannot know what the most sustainable way of living is. There are many ideas about what is sustainable, but none of them can be authoritatively prescribed to others because what might seem sustainable now might turn out not to be later and, furthermore, what might be sustainable here might not be sustainable elsewhere. This observation has tremendous implications for teaching and learning. […] There are too many realities out there and, to make things worse, these realities shift and transform constantly."

Two trends can be identified in teaching about sustainability issues: Environmental Education (EE) and Education for Sustainable Development (ESD). They differ mainly in the way the economical and societal sides of environmental issues are incorporated into teaching (McKeown & Hopkins, 2003). EE is a concept from the 1970s, defined in for instance the Belgrade and Tbilisi charters. According to the Belgrade Charter, the goal of EE is: "To develop a world population that is aware of, and concerned about, the environment and its associated problems, and which has the knowledge, skills, attitudes, motivations and commitment to work individually and collectively toward solutions of current problems and the prevention of new ones." (UNESCO, 1976, p. 2).

On the other hand, ESD has a broader focus. After the Rio de Janeiro United Nations Conference on Environment and Development, which placed the concept of ESD on the agenda globally, "the overall intent had moved from environmental protection and pollution reduction to addressing the needs of both environment and society. The goal shifted to finding a realistic and balanced approach to environmental protection while alleviating human suffering and the ravages that accompany poverty." (McKeown & Hopkins, 2003, pp. 119–120). This broadening of the scope led to the rise of the concept of ESD (Sinakou et al., 2019).

Some scholars voice concern for the global shift from EE towards ESD. Common criticism includes the increasing impact of globalization and neo-liberalism (Jickling & Wals, 2008), and the stronger emphasis on the economic aspects of sustainability related SSIs, thus potentially removing the inherent worth of nature from the decision-making process (Kopnina, 2014). In this article, we refer to both the concepts of sustainability and the environment, where applicable.

To empower students so they are able to make informed decisions and take appropriate actions regarding shifting and uncertain sustainability issues, science education needs to elicit student's Environmental Citizenship (Taylor et al., 2019). An environmental citizen is aware that self-interested behaviour will not always sustain public goods such as the environment, they make a commitment to the common good, and have a sense of international and intergenerational justice (Dobson, 2007). Environmental Citizenship can thus be defined as

"the responsible pro-environmental behaviour of citizens who act and participate in society as agents of change in the private and public sphere, on a local, national and global scale, through individual and collective actions" (ENEC, 2018). An environmental citizen furthermore has the "willingness and the competences for critical and active engagement" (ENEC, 2018).

As this definition shows, education about sustainability issues should not only focus on the individual, personal side, but should also stress the community or societal aspects of environmental issues (Schindel Dimick, 2015). This is in line with shifting the educational perspective from personally responsible citizenship to a more participatory or social-justice view on citizenship (Westheimer, 2008). By combining the personal with the societal or governmental side, EC competence is fostered.

To some, the notion of citizenship competence entails an individualistic element (Biesta, 2007). This marginalization of the social and public dimension of citizenship has been found in citizenship curricula worldwide (Estellés & Fischman, 2021). A recent study on teachers' beliefs regarding EC also shows that their understanding of the concept is limited to the local scale, the individual dimension and the private sphere (Georgiou et al., 2021). This is directly opposite of what Environmental Citizenship, and therefore its competence, entails: EC is by nature a collaborative and socially interwoven construct, not an isolated one. EC assumes an individual and all of their connections to others, including their surroundings and their society. Our view on EC in schools conforms to this notion. Mirroring this, Biesta (2007) argues that an overtly individualistic view on citizenship is detrimental. The true challenge lies in living together as a collective, making decisions when different opinions and views exist and therefore should be taken into consideration.

It must be noted that schools are not the only institution in which young people can practice with EC. As Biesta (2007) argued, this instrumentalistic line of reasoning can be found in many democracy or citizenship programmes. In our view, as in Biesta's, schools are but one of the many arenas in which Citizenship learning takes place. Schools can offer children the opportunity to practice what being a citizen entails, creating conditions for children in which they experience the decision-making process and practice other EC aspects.

Environmental citizenship competence

The concept of 'competence' is typified as being hard to define (Hoskins et al., 2011), but in a citizenship context it is understood to consist of a complex combination of knowledge, attitudes, behaviour and reflection that together form one's capacity to act in different situations (Ten Dam et al., 2011). When these four aspects of citizenship competence are viewed from a sustainability perspective, they form one's level of EC competence. Concerning sustainability, key competences include normative competence (including empathy, desirability, and multiple perspectives), anticipatory competence (crafting pictures of the future), and strategic competence (interventions and their feasibility)(Wiek et al., 2011). These competences too are

part of what being an Environmental Citizen entails. Even in a view where citizenship is only present in interactions between individuals, and where it is not a certain set of skills, values and attitudes an individual possesses (e.g. Biesta, 2007), there still are skills, attitudes, that persons can practice so as to facilitate these interactions between individuals. Therein lies what EC competence is.

Knowledge in case of EC can have different guises. Central in pro-environmental behaviour is knowledge that is action oriented. This is underscored by the relation of this type of knowledge to Wiek et al.'s (2011) five key competences for sustainable development. Action oriented knowledge relates to four aspects: i) knowledge about causes (why), ii) knowledge about effects (what), iii) knowledge about visions (where), and iv) knowledge about strategies (how)(Jensen, 2002). Next to this action-oriented knowledge, EC knowledge consists of understanding of scientific processes related to sustainability and insight in the societal and personal aspects of sustainability issues. When teaching about SSIs, three aspects of knowledge should be taken into account (Owens et al., 2019). These are i) knowledge of scientific concepts underlying for instance climate change and toxicity of chemicals, ii) societal knowledge, which for instance deals with societal norms and policy, and iii) personal knowledge, among others dealing with understanding personal values and emotional connection with sustainability.

Science curricula traditionally focus on content knowledge, or Jensen's (2002) knowledge about effects, the 'what', and Owens et al.'s (2019) knowledge about scientific concepts, thus conveying a narrow view of sustainability issues to students. Illustrating this, a study on the occurrence of this broader view of sustainability education in a Swedish context showed that key concepts related to the different types of knowledge were underrepresented, and students did not convincingly perceive them in classroom practice (Boeve-de Pauw et al., 2015). This same overrepresentation of the ecological side and of issues such as recycling and renewable energy was found in a qualitative study on student environmental knowledge and attitudes in the Basque community in Spain (Agirreazkuenaga & Martinez, 2021).

Sustainability *attitudes* can be described by thoughts, desires and willingness regarding the environment and sustainability issues. Emotions such as anxiety, sympathy, hopelessness, and feelings of apathy play an important role in forming one's attitude towards sustainability issues, thereby impacting one's action competence (Ojala, 2013). Furthermore, a first intuitive reaction is one of the primary constituents of moral reasoning (Haidt, 2001). Global trends in citizenship education tend to overlook the importance of emotions and prior experiences of students during such citizenship activities such as decision-making, which places unrealistic expectations on CE and its potential to help solve global issues (Estellés & Fischman, 2021).

Sustainability attitudes are influenced by the values a person has regarding the environment and sustainability (Torkar & Bogner, 2019). Environmental concern, for instance, is affected by the attitudes 'utilization of nature' and 'preservation of nature', and vice versa. In the influential value-belief-norm theory, environmental concern has three potential causes: i) egoistic or

'self' value orientations, ii) social-altruistic or 'other people' orientations, and iii) orientations focussed on all living things, 'biospheric' value orientations (Stern & Dietz, 1994; Torkar & Bogner, 2019). These three orientations interact in forming sustainability attitudes and values (Torkar & Bogner, 2019).

Sustainability attitudes are known to change over time. In Germany and Austria, positive attitudes towards the environment and sustainability issues were found to be decreasing among lower secondary students compared to levels in the late 90s (Elster, 2007). However, it can only be assumed that this sentiment has at least partially changed in recent years, as shown by popularity of movements such as Fridays For Future[2]. A study on English lower secondary students' attitudes towards sustainability shows that many students feel the environment is important, yet they do not want to learn more about it in general (Jenkins & Pell, 2006). English students seem to believe that there is still time to secure a sustainable future, yet they are not willing to adopt more sustainable lifestyles.

Sustainability *behaviour* encompasses actions related to sustainability, and one's confidence in carrying out these actions. Different types of environmentally significant behaviours exist, with activism, nonactivist behaviour in the public sphere, private-sphere environmentalism, and organisational environmental behaviour being the four main types (Stern, 2000). Environmental behaviours are affected by values such as altruism, egotism, a person's ecological worldview, perceived adverse effects to objects that a person values, perceived ability to reduce this threat, and a sense of obligation to take pro-environmental actions (Stern, 2000). In redefining action competence for sustainable development, Sass et al. (2020) identified a set of core features for action competent individuals. These include knowledge and skills, commitment and passion to contribute, and confidence in one's own influencing possibilities and one's capacity to change. Concerning actions on an individual and a collective level, Sass et al. (2021) found that Flemish teens are most prone to select individual action-taking rather than actions with a collective nature. A notable age dip in sustainability related behaviour has been found to exist, with 12-13 year olds and 18-19 year olds showing more environmentally friendly behaviour than their 15-16 year old peers in both a Swedish and a Taiwanese study (Olsson et al., 2019).

Finally, in an Environmental Citizenship context, sustainability *reflection* is understood to entail critical contemplation of sustainability issues. On the one hand, this deals with how frequently students think about sustainability issues, and what issues they recognise in their direct surroundings. On the other, reflection in an EC context concerns adopting a critical outlook on the world. 'Good citizenship' nowadays entails 'being able to make a critical contribution to society' (Ten Dam et al., 2011, p. 355), which underscores the importance of reflection as an integral element of citizenship competence. It furthermore connects to Bandura's concept of self-reflectiveness, which he defines as the "metacognitive capability to reflect upon oneself and the adequacy of one's thoughts and actions" (2001, p. 10).

2 See for more information: https://fridaysforfuture.org/

Reflection in an EC context thus includes critical insight in sustainability processes and one's own role or place in these processes, and critical insight in possibilities for agency or change (Ten Dam & Volman, 2007). The importance of reflection in citizenship competence stresses that citizenship education not only aims for adaptation of prescribed actions, but of a critical reflection during decision-making (Biesta, 2009; Ten Dam & Volman, 2007). In Wardekker's view on moral education, conscious reflection enables a person to become autonomous as opposed to conformist: "… somebody who, when co-operating with others, is able to defend his or her actions and the values and points of view that guide it, but is also willing to reflect critically on them. It is somebody who contributes to the maintenance of rules but also to their changing and to the creation of new rules. It is somebody who is dedicated to something, but is also able to change principles if necessary. The autonomous person is always learning and contributing to the learning of others, both cognitively and morally." (2001, p. 113). An Environmental Citizen employs critical reflection in a manner corresponding with Wardekker's view. It furthermore relates to the concept of scepticism as one of the four central pillars of Socio-Scientific Reasoning (Sadler et al., 2007). Adopting a critical stance towards information sources is instrumental for SSR and for EC.

In an EC context, the concept of reflection relates to 'sustainability consciousness', which has been described as "the experience or awareness of sustainability phenomena" (Gericke et al., 2018, p. 3). Apathy regarding sustainable behaviours might inhibit student reflection on sustainability issues, since a divide is known to exist between consumers on the one hand and sites of environmental degradation on the other (Dutta & Chandrasekharan, 2017), rendering the more severe and acute impacts of unsustainable processes more abstract and invisible. Reflecting on sustainability with others is a successful way to explore norms and values of others regarding these issues.

Summarizing, Environmental Citizenship competence is understood to consist of a complex combination of knowledge (of sustainability processes, of causes, effects, visions and strategies), attitudes (of for instance emotions such as apathy, anxiety or motivation, and of intuitive reactions), behaviour (including action competence, and action-taking in the private or public sphere), and reflection (reflecting critically on current and future sustainable processes and one's own role in these). Measuring (aspects of) EC competence has been done in previous studies (e.g. A. C. Hadjichambis & Paraskeva-Hadjichambi, 2020b). However, since the vast majority of these studies has adopted a large scale, quantitative approach, an in depth, qualitative view is as of yet missing. This article aims to provide such a view, based on the Dutch context, for it would help us understand the reasons behind findings from previous quantitative studies.

3.3 Method

In order to characterize current EC of Dutch lower secondary students, we conducted semi-structured interviews with students from the target population. This qualitative view can provide a valuable addition to the often quantitative description of current EC of students. It could for instance show reasons behind quantitative findings by providing qualifiers and conditions or explanations.

Participants

Forty-two students were interviewed (F: 25, M: 17; average age 13.3), from a total of five different schools in the Netherlands. Participating schools are from five different towns and spread out over four provinces. 90.5% of the sample consists of urban schools, whilst 9.5% is from rural areas. This ratio closely resembles the Dutch urbanization level of 91.5% (United Nations, 2018). As can be seen in Table 3.1, spread of educational type of the students (vocational, higher general, and pre-university level) slightly favoured the pre-university level. Comparison of differences between levels is beyond the scope of this article. Educational type data were collected to keep track of diversity of the sample. The sample size is adequate for our aims since saturation of data occurred after the 20th participant's data were analysed, meaning adding further participants would be redundant. Additionally, our sample covers a wide variation of opinions, with all but one of the questions leading to positive (yes), negative (no) and mixed (sometimes) student responses. From this, it follows that our sample enables us to better understand students who show aspects of EC and those who do not.

TABLE 3.1 | Educational background of participants. Number of students per educational type and year.

Educational type	Dutch name	Number of students	Year 1 (age 11-12)	Year 2 (age 12-13)	Year 3 (age 13-14)
Vocational education	vmbo	7	3	2	2
Higher general education	havo	10	4	4	2
Pre-university education	vwo	25	11	12	2

Informed consent forms were collected from parents or guardians. Students were interviewed by one researcher (the first author), during regular school hours, and interviews took place at their school in dedicated breakout rooms. Favourite subjects of the students varied greatly, with the most popular ones being sports (10/42), Biology (6/42), English language (5/42) and Visual arts (4/42). These background data indicate that a broad range of students participated in this study.

Instruments and data collection

Interviews were carried out during early Spring of 2019, were semi-structured, and lasted 11 minutes on average. The interview scheme is provided in Table 3.2 and contained questions related to the four aspects of EC competence –knowledge, attitude, behaviour and reflection–

described above. The questions were based on many insights from literature. The knowledge questions relate to the student's definitions and knowledge about causes of sustainability issues; the attitudes questions concern anticipatory competence, anxiety and emotional responses, personal relevance, altruistic, egoistic, and biospheric visions, hopelessness, and change strategies; the behaviour questions relate to action competence, to decision-making, and intuitive reasoning; and the reflection questions concern scepticism, critical reflection, perspectives, normative aspects, and intragenerational perspectives. The interview scheme was discussed with an experienced teacher educator to ensure student understanding of phrasing, thus preventing students misunderstanding the questions.

TABLE 3.2 | Interview scheme with questions categorised according to the four main components of citizenship competence.

Category	Question	Connection to theory
Knowledge	What does the word sustainability mean according to you? What does the word sustainability make you think about?	Definitions (Benninghaus et al., 2018)
	How did problems related to sustainability arise? Why are they still there?	Causes (Jensen, 2002)
Attitudes	Do you think about the future of the planet? If yes, what do you think about the future?	Anticipatory competence (Wiek et al., 2011)
	Are you worried about the future of the planet?	Anxiety (Ojala, 2013), effects (Jensen, 2002)
	Do you think the environment is important? Would you like to learn more about it?	Personal relevance (Blatt, 2014), egoistic/ altruistic/ biospheric (Torkar & Bogner, 2019)
	Would you say problems related to sustainability are easily solved? Why?	Hopelessness (Ojala, 2013) and change strategies (Jensen, 2002)
Behaviour	Do you keep in mind sustainability in your daily life? How?	Personal relevance (Blatt, 2014) and Action Competence (Sass et al., 2020)
	How do you reach a decision or point of view related to sustainability?	Decision making in education for sustainability (Garrecht et al., 2018), intuitive reasoning (Haidt, 2001)
Reflection	Do you talk about sustainability at school? And at home? And with friends? What do you discuss during these moments?	Perspectives (Sadler et al., 2007); Normative competence (Wiek et al., 2011)
	Do you sometimes question what is true when you hear something about sustainability? Or who is trustworthy?	Scepticism (Sadler et al., 2007) and Critical reflection (Wardekker, 2001)
	Do you notice problems related to sustainability around you? Do you think people elsewhere notice these problems?	Intragenerational perspectives (Benninghaus et al., 2018)

Data analysis

Interviews were audio recorded and transcribed verbatim, omitting vocalised pauses. Interviews are considered to be a suitable method of data collection for grounded theory (Kolb,

2012). Transcripts of the recordings were analysed in Microsoft Excel (version Professional Plus 2019) using the constant comparative method until theoretical saturation of codes occurred (Glaser, 1965). The constant comparative method can be described as a form of grounded theory during which data analysis and theory generation occur simultaneously. It consists of four stages. During the first stage we coded the transcripts in as many categories as possible. The underlying rule here was: "while coding an incident for a category, compare it with the previous incidents coded in the same category" (Glaser, 1965, p. 439). Thus, by going through the categories while coding new incidents, theoretical properties of categories were constantly fine-tuned. We wrote down memos when encountering difficulties in coding or when ideas or connections were made during the coding process.

The second stage consisted of integrating categories and their properties. This led to the development of a coherent set of categories. It furthermore made properties of and differences between categories clear. The third stage consisted of further delimiting the theory, which occurs on two levels. First, fewer and fewer modifications of categories became necessary. Second, the original list of categories shrunk, and theoretical saturation of categories occurred. The final list of categories can be found in Appendix 3.1: Description of categories for coding.

The fourth stage consists of pinpointing the underlying themes in the data, leading to the final results of the analysis. It is based on the descriptions of the categories and the collected memos. Coded data can be used to illustrate examples. The constant comparative method has been found to be compatible with educational research (Kolb, 2012). 70% of the data were coded by a second independent researcher (the second author), using the same coding scheme as developed during data analysis. Differences in coding were discussed by the two researchers and decided upon by intersubjective agreement. Before discussion, agreement was 86,2 percent, after discussion 100,0 percent agreement was reached.

3.4 Results

When analysing the 42 student interviews, several themes present themselves for the four aspects of EC competence, knowledge, attitudes, behaviour, and reflection. An average of six categories per question was found (see Appendix 3.1: Description of categories for coding).

The results are shown here by common trends that were found during data analysis, represented by a textual statement with the corresponding number of students whose answer fell in that category between brackets. These categories originated from interpretation of the data, and are thus not predetermined but inferred from the transcripts. Graphs are included that list the most common themes, offering information about EC of the interviewed students at a glance. To show what kind of data lie below these categories, representative and illustrative quotes from the interviews are included.

Knowledge about sustainability

The following themes can be found in student answers to the knowledge-based questions (Table 3.2), on the definition of sustainability, causes of sustainability issues and reasons for their persistence. Out of all the interviews, two thirds of the students (27/42) associate sustainability with energy use and about half of the students (20/42) mentioned recycling as being a main trait of sustainability (Figure 3.1). When asked to define sustainability, a typical student answer looked like

> "Well, then I think mainly about sustainably using energy, and with, well, using nature in a sustainable way and such, but, [...] for instance with energy, to save as much as possible and to save nature as much as possible as well." (Student 15)

Other main aspects of sustainability that were mentioned by about a quarter of the students were caring for the environment (17/42) and minimizing use of energy, water, and other resources (12/42). Less prevalent views included students mentioning pollution (8/42), and conservation of for instance woodlands (7/42). Two students were able to give a description that closely fitted the Brundtland definition, with one of them for instance saying:

> "Yeah, I think that this is like, that you make it so that you can live nicely, but that you do not let the world get destroyed from that, you know." (Student 10)

One student did not know what sustainability was and could not give any description or examples.

Regarding the causes of sustainability issues, the following themes were found. Nineteen students think sustainability issues are caused by inventions such as cars, airplanes, industry, and electronics (Figure 3.1). Other less frequently mentioned causes of sustainability issues include a quarter of students saying pollution end exhaustion (11/42), people in general, including population growth and general behaviour (10/42), and high life standards leading to unsustainable lifestyles (8/42) being to blame. One student explained:

> "Well I think that it mainly went wrong with, yeah there are many people, that, and yeah there have to be more houses and such, and for that for instance nature reserves are kind of ruined, how can I say that, and yeah, cars, that is not a very smart invention either, people fly a lot more, which isn't good either, people eat more meat, that isn't good either." (Student 23)

Three students placed the cause much further back in time, indicating that these problems started growing since the first Industrial Revolution.

The reason for the persistence of sustainability issues is less divisive to the interviewed students. 26 students think that sustainability issues still persist because people in general do not cooperate to help solve them, because of matters of habit (12/42) or because they are believed to be egoistic (8/42). Twelve students felt a lack of available solutions, caused for instance by

research and solutions being too expensive (3/42) were the reason for issues still persisting. Six students thought this was caused by high life standards that people pursue nowadays instead.

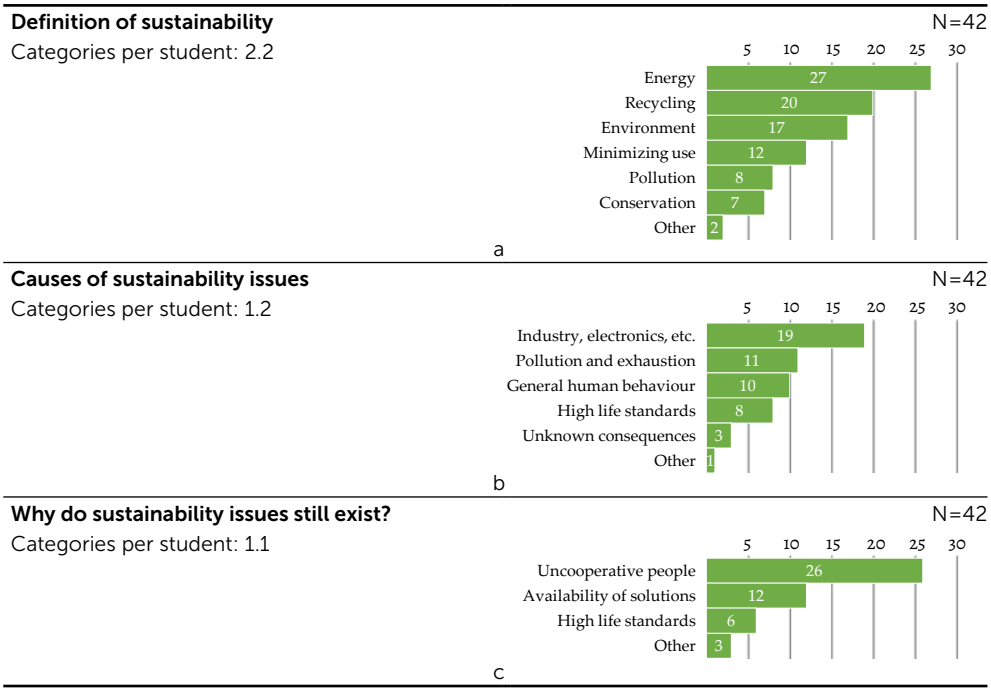

FIGURE 3.1 | Categories present in student answers related to (a) definitions of sustainability, (b) causes of sustainability issues, and (c) reasons for their persistence, with n=42 lower secondary students. Total number of categories and average number of categories applied to student responses are given per question. Numbers next to the bars represent students who answered in the corresponding categories.

Attitudes towards sustainability

The attitude questions that were put to students during the interview related to their ideas about the future, how easy or difficult they think it is to solve sustainability issues, and whether they would like to learn more about sustainability at school.

Sustainability attitudes ranged from negative feelings towards the future to a more positive view of solving sustainability issues. Most students think about the future of the planet at least occasionally (38/42, Figure 3.2), with seven students thinking about it (very) often. Fourteen students expect the future to be bleak, describing what could be summarised as a doom scenario, with extinction of animals, litter and air pollution becoming widespread. Illustrating this, one student said:

> "Because, we just have fifteen years or so to solve all of this, to solve, you know, the plastic in the water, and how many trees are being cut down, and, the bees who can no longer

pollinate flowers, which makes them grow and which provides us with oxygen, and that is, you know, also with the water level that is rising, there are many problems in the world, and these are, most of them are the fault of humans, so it would be weird if we did not solve them ourselves." (Student 37)

Researcher: "Yeah, so you have the feeling that there are many difficult things going on, many problems, and perhaps we have caused them,"

Student: "Yes"

Researcher: "So you feel like, you think about these things, and are you also worried about the future of the planet?"

Student: "Yeah, because, later, people will live here as well and they might die because of starvation or something, because there is no food left or something, or because there is too little oxygen, that they will suffocate, and maybe even because they won't have any clean drinking water anymore, because there are tiny pieces of plastic in the water that cannot be sieved out because they are too small"

Researcher: "Yeah so it aren't ever positive things you think about when you think about the future?"

Student: "No, except for that we can perhaps invent things, but yeah, that perhaps isn't possible either if you do not have the right materials or, for instance if scientist can no longer work because they are ill."

When thinking about the future of the planet, two other main themes that about a third of the students mention are effects of sustainability issues on nature (17/42), and an urgent notion that it is time to act and that we should start solving these issues right now (14/42). Less common themes included effects on humans in general (13/42), pollution (11/42), and wondering what the future would look like for themselves (9/42). One student in the category 'other' felt that enough is been done about sustainability, so they did not feel they needed to think about the future of the planet anymore. Two students do not think about the future, but they still added comments when the question was put to them. One student felt they should think about it more. Another mentioned they did not think about it on their own, but when encountering the topic on social media they felt the future would look bleak.

31 students are worried about the future, with a further three expecting to become worried at a later point (Figure 3.2). However, eleven students expect that sustainability issues will become inhospitable only after their lifetime, which tempers their worries about the future for the moment. They thus think that these issues will not affect them, which is the main reason for not being worried about the future. However, some students in this group (4/42) still feel responsible for next generations. Elaborating on this, a student says:

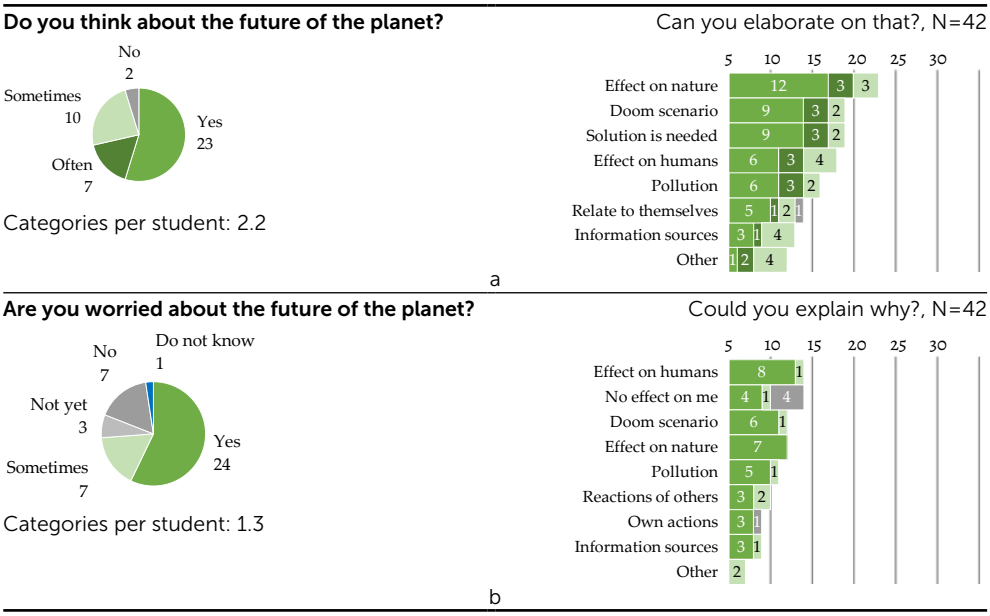

FIGURE 3.2 | Categories present in student answers related to attitudes towards sustainability. These relate to (a) students thinking about the future, and (b) the level of concern students have about the future, with n=42 lower secondary students. Total number of categories and average number of categories applied to student responses are given per question. Pie charts represent number of students that answered to the question in bold, whereas bar graphs represent number of students answering in the corresponding categories. Colours in the pie charts and bar graphs correspond.

> "Yes, sometimes I think for instance, if we talk about that land ice at sea, like, the ice that melts than I think this is not really going in the right direction, and, look, maybe it is not during my life, maybe there is, nothing will really happen, but yeah, it doesn't say about people, in so and so many years, when I am already, yeah, when I have already passed away, then yeah, if we are going to use so much stuff now and, and just destroy the whole world a little bit, like, then the people that live a 100 years later, they won't have anything at all left anymore." (Student 1)

Another mitigating factor is the reaction of adults in the students' surroundings. Three students mention that they see adults around them who are not worried at all about sustainability, which comforts them and thus takes away their own worry about sustainability. Other themes, which are mainly causes for worry, include effects on humans (9/42) and on nature (7/42), and pollution in general (6/42). A final theme is the perceived effect of their own actions, with three students feeling they should act now and do something about sustainability issues, which makes them feel anxious, while one other student feel less worried because they think their actions will not have any significant effects anyway.

Zooming in explicitly to the context of the environment, the results in Figure 3.3 show that all students believe the environment is important for them. Reasons given for this vary from an experienced responsibility for the future of animals and next generations (14/42), feeling the environment is an urgent theme on which action should be taken as soon as possible (11/42), to caring mainly about their own future (4/42). Two students mentioned feeling incompetent to do something about the environment.

Over three quarters of the students (37/42) want to learn more about the environment and sustainability, with twelve of them being interested under certain conditions. By far the most common reason is wanting to learn what they can do themselves to live more sustainable lives (21/42). Moreover, ten students share the sentiment of student 37, who wants to know "*what is actually happening, and how it works*", voicing a common desire for more nuanced information on sustainability issues that they expect to get from their teachers.

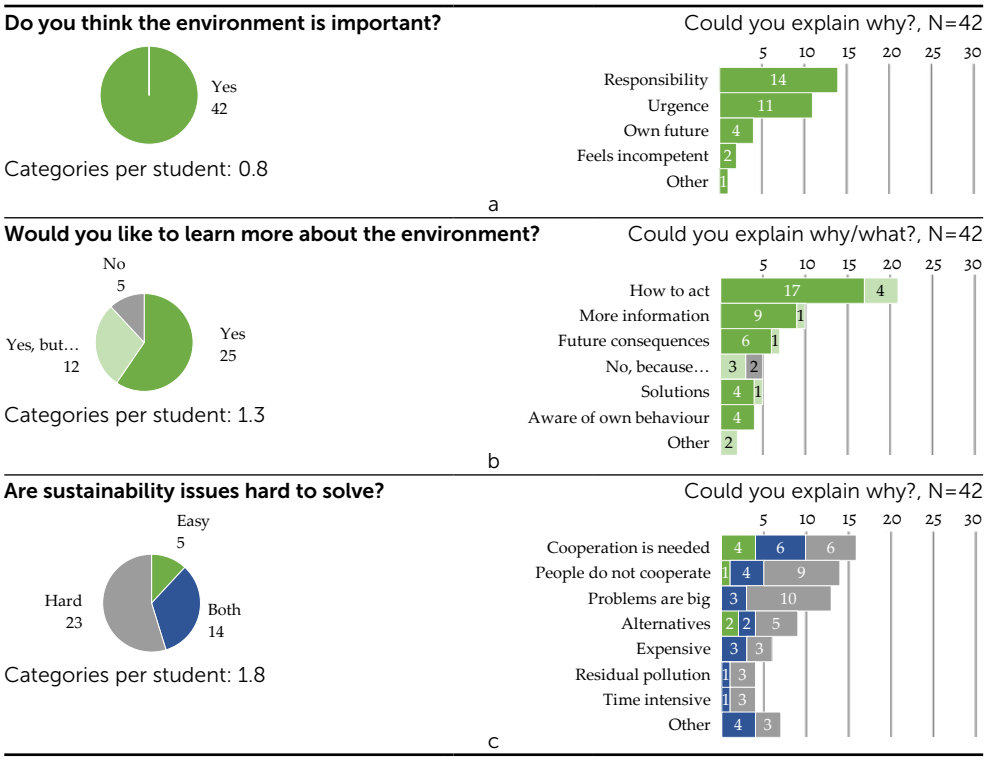

FIGURE 3.3 | Categories present in student answers related to attitudes towards sustainability. These relate to (a) perceived importance of the environment, (b) wanting to learn more about the environment, and (c) perceived difficulty of solving sustainability issues, with n=42 lower secondary students. Total number of categories and average number of categories applied to student responses are given per question. Pie charts represent number of students that answered to the question in bold, whereas bar graphs represent number of students answering in the corresponding categories. Colours in the pie charts and bar graphs correspond.

Other common themes are a desire to know possible consequences for the future (7/42), for instance showing what will happen if we do not act now; and possible solutions and current strategies (5/42). Summarizing, one student says:

> "I mean, probably, I would probably think it is interesting to learn more about it, but it should then be things like how do you help with it and such, not things that you already know, because actually we kind of know most of the things already, because we do hear things about it of course, so yeah […] how you can help or how you can help other people to help." (Student 38)

This quote also illustrates one of the main reasons for not wanting to learn more about the environment and sustainability. Five students feel they know enough about the topic, which is the main reason for not wanting to learn more about it at school.

Going back to sustainability in general, just over half of the students (23/42) think that sustainability issues are difficult to solve, and a further fourteen feel there are both hard and easy aspects to them (Figure 3.3). Main reasons for this experienced difficulty are that people do not cooperate with solving sustainability issues (15/42), that the problems are big and complex (13/42), and that alternatives are too expensive or unavailable (7/42). However, two students do think alternatives are there, and therefore claim sustainability issues are easy to solve. Five students say sustainability issues are easy to solve, with four of them saying that if everybody cooperates, these issues would not exist. Describing their ideas in further detail, one student says:

> "Well, quite difficult because, not everyone wants to help, to solve the climate. If you say, hey, everybody has to do solar panels, you cannot make that obligatory, because it costs money, and not everybody has money for that, well yeah, and if you have to change cars you also have to make that sustainable, and then, what do you do with all of these other cars, that is of course difficult then." (Student 14)

Other difficulties with solving sustainability issues are given by one student each. These include population growth making problems bigger instead of smaller, and difficulty with making rules for what is allowed and what is not, thus complicating solutions.

Behaviour related to sustainability

During the interviews, several questions focussed on sustainability behaviour. From these, it followed that most students (36/42, Figure 3.4) say they consider sustainability in their daily lives at least sometimes, with behaviours such as not littering and sorting waste (25/42), saving energy and water at home (7/42), and choosing sustainable means of transportation (7/42) being the most common behaviours. Some factors, such as parents making the decisions for them (2/42), and matters of habit (6/42), make it more difficult for students to behave in a sustainable manner. One student says:

> "Oh yes, but I mean, you have of course, for instance being a child you cannot do much, because you for instance do not really have much of a choice in what happens at home, regarding groceries and everything that is thrown away and such, but I try to always say like, OK, we just have to do this in this way, I try to pay a little attention to everything and how it happens." (Student 38)

Other sustainability behaviours that were mentioned by fewer students include adopting a vegetarian diet (3/42), supporting charity (1/42), and making the garden greener (1/42), among others.

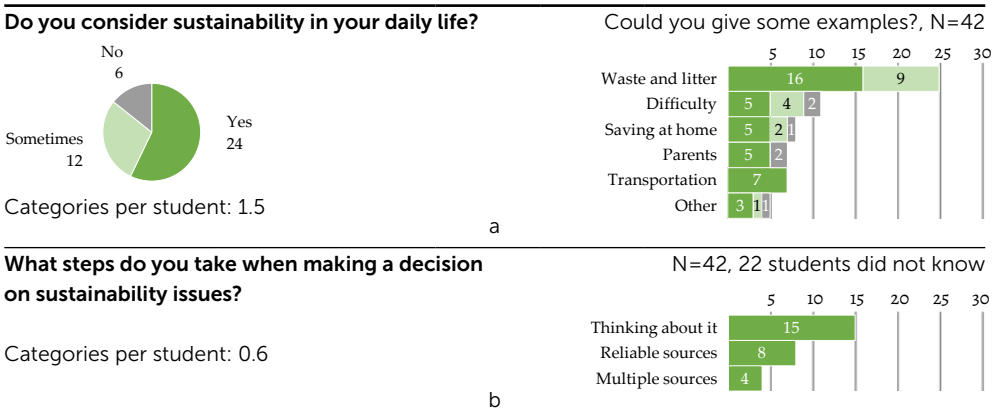

FIGURE 3.4 | Categories present in student answers related to sustainability behaviour: (a) most common sustainable daily life activities, and (b) decision-making process, with n=42 lower secondary students. Total number of categories and average number of categories applied to student responses are given per question. Pie charts represent number of students that answered 'yes', 'no', and 'sometimes' to these questions, whereas bar graphs represent number of students answering in the corresponding categories. Colours in the pie charts and bar graphs correspond.

Describing the steps they take when making a decision about sustainability issues proved difficult for students, with more than half of the students having no idea how they came to their decisions (22/42). Steps that were mentioned were mostly equally vague. A typical student answer looked like this:

> "I don't know, I just have always had a very strong own will and a very strong own opinion about everything actually, I'm always quite certain of what I think, I don't know how that forms, but, [...] it just comes on its own." (Student 38)

Fifteen students answered in a similar vein, mentioning that they came to their decision by thinking through the issue on their own. Other strategies include looking at sources they deemed reliable, such as the internet and the national news (8/42), and looking at multiple sources to cross-check information (4/42).

Reflection on sustainability

Students seem to reflect on sustainability issues in different social environments. Sustainability is a topic that 31 students discuss at school (Figure 3.5). Students report sustainability issues are most commonly discussed during geography (13/42), biology (11/42), and a dedicated course called '*Green Broadly*' (9/42, all from the same school). About the same number of students discusses sustainability at home, with parents or other family members (30/41, one student missing). Common topics include recycling or sorting waste (12/41, data not shown), minimizing use of energy, water, and other commodities (8/41), and alternative energy sources (7/41). The vast majority of students does not discuss sustainability with friends (29/41, one student missing), with 6 students elaborating that they only do so in a school context, and only five students responding with a clear yes.

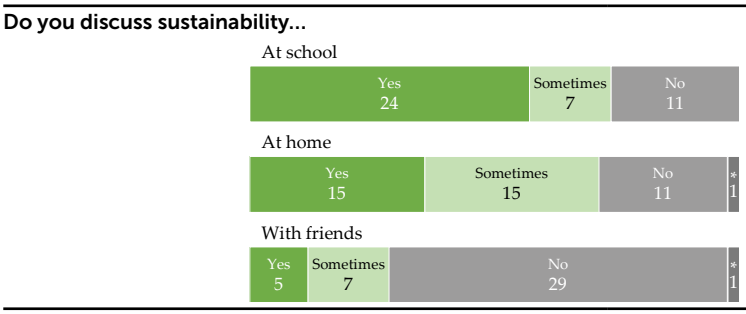

FIGURE 3.5 | Discussing sustainability at school, at home or with friends, with n=42 lower secondary students (* except for 'sustainability at home' and 'sustainability with friends', n=41).

During the interviews, the question was put to the students whether they critically consider things they hear about sustainability. Over half of the students (24/42) say they at least sometimes doubt what they hear about sustainability, whereas the other half of them reports never to question sustainability related information at all (Figure 3.6). Twelve students doubt when hearing blown-up or attention-grabbing statements, while seven doubt when hearing conflicting information. A student explains:

> "Sometimes, yeah, there is a lot of fake news, that something happened that isn't true at all, but mostly I do believe it, that things happened, and yeah if it is really big, then I will first check to see if it is like, reliable, but otherwise I believe it, [...] then I will check is it reliable, can I find this somewhere else too, [...] for instance are you on a website that I have never seen before and nobody talks about it either, or do you just see that it is posted nowhere else, or no-one talks about it, than you really see that it is fake." (Student 34)

Fifteen students say that they do not question sustainability information when they hear about it on the national news or other sources they deem trustworthy, with a further three claiming they never doubt what they hear about sustainability because it mostly is information they already knew. Two students say they never hear anything about sustainability at all.

When asked to think about sustainability issues in their direct surroundings, 25 students recognise these issues around them (Figure 3.6). Examples that students are able to give of these issues are mostly weather related (19/42), with rising temperatures, a lack of snow, and warmer winters being the most prevalent. Six students mention seeing litter and pollution in their direct surroundings. On the other hand, fourteen students think there are no sustainability issues in their direct surroundings at all, and a further three students are unsure about issues occurring close to home.

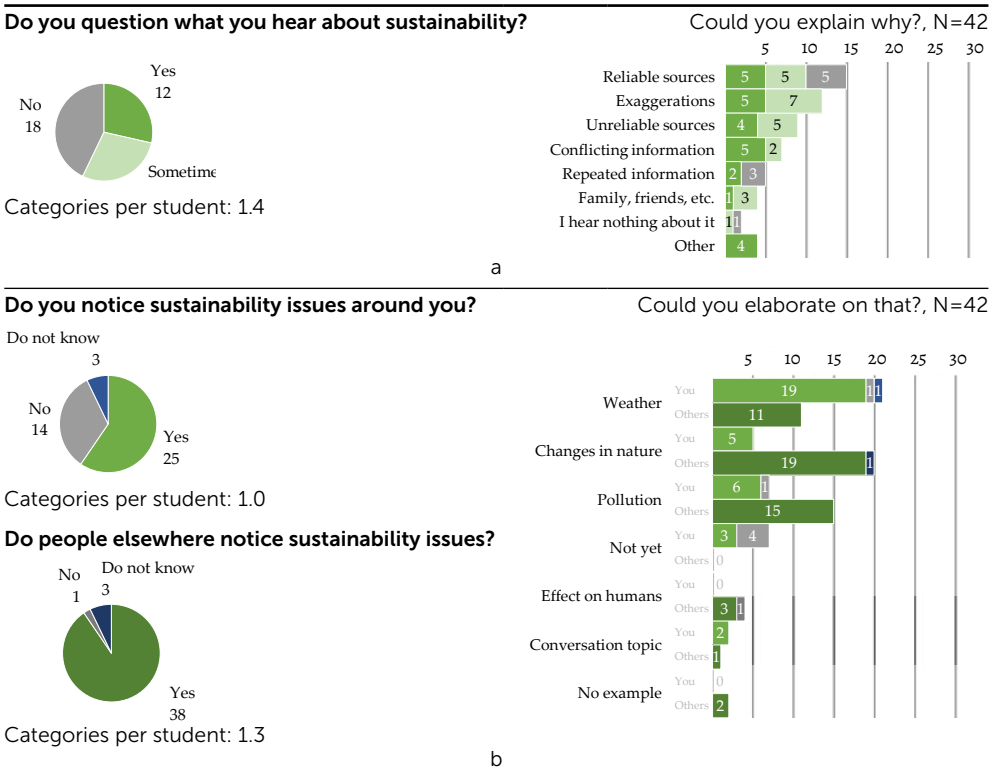

FIGURE 3.6 | Categories present in student answers related to sustainability and reflection: (a) critical reflection on information about sustainability, and (b) most common sustainability issues perceived in direct surroundings next to perceived sustainability issues elsewhere on the planet, with n=42 lower secondary students. Total number of categories and average number of categories applied to student responses are given per question. Pie charts represent number of students that answered 'yes', 'no', and 'don't know' to these questions, whereas bar graphs represent number of students answering in the corresponding categories. Colours in the pie charts and bar graphs correspond.

In contrast, almost all of the students believe sustainability issues (also) occur elsewhere on the planet, with only three students not knowing for certain and one student believing sustainability issues do not occur at all. Common examples that the students give are effects on nature (19/42) such as extinction of animals and natural disasters, pollution related issues (15/42) such as smog in cities or plastic soup, and, just like with sustainability issues closer to

home, weather issues (11/42), although they are of a different nature, with for instance droughts or storms being mentioned often. Commenting on the difference between issues close to home and issues somewhere else, a student explains:

> "Well, you hear a lot on the news, like, look, in The Netherlands I do not see it very much yet, well, only that it gets very hot sometimes, or that it rains a lot all at once or that there's snow in May, but you see that in other countries they have a lot more trouble because of flooding, mud streams and heatwaves and all that." (Student 21)

The three students who were unsure about sustainability issues occurring elsewhere claim that they cannot know for certain what happens in other places because they have not witnessed it themselves.

3.5 Discussion and conclusion

With our data, we provide a qualitative view on student EC at lower secondary level. Our study thus offers possible explanations for the quantitative findings of most studies looking into this concept thus far. We hereby offer students the chance to elaborate on their EC knowledge, attitudes, behaviour, and reflection, giving qualifiers and reasons for previously found trends. Lower secondary student Environmental Citizenship (EC) competence in our student sample can be characterised as follows.

Knowledge

When defining sustainability, the interviewed lower secondary students mainly use planet aspects, with only a very small group including prosperity and people elements in their definitions. It thus appears that students adopt a relatively narrow view of sustainability, neglecting two aspects of the triple bottom line (Benninghaus et al., 2018). Next to this planet focus, students do not often mention scientific concepts such as the enhanced greenhouse effect, climate change, or CO_2 emissions in their explanations. Instead, they mainly stick to daily life contexts such as general energy sources, recycling, sorting waste, and plastic litter outside when discussing their associations with sustainability. This is a reflection of findings from for instance the Basque community in Spain (Agirreazkuenaga & Martinez, 2021). It thus seems that despite a global shift from Environmental Education to Education for Sustainable Development, and therefore a stronger focus on social and economic aspects of sustainability, lower secondary students still view sustainability from a mostly environmental perspective. This is in line with previous studies, where both young people and their teachers employ a planet-based view of sustainability (e.g. Agirreazkuenaga & Martinez, 2021; Benninghaus et al., 2018; Georgiou et al., 2021; Sass, Quintelier, et al., 2021). It seems that the stronger focus on ESD has not yet led to a shift away from the ecological side of sustainability issues as warned for by the likes of Kopnina (2014).

According to many of the students, people not cooperating in solutions is the main reason for persistence of sustainability issues, because of egoism or matters of habit. It thus seems that Dutch students mainly have a neoliberalist view on solving sustainability issues, situating "citizen participation as an individual concern that removes states from responsibility for public goods, such as the environment" (Schindel Dimick, 2015, p. 309). Many of the interviewed students thus seem to strengthen the findings of Estellés and Fischman, who in their review of Global Citizenship Education theory and curricula stated that "without paying attention to the social and public dimensions [of citizenship] and to the civic demands for government interventions addressing the environmental crisis and the multiple and intersecting inequalities defining contemporary societies, the mainstream GCE cannot deliver on its lofty promises." (2021, p. 232).

Slightly placing this in perspective, a small group of students does mention that governments should be more directive in solving sustainability issues, for instance by obliging citizens to behave in a sustainable manner. In addition to that, students perceive that causes of sustainability issues relate mainly to bigger scale human behaviour, with transportation, industry and electronics being the main culprits. They do not often relate causes of sustainability issues to their own personal behaviour. As far as action-oriented knowledge of sustainability goes (Jensen, 2002), the students from this study show a limited understanding of the causes (mostly caused by behaviour of individuals other than themselves) and effects (mostly planet-based, overlooking social and economic effects). Interestingly, concerning change strategies, the interviewed students suggest more collective, large-scale changes to be necessary for solving current issues.

In conclusion, despite a prevailing neoliberalist view among students on how to solve sustainability issues, their views on what caused the issues in the first place focus less on the individual, rather taking into account effects of industry and the way society is structured. This shows a contrast between personally oriented citizenship on the one hand, where citizens should abide to the law, with more participatory or social-justice oriented citizenship on the other, which focusses more on actively changing existing systems (Wardekker, 2001; Westheimer, 2008).

Attitudes

The interviews show that attitudes of young people towards sustainability and the environment are multifaceted and complex. They seem to be strongly topic dependant, and students are able to give many conditions and qualifiers when describing their attitudes towards sustainability.

The students in our sample think sustainability and the environment are important. These findings provide a different view from the decreasing trend in environmental interest reported by Elster (2007), based on questionnaire data from 1,247 German and Austrian lower secondary students. Whether this difference depends on the Dutch context or the fact that over a decade has passed since Elster collected their data cannot be said.

Concerning the extent to which students desire to learn more about environmental issues, Jenkins and Pell (2006) conclude that, within their student pool, at best a moderate level of interest can be found. Data from the current study suggest that interest in sustainability is strongly topic dependent, with for instance interest in 'what can I do to help' being very high among half of the students, but interest in more content knowledge and the current state of the world being much lower in the current sample. This suggests a desire from students for more action-oriented education as opposed to a traditional educational approach that most strongly focusses on knowledge about effects of sustainability issues (Jensen, 2002).

The interview data on students worrying about the future provide a more nuanced view on the conclusions drawn in the ICCS 2016 report (Schulz et al., 2018). ICCS16 shows that just over half of the Dutch students who partook in their study see sustainability issues as a threat to the future, which places the Dutch average more than 10 percentage points below the international average of 76%. However, three quarters of the interviewed students in the present study claim that they are worried about the future or will be worried at a later point in their lives, and about a fifth of the students thinks about the future very often. These data much more closely resemble the ICCS16 international average of 76%, indicating that Dutch students are not necessarily less worried than students in other countries, but some of them worry only under certain conditions. These conditions include not being worried for their own lifetime or only worrying about specific sustainability issues such as plastic soup. Other reasons include students not being worried about the situation in The Netherlands, but worrying for other places, like this transcript shows:

> Student (9): "Yeah, for The Netherlands it isn't too bad, but when you look at China for instance, there are so many smog clouds, they have to take drastic precautions."
>
> Researcher: "Yeah, but you feel like this isn't happening on that scale here yet?"
>
> Student: "Yeah it is less here, it is more calm here."

This excerpt also shows that many students adopt egoistic value orientations regarding sustainability issues. These were common in for instance discussion of solutions to sustainability issues, prevention of new ones, and why they think about the future of the planet. However, it must be noted that equally as many students show signs of altruistic or even biospheric orientations instead. These occurred most frequently when discussing the importance of the environment, and thinking about the future of the planet. It thus seems that all three categories of value-belief-norm theory (Stern & Dietz, 1994; Torkar & Bogner, 2019) occur at this age.

It is furthermore noteworthy that many of the negative views on the future of the planet did not come up during the first part of the interview, during which students defined sustainability and mentioned their first associations with the topic. There seems to be a discrepancy between their fears and worries on the one hand and their first reaction to sustainability on the other. However which way you look at it, the negative emotions discussed by Ojala (2020)

are widespread among the interviewed students and should thus be taken into account during sustainability education.

To many students, solving sustainability issues is a difficult matter. They feel that people have gotten used to their unsustainable ways and habits, thus postponing adaptation of sustainable alternatives. Furthermore, students think people are egocentric and do not consider the effects of their behaviour on others or on future generations. However, they mention that if people are inclined to cooperate in solving them, sustainability issues can be solved quite easily. This places their negative feelings about the future in perspective, since they seem to see enough possibilities, but solutions require a change in public opinion. These findings are similar to those of Jenkins and Pell, who conclude that English students believe that "while environmental problems may make the future look bleak, the situation is not irremediable" (2006, p. 769). It furthermore shows openings for prevention of feelings of hopelessness and stimulation of agency as discussed by Ojala (2020). These emotional connections could be strong motivators for facilitating the deliberation process and better understanding student action-taking in the classroom (Ojala, 2013).

Behaviour

From the student interviews it becomes apparent that students undertake limited sustainable actions. They mostly relate to small, at home behaviour such as sorting waste, switching off lights when leaving a room, and shortening time spent in the shower. Stern (2000) would typify these behaviours as belonging to the category of private-sphere environmentalism. In Westheimer's (2008) view, these actions are examples of personally responsible citizenship. Sass, Quintelier et al. (2021) found a similar overrepresentation of individual actions in their qualitative study on Flemish adolescent action-taking regarding the Sustainable Development Goals. However, just like in our sample, there still was a group of students who voiced a desire for collective action-taking. Quantitative studies support this image of students not cooperating in collaborative efforts (such as committees or welfare organizations) but choosing to focus on individual behaviours (such as reducing water use, sorting waste)(e.g. Gericke et al., 2018). Students from our sample explain that they feel they are dependent on decisions by their parents when discussing their sustainable behaviour.

As seen from the attitude results, students in this study felt saving the future is still possible, but their willingness to give up certain unsustainable behaviours, such as showering a shorter amount of time or adopting a vegetarian diet, was low. Several students explicitly state this, and similar conclusions are present in previous research (i.e. Jenkins & Pell, 2006). Most of these students would therefore not be considered action-competent, since their commitment and passion to contribute to action is lacking or absent (Sass et al., 2020). However, it is a positive sign that the interviewed students are still seeing possibilities for actions, which is a core feature of action competence (Sass et al., 2020).

Since this study concerns young students, who depend on their parents for many important decisions in their daily lives, parental influence could be both a stimulating and an inhibiting factor on the students' sustainable behaviour. In Sass et al.'s model of action-competence for sustainable development, this relates strongly to the 'outcome expectancy' feature, or confidence in one's influencing possibilities (2020). Some students in our study explicitly mention this dependence on others for their sustainable behaviours, for instance stating they are planning to lead more sustainable lives when living on their own. This might be a hindrance to developing confidence in their own influencing possibilities. In a study with Swedish upper secondary students, this aspect of action competence has been singled out as particularly difficult to foster (Olsson et al., 2022). Other studies have shown that students being dependent on the decisions of adults is a sentiment shared by teachers, who feel their students have limited means to have an impact on the sustainability of the situation at home (Aarnio-Linnanvuori, 2019). In their study, by far the most prevalent environmentally responsible behaviours that teachers could think of that where attainable for students related to sorting waste and litter. The interview data from the current study support these teacher beliefs, for they show these exact behaviours were the most prevalent in student answers too.

As far as metacognition regarding the opinion-forming process goes, most students from this study do not have a clear idea how they make their decisions regarding sustainability issues. Furthermore, the students who do know what steps they take mostly report that their preferred strategy for decision-making is thinking about the issue by themselves. This behaviour cannot be characterised as the desired form of critical thinking that is necessary for dealing with SSIs in a responsible manner, which calls for interpreting statements, looking for bias and values and judging evidence (Karahan & Roehrig, 2017). Despite some students claiming they look at reliable sources and cross-check information, the interviewed students do not seem to adopt a critical stance to what they hear about sustainability. However, some sources, such as social media, are deemed untrustworthy by students, showing they do not take everything they hear about the topic for granted. It seems these students need help in using their first, intuitive response to sustainability issues to explore their underlying values and develop action strategies accordingly (Haidt, 2001; Ojala, 2013).

Reflection

The interviewed students show first signs of critical reflection regarding their own agency, as discussed in the section on behaviour. They, too, show some signs of critical reflection regarding solution strategies and their expected effectiveness. These correspond with conscious reflection as discussed by Wardekker (2001) and self-reflectiveness as defined by Bandura (2001). However, the interviewed students are less prone to reflect on other areas of sustainability. Concerning for instance adopting a critical stance towards information sources, just over half of the students report doubting information at least sometimes, with about a third of them saying they never doubt what they hear about sustainability. The most common

causes for being sceptical towards information was triggered by click-bait titles that students encounter online, which many of these students deem to be attention grabbers, selectively twisting information to sell stories to a bigger audience. About a third of the interviewed students therefore lack the scepticism-component of Socio-Scientific Reasoning (Sadler et al., 2007). These findings are in line with Karahan and Roehrig (2017), who reported on students generally lacking these kind of critical information valuing skills.

As far as frequency of reflection on sustainability issues goes, students seem to think about these issues mainly in a school context or, to a lesser extent, at home with their family. Almost none of the students discuss sustainability with their friends, most of them scoffing at the idea when the question was put to them during the interview. This divide suggests that there is a gap between the personal, introspective world of the students on the one hand, wherein most of the students are worried about the future and feel sustainability and the environment are important to them, and the social world of the students, in which they do not speak about it with friends or peers. This lack of collective reflection on sustainability, especially with peers, is detrimental for the action competence of students regarding sustainability issues (Sass et al., 2020).

Sustainability issues that students recognise in their own surroundings are relatively harmless in the short term, mainly relating to changing weather conditions. Half of the students report experiencing warmer, dryer or more changeable weather compared to conditions in the past. Litter is also a relatively widely seen problem. In contrast, students believe that issues that occur elsewhere are of much graver nature in the short term, for instance concerning extinction of animals, natural disasters such as mudslides, and large-scale pollution such as plastic soup or smog. Furthermore, effects on humans, such as a need for facemasks because of heavily polluted air, are only seen elsewhere, and in our students' view do not occur in their direct surroundings. Summarizing, about two thirds of the students sees relatively unimpactful sustainability issues in their own surroundings, whereas the vast majority of students think severe sustainability issues are experienced elsewhere in the world. This contradiction further strengthens the idea that sustainability is a concept that is on the margin of the students' minds, and that sustainability issues are experienced as something that is happening far off. It relates to "cognitive and emotional disengagement" caused by the "physical distance between consumers and the sites of environmental degradation" (Dutta & Chandrasekharan, 2017, p. 1194). Our data clearly show that to these students there is a difference between sustainability issues close to home and issues that happen elsewhere. Ultimately, both this experienced difference and the physical distance could lead to what Dutta and Chandrasekharan describe as "feelings of apathy and resignation" (2017, p. 1194), also among students, which would surely compromise efforts of teaching EC. However, at least partially contradicting this, the fact that students do claim to worry about sustainability and the future and that they say they think about these topics regularly tells a different story. It thus seems that, once again, the relationship of the interviewed lower secondary students with sustainability is a complicated one.

Summarizing, our qualitative data provide a background to the often quantitative data that is currently available about student EC at secondary level. With this, students are given a voice to explain findings from those qualitative studies. For instance, our data provide suggestions for the common trend of relatively low scores for sustainability attitudes and values of young people in many countries, including Spain, Flanders, and Sweden (Ariza, Boeve-de Pauw, et al., 2021) and Cyprus (A. C. Hadjichambis & Paraskeva-Hadjichambi, 2020b). From our data it becomes apparent that there are indeed groups of students who have unsustainable attitudes. Underlying factors here seem to be a feeling of disconnect, with students often believing sustainability issues will not affect them in their life time. This places findings from earlier studies in perspective.

In a similar manner, our data support findings from Gericke et al. (2018), who found sustainability behaviour to be lacking when compared to their other subscales. However, we can see from our data that the reason for this in our case is that students are often willing to behave sustainably, yet they feel they are incapable of making a difference or that they are not the ones making the decisions at home. In other words, their outcome expectancy is low, leading to a lack in action competence (Sass et al., 2020). This, again, describes a possible explanation from earlier findings regarding student EC.

Limitations

Despite considerable care that has been taken to provide a representative sample of the Dutch lower secondary student population, the students who are enrolled in pre-university level education (*vwo* in Dutch) are slightly overrepresented. This must be taken into consideration when interpreting the data. Furthermore, since the focus of this study was on said Dutch context, these data might not describe trends that are present in other countries, with their specific educational systems and regional sustainability issues certainly affecting local student populations. However, these data can still be of interest to researchers and educators from other contexts, since they provide a qualitative layer of insight into what is now currently a mostly quantitative affair. Furthermore, they provide empirical evidence for theoretical notions and trends in policy that have been described in sustainability and citizenship education literature across the globe.

Implications for classroom practice

From our analysis of the data, the students from our sample show a conflicting stance towards sustainability. On the one hand, they think it is an important issue, with most of them believing our current unsustainable lifestyle will lead to major issues in the foreseeable future. Students worry about the topic, and they feel something should be done quickly to solve sustainability issues. They often adopt altruistic or biospheric orientations towards sustainability. Underscoring this sense of urgency, and in line with prevailing neoliberalist thinking, students

want to know what they can do themselves to live sustainable lives. On the other hand, many students feel sustainability issues do not appear in their immediate surroundings. They seem to believe that these issues have an impact on people who live elsewhere in the world or will only have a sizeable impact on future generations. For these students, egoistic orientations were more common. Moreover, sustainability is not a topic that lower secondary students discuss with peers. Scientific concepts, such as the processes driving climate change, are not connected explicitly to sustainability issues in the students' view.

From our data it becomes clear that many students currently do adopt individualistic ideas of citizenship and what it entails (Biesta, 2007). We therefore urge educators to place a focus on the cooperative nature of developing interventions for sustainability issues, letting students experience that working together and making decisions as a collective are areas that can have real impact. This is in line with previous findings from literature (e.g. Estellés & Fischman, 2021), our qualitative study further underscores this.

This has several implications for science education practice. Science educators are recommended to focus on specific issues in the daily lives of the students, to which they are able to connect personally as well as to which they can connect their scientific knowledge, to make them appreciate their place in the issue and make them realise that these issues do not only affect others at a distance, but make them see that sustainability issues also affect them in their immediate surroundings. In doing so, educators could focus on strategies that the students are able to implement themselves, showing what can be done to intervene in sustainability related SSIs. With this, the focus should not only be on private sphere behaviour of the students, but also on for instance policy and governmental strategies, hereby moving away from a purely neoliberalist view towards a more complete form of EC. This way, education could move towards more participatory and social-justice oriented citizenship, thus enabling students to look at the root causes of problems instead of keeping the narrow focus on personal responsibility. This would help to temper the negative images of the future and of sustainability that students sometimes have, as well as appeal to what they want to learn about these types of issues. In doing so, teachers could be more effective in teaching science education for EC.

Acknowledgements: The authors are grateful to the students who volunteered to take part in this study and to the teachers who facilitated this.

Appendix 3.1 | Description of categories for coding

Knowledge questions

1. Definition	
Energy	Mentioning energy source(s), such as lighting, power, etc., or transportation (car, bus, etc.)
Recycling	Recycling, refurbishing, less waste, less rubbish, preserving resources
Environment	Acting in an environmentally friendly manner, against climate change, against hole in the ozone layer, etc.
Minimizing use	Lower production levels, using less stuff/food/energy/water, using stuff as long as possible
Pollution	Keeping nature/surroundings clean, no litter, less emissions
Conservation	Conserving current state of the world, cyclic processes, renewable
Other	Brundtland definition, high costs/expensive, food production
2: Cause of problems	
Industry, electronics	Cars, fossil fuels, aircrafts, industrial revolution, electricity, factories, electronics, higher energy use, innovations
Pollution and exhaustion	Emissions, pollution, exhaustion, less frugal lifestyle, lots of waste, greenhouse effect, nature has to give way
General human behaviour	Population growth, human behaviour
High life standards	Increase in prosperity, luxury lifestyles, eating more meat, lazier lifestyles
Unknown consequences	Consequences became clear only recently, disadvantages were unknown before, problems started long ago
Other	Natural changes in Earth's system
3. Persistence of issues	
Uncooperative people	Not every country is helping, people are egoistic/go for themselves/ do not believe in sustainability issues/do not know about sustainability issues/procrastinate/are too poor/stick to their habits, no-one starts, many different opinions exist
Availability of solutions	Solutions are expensive/not yet ready/unavailable/have disadvantages, we only recently started solving the issues
High life standards	People want to live too luxuriously/want too much
Other	Complexity of the issues, population growth, use of fossil fuels, it is too late already

Attitudes questions

4. Thinking about future of the planet	
Effect on nature	Extinction of species (mainly animals), climate change, less nature, deforestation
Doom scenario	Very negative and irredeemable view on the future, fires, no more nature, scarcity of food, lack of oxygen
Solution is needed	We need to act now, otherwise it will be too late, feeling he/she needs to do more about it, sense of urgency
Effect on humans	Sea levels rising, floods, effects on future generations, famine, financial consequences

Pollution	Air pollution, litter, plastic(soup), pollution in general
Relate to themselves	Feeling of disempowerment, students themselves or others are in the wrong, feeling of effects happening after their lifetimes/somewhere else, forgetting to take into account in daily life
Information sources	Mentioning when they come into contact with it, i.e., on the national news, social media, etc.
Other	Solutions, fossil fuels, what might happen, climate deniers
5. Worry about the future of the planet	
Effect on humans	Sea levels rising, floods, effects on future generations, famine, draught, financial consequences
No effect on me	Does not expect it to affect them personally, problems for future generations, or somewhere else, feels indifferent
Doom scenario	Very negative and irredeemable view on the future, fires, no more nature, scarcity of food, lack of oxygen
Effect on nature	Extinction of animals and plants, extreme weather, less nature
Pollution	Litter, plastic(soup), emissions, etc.
Reactions of others	Other people are not worried either/do nothing about it either, many people do not believe sustainability is an issue
Own actions	Does not know how to act, feels helpless and/or guilty, wants to take action
Information sources	Mentioning when they come into contact with it, i.e., on the national news, social media, etc.
Other	People are doing enough right now, I feel I should worry more
6. Importance of environment	
Responsibility	Otherwise it is unfair to others (people, nature, animals, the Earth itself), impact on others in the future
Urgence	Something needs to happen now
Own future	Wants to save their own future, their own surroundings, wants to prevent it from being bothersome in the future, thinks litter is ugly
Feels incompetent	Feels useless, unable to act in a meaningful way
Other	Does not help to just talk about it, gets mad if sees people being disrespectful
7. Learning more about the environment	
How to act	Wants to know what they can do themselves, a good way to act, what do we need to do
More information	What is happening right now, what is really going on, what is true, need for nuance, what is truly sustainable
Future consequences	Wants to know the consequences, what is going to happen, what will happen when we do not act now, concerning their own surroundings and their own future
No, because...	I already know this by now, does not stick anyway, others are not interested in it, it is mainly political anyway
Solutions	What is the school doing, what are other people/companies doing, what solutions are implemented already, why do current solutions not work/ why are they not enough?
Aware of own behaviour	What do we do ourselves, others will become aware of the consequences of their actions
Other	Does not want to accidentally harm the environment, does not really know

8. Solving of issues easy or hard	
Co-operation is needed	Easy if everyone helps, cooperation is needed, when governments help, when general consensus agrees, but everyone is needed
People do not cooperate	Not all countries cooperate, people are egoistic/go for their own comfort/do not believe in sustainability/do not know about the problems/are poor/procrastinate/stick to their habits, there are many opinions about it
Problems are big	There are many problems, problems are big/on a large scale, problems occur elsewhere/far away
Alternatives	Alternatives have negative impacts too, are not in use yet, if there were alternatives it would be easy
Expensive	Finding solutions is expensive, implementing solutions is expensive, it is expensive
Residual pollution	Problems will never be totally solved, there will always be residual pollution
Time intensive	Solving this costs a lot of time, coming up with solutions takes a lot of time
Other	Otherwise they would have been solved already, difficult to monitor, population growth, power of big companies

Behaviour questions

9. Student behaviour	
Waste and litter	Sorting waste, picking up litter, throwing litter in the bin, recycling, using less plastic, using things for extended periods of time
Difficulty	Difficult to pay attention to this, intention for later, habits are too strong, wants to but does not do it
Saving at home	Saving energy, water, using solar panels, decreasing heating temperature, less time spent in the shower, not letting the tap run for too long, switching off lights
Parents	Parents remind the student to do so, student pressures parents into doing so, student has little to say on the matter because the parents decide
Transportation	Using alternative transportation such as bicycle, public transport, electric car
Other	Greener garden, when making purchases, adopting a vegetarian diet, supporting charity
10. Opinion-forming steps	
Thinking about it	Students use their own ideas to form an opinion, thinking over the issue by themselves, or claiming this happens of its own, mainly based on own experiences from their direct surroundings
Reliable sources	Students use sources that they feel are reliable, such as the news, a popular sketch show that critiques society (titled *Zondag met Lubach,* Sunday with Lubach), information from school, or found on reliable webpages
Multiple sources	Students use multiple sources to cross-check information, consider the pros and cons, looking at both sides of the dilemma, and basing their decision on multiple experts

Reflection questions

11. Questioning and critical thinking	
Reliable sources	Sources that students consider to be reliable, such as reliable webpages on the internet, text books from school, the news, documentaries, scientists and other experts
Exaggerations	Hyperbolic stories, attention grabbing stories, click-bait, stories that are meant to create fear, stories that focus solely on views/are aimed to attract large audiences, huge claims
Unreliable sources	Sources that students consider to be unreliable, such as social media, unknown websites, uncertainties in the scientific method
Conflicting information	Information that conflicts with other information or personal experience
Repeated information	Repetition of information that students already know, information that confirms prior knowledge
Family, friends, etc.	People from the student's direct surroundings, friends, family and others
I hear nothing about it	Student does not hear anything about sustainability, or are not aware of this
Other	Content-related questions, unable to check facts themselves
12. Issues close to home	
Weather	Student experiences weather changes such as higher temperatures, less snow, warm winters, drought
Changes in nature	Student claims seeing less animals (insects), forest disappearing, or seeing dead animals
Pollution	Student sees litter outside, on the streets and in nature
Not yet	Student does not experience this yet, claiming for instance that they have not yet lived long enough, or seeing solutions but not yet the problems that are associated with them
Conversation topic	Student encounters people talking about it, also on social media and on the news
13. Issues elsewhere	
Weather	Effects on weather, such as drought, climate change/global warming, rising temperatures, extreme weather
Changes in nature	Effects such as sea levels rising, ice melting, natural disasters, extinction of animals, deforestation
Pollution	Air pollution, plastic (soup, in animals, etc.), pollution in general, huge piles of waste
Effect on humans	Effects on humans, such as diseases, wearing facemasks because of pollution, etc.
Conversation topic	Student encounters people talking about it, also on social media and on the news
No example	Student cannot think of an example

4

The environmental citizenship opinions questionnaire: a self-assessment tool for secondary students

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Abstract

Introduction: We present a validated instrument for assessing Environmental Citizenship (EC) of students in lower secondary education. The Environmental Citizenship Opinions (ECO) questionnaire focusses on general citizenship components, key sustainability competences, and Socio-Scientific Reasoning aspects. By combining these domains, our work provides a needed innovation as these different aspects of EC have not previously been covered in one single, balanced and validated measurement instrument. **Methods**: The ECO-questionnaire was validated through a pilot round and a subsequent large-scale study (781 lower secondary students). Several rounds of Confirmatory Factor Analysis resulted in a final model of 38 items divided in 7 first order and 5 second order constructs. **Results**: The final model fit statistics indicate near-excellent quality of our model (RMSEA = 0.036, CFI = 0.93, TLI = 0.93, SRMR = 0.05), which consists of EC knowledge, EC attitudes, EC skills, EC reflection and complexity of EC issues. Calculations on the relative attribution of each of the five main constructs to overall environmental sustainability citizenship, highlight that attitudes and reflection skills are the most important constituents. **Discussion**: Our results present the ECO-questionnaire as a valuable, valid and reliable tool to measure Environmental Citizenship of students. Applications in practice include monitoring student's development and supporting teachers during the challenging task of effective teaching for EC in and outside the classroom.

Keywords: environmental citizenship, questionnaire, lower secondary, confirmatory factor analysis, sustainability education

4.1 Introduction

Sustainability issues and Environmental Citizenship (EC) are increasingly important themes for (science) education throughout the world. The UN Decade of Sustainable Development (UNESCO, 2014), the UN Sustainable Development Goals (United Nations, 2019), and EU Competences for Lifelong Learning (European Commission, 2019) all pay explicit attention to sustainability and EC. A key aspect of EC is collective and individual decision-making and action-taking on sustainability issues (Benninghaus et al., 2018). Since many sustainability issues can be labelled as wicked problems, this decision-making is a complex and open-ended endeavour (Lönngren & van Poeck, 2021). Because of this wicked nature, taking appropriate action on sustainability issues first demands opinion-forming to determine what course of action to take. Furthermore, many sustainability issues can be considered Socio-Scientific Issues (SSIs), since they are open-ended, complex, concern multiple stakeholders, and have both scientific and social ramifications (Ratcliffe & Grace, 2003). Opinion-forming and dialogue have been singled out as being of critical importance as educational strategies for effective SSI education in general (Cian, 2020) and sustainability education specifically (Garrecht et al., 2018).

It is clear then that opinion-forming plays an important role in EC from a theoretical perspective. Many national and local science curricula also acknowledge the importance of opinion-forming in a sustainability context. The Next Generation Science Standards in the US for example pay explicit attention to this aspect of EC, for instance in its section on human sustainability: "When evaluating solutions, it is important to take into account a range of constraints, including cost, safety, reliability, and aesthetics, and to consider social, cultural, and environmental impacts" (NRC, 2012, p. 208). In a similar fashion, the Dutch national curriculum aims to teach secondary school students how to make conscious decisions regarding sustainability issues and how to oversee the consequences these decisions might have (SLO, 2016).

Despite a widespread implementation of sustainability opinion-forming and decision-making in national curricula, science teachers struggle with assessing progress of fostering these EC competences in an educational setting. In a large-scale interview study with science teachers in the Netherlands, we found that about half of them feel ill-equipped to teach about citizenship in their science lessons, because of difficulty with differences of opinion, of guiding discussions, and a lack of assessment and evaluation tools (Van Harskamp et al., 2021). Many teachers from this study aimed for opinion-forming as an EC learning outcome, yet they felt this was hard to teach as well as to assess. Similarly, throughout a three year long professional development course, teachers in Sweden indicated that their main struggle when implementing education for sustainable development into their educational practice, is the assessment of the students' learning outcomes (Boeve-de Pauw et al., 2022). There appears to be a clear need for validated assessment tools that teachers can use to track EC development of their students in general, and on opinion-forming and decision-making aspects of EC specifically. The research community could employ this type of tool to assess effectiveness of interventions.

There have been previous efforts to develop assessment instruments for EC or closely related concepts, each with their own specific focus. However, in the current landscape of assessment instruments, opinion-forming regarding sustainability issues is underrepresented. For instance, Gericke et al. (2018) developed an instrument based strongly on the Sustainable Development Goals, which means opinion-forming aspects are represented less clearly. It focusses on EC aspects related to taking pro-environmental action and preventing new environmental issues, but since EC is a broader, complex concept, "it [their questionnaire] might need to be complemented with other instruments when evaluating educational interventions, depending on what specific aspects of EEC need to be evaluated" (Ariza, Boeve-de Pauw, et al., 2021, p. 18). On the other end of the spectrum, Ten Dam et al. (2011) developed an assessment tool that focuses specifically on general citizenship competence, without the ambition to include sustainability competences. Although there are other examples (e.g., Bouman et al., 2018; A. C. Hadjichambis & Paraskeva-Hadjichambi, 2020b; Olsson et al., 2020; Sass, Boeve-de Pauw, et al., 2021), none of the existing assessment tools paint an integrated picture of EC competence that would render the instrument useful for assessing educational goals related to sustainability opinion-forming and decision-making.

Most existing instruments focus on learning aims that deal with attitudes and sustainability behaviour, whereas learning aims related to sustainability opinion-forming and the ability to take part in dialogue about sustainability issues remain uncovered. Additionally, none of the existing assessment tools focus specifically on lower secondary level, or more precisely 11–15-year-olds. During this age, students have been found to go through a dip in sustainability attitudes and behaviours (Olsson et al., 2019), or a dip in sustainability knowingness, attitudes and behaviours in for instance Sweden (Olsson & Gericke, 2016) and Taiwan (Olsson et al., 2019). Similarly, Ten Dam et al. (2014) found that students age 14-15 scored slightly lower on citizenship attitudes and reflection compared to their younger peers. They argue that people in this age category might be busier with developing their own identity and are therefore less interested in processes around them. To better describe the changes that this age category is going through, it is worthwhile to assess EC opinion-forming and decision-making for this specific age group.

To this end, the current study aims to develop and validate an assessment tool that focusses on opinion-forming and decision-making aspects of EC at lower secondary level. First, the concepts of sustainability and EC competence are defined, after which relevant pre-existing assessment instruments are discussed. We then move on to describing what these instruments have to offer, and what is still lacking based on research literature about EC. Next, we describe the developmental process of our assessment instrument and discuss how it was validated. Finally, we discuss the possibilities of our instrument and implications of its development for practice.

4.2 Theoretical background

Defining sustainability remains challenging, yet the definition from the influential Our Common Future report is widely used. It defines sustainable development as development 'that meets the needs of the present without compromising the ability of future generations to meet their own needs' (WCED, 1987, p. 14). Sustainability has three main dimensions: ecology, society, and economy, more commonly referred to with the three Ps of people, planet, and prosperity (Benninghaus et al., 2018). This complexity has led to sustainability issues being dubbed wicked problems (Lönngren & van Poeck, 2021). Being able to form informed opinions and make informed decisions regarding sustainability issues while taking into account their inherent complexity is an important characteristic of EC (Ojala, 2013; Olsson et al., 2022).

As is commonly the case with sustainability-related competences, and as can be seen from the definition of Our Common Future, EC includes a focus on developments within and between generations, and on collective and individual action-taking (Benninghaus et al., 2018). This focus of EC on justice within and between generations culminates in decisions that take into account people elsewhere and in other points in time. Taking action in this sense requires opinion-forming regarding possible action strategies and action possibilities. Wiek et al. (2011) have marked a set of five key competences for sustainable action-taking, which therefore are important constituents of EC: i) systems thinking competence, which involves variables and complex cause-effect chains; ii) anticipatory competence, concerning past, present, and future effects, plausibility and risk; iii) normative competence, involving values, fairness and justice; iv) strategic competence, which concerns interventions, success factors and obstacles; and v) interpersonal competence, focusing on collaboration and empathy. An environmental citizen is able to employ these competences when taking sustainable action. These five competences should therefore be covered by assessment tools for EC that aim to assess learning outcomes related to sustainable opinion-forming and decision-making.

Another main constituent of the opinion-forming and decision-making process is reasoning about sustainability issues. Because many sustainability issues are SSIs, the concept of Socio-Scientific Reasoning (SSR) is relevant for an instrument assessing opinion-forming and decision-making aspects of EC. Sadler et al. (2007) identified four main dimensions when coining the concept of SSR: i) recognizing inherent complexity of SSIs, for instance related to environmental, social, and economic sides of the dilemma; ii) examining issues from multiple perspectives, ensuring points of view from different stakeholders and individuals are heard; iii) appreciating that SSIs are subject to ongoing inquiry, related to uncertainty and risk associated with SSIs and sustainability issues; and iv) being sceptical to information about issues, for instance consulting multiple sources and checking conflicts of interest of authors of information. SSR fits well in an educational context that observes holism and pluralism, which are two central concepts of effective education for EC (Boeve-de Pauw et al., 2015; Olsson et al., 2022). Holism, on the one hand, concerns observing different dimensions of issues, for

instance related to spatial and temporal dimensions and ecological, social, and economic aspects (Öhman, 2008). Pluralism, on the other hand, concerns leaving room for different points of view, different values, emotions and other affective or normative considerations in education for EC (Sund & Öhman, 2014). SSR fits well into these essential aspects of EC, for instance because of its inherent focus on complexity (ensuring holism) and multiperspectivity (ensuring pluralism) in dialogue about controversial issues. It therefore is worthwhile to pay attention to the four aspects of SSR in education for EC, since they are known to influence the opinion-forming and decision-making process in the context of SSI, and, to that extent, of sustainability issues.

Existing assessment tools

Several EC assessment instruments exist, each of them with a different emphasis. The Sustainability Consciousness Questionnaire (SCQ; Gericke et al., 2018) introduces the concept of sustainability consciousness. It is defined by the researchers as 'the experience or awareness of sustainability phenomena. These include experiences and perceptions that we commonly associate with ourselves such as beliefs, feelings and actions.' (Gericke et al., 2018, p. 3). The SCQ contains items on sustainability knowingness, or 'what people acknowledge as the necessary features of [sustainable development]'; sustainability attitudes, which explore attitudes towards sustainable development, and sustainability behaviour, or 'what people do in relation to [sustainable development]' (Gericke et al., 2018, p. 5). Each of these dimensions is divided in environmental, social, and economic items. Overall, the SCQ is strongly connected to the UN's Sustainable Development Goals. Because of this focus, it does not incorporate the reflexive component of citizenship competence as defined by Ten Dam et al. (2011). The SCQ is tailored to monitor development related to knowingness, attitudes and behaviours, with a focus on EC goals such as civic participation, critical and active engagement, and solving and preventing environmental problems (Ariza, Boeve-de Pauw, et al., 2021). It does not include items or subscales related to opinion-forming or discussion, and is therefore less suitable to track learning in these areas of EC.

Another recent instrument is the Environmental Citizenship Questionnaire (ECQ), developed by Hadjichambis and Paraskeva-Hadjichambi (2020b). It contains three main categories: activities as an environmental citizen, competences of an environmental citizen, and intention to act in the future as an environmental citizen. The ECQ is rooted firmly in the definition of EC as formulated by the ENEC project (ENEC, 2018). This translates into items that are often based on activism, social and environmental justice, and fairness. It also contains highly specific EC actions that students could perform, such as organizing an online discussion group or contacting elected representatives to discuss their sustainability policy. Because of this highly specific nature, the ECQ is deemed less suitable for measuring EC in a more general, less applied context. Its items are less suitable to track other citizenship learning aims such as dialogue skills. The ECQ is aimed mostly at assessing learning aims that concern sustainability behaviour.

Several other researchers chose a narrower focus, for instance developing instruments limited to environmental or sustainability attitudes (Milfont & Duckitt, 2010) or values (Bouman et al., 2018). The recently developed Action Competence in Sustainable Development Questionnaire (ACiSD-Q) aims to assess the concept of Action Competence in the context of sustainable development (Sass, Boeve-de Pauw, et al., 2021). The authors identify four aspects of AciSD: i) relevant knowledge, ii) willingness of individuals to take action, iii) capacity expectations related to trust in one's capacity for change and self-efficacy, and iv) outcome expectancy which concerns a trust in effectiveness of the action. It goes one step beyond the Self-Perceived Action Competence for Sustainability Questionnaire (SPACS-Q; Olsson et al., 2020), which does not discern between the two capacity expectations of the AciSD. Other large-scale studies incorporate subscales or sets of items that relate to EC or sustainability in more general instruments. An example is the Relevance Of Science Education (ROSE) questionnaire (Schreiner & Sjøberg, 2004), which focusses on the participants' views on science. While these instruments each incorporate aspects of EC and sustainability, they are not specifically designed to assess these concepts in relation to opinion-forming and decision-making.

On the other end of the spectrum are studies that aim to measure citizenship in general, while sometimes touching on aspects of EC and sustainability. An example is the Civic and Citizenship Education Study (ICCS; Schulz et al., 2018). This study contains several items that explore the perceived threat of environmental and sustainability issues to the participant's life quality, thus dealing with EC attitudes. Ten Dam et al. (2011) developed the Citizenship Competences Questionnaire (CCQ), which focuses solely on citizenship competence. Its four main constituents are Knowledge, Attitudes, Skills, and Reflection. In this context, reflection entails adopting a critical outlook on oneself, situations in the world and one's personal role in these situations (Ten Dam & Volman, 2007). It relates to self-reflectiveness, evaluating your thoughts and actions, and discussing these with others (Bandura, 2001).

While all these instruments focus on EC or related concepts, there is as of yet no assessment tool that specifically focusses on opinion-forming and decision-making aspects of EC. The discussed instruments are therefore less suitable for assessing learning aims related to one of EC's central concepts, opinion-forming. Such a tool should incorporate the five key sustainability competences of Wiek et al. (2011) and the four aspects of Socio-Scientific Reasoning (Sadler et al., 2007). Finally, most of these instruments are aimed at upper secondary students, mostly ignoring lower secondary level. In sum, it is fair to state that within the landscape of survey tools focusing on EC of students in formal education, there is both a conceptual gap regarding integrated assessment of opinion-forming and decision-making literature as well as regarding the specific age of early adolescence (11- to 15-year-olds). With the current study we aim to fill exactly these gaps.

Conceptualizing our assessment tool

Common aspects of many of the previously discussed tools are knowledge, attitudes, skills, and reflection. These, according to Ten Dam et al. (2011), are the main constituents of citizenship competence. In their model, knowledge is interpreted on a meta-level, concerning knowing what principles underly citizenship, and knowing how to deal with differences of opinion. Citizenship attitudes, according to Ten Dam et al. (2011), relate to thoughts, desires, and willingness to act, concerning a desire to learn about different opinions, willingness to explore conflicts, and upholding social justice. Citizenship skills in their vision refer to an estimation of what one can do in relationship to asserting opinions of oneself and others, and being able to function in unfamiliar social situations. Finally, reflection is important for citizenship for its critical character: "'Good citizenship' therefore implies that they can critically evaluate different perspectives, explore strategies for change, and reflect on issues of justice, (in)equality and democratic engagement" (Ten Dam et al., 2011, p. 354). In this interpretation of citizenship, reflection entails thinking about conflicts of interest, about equality, democracy, the possibilities to solve conflicts. These four aspects of citizenship competence should therefore be central to an EC assessment tool, since such a tool concerns citizenship in context of sustainability. Translating Ten Dam et al.'s (2011) four aspects of general citizenship competence into a sustainability context, knowledge in the case of EC relates to students understanding what sustainability entails. Sustainability attitudes describe the relation between the student and sustainability, such as their interest in the topic and their willingness to invest in a sustainable world. EC skills relate both to discussion skills and the ability to make sustainable decisions. They include the ability to discuss opinions while leaving room for multiple perspectives or ideologies. They furthermore include a critical attitude towards information sources and the skills to find out suitable courses of action. Finally, sustainability reflection concerns how often students think about sustainability related themes, and whether they discuss these topics at home or with friends. These four aspects of citizenship form the first four main constructs of EC that we aim to integrate into our novel assessment tool (Figure 4.1).

Environmental citizens are able to reason about complex sustainability issues in order to determine suitable courses of action. This type of reasoning closely resembles Socio-Scientific Reasoning as described by Sadler et al. (2007), for instance because of its previously discussed holistic and pluralistic outlook and its collaborative nature, which are important aspects of effective education for EC (Boeve-de Pauw et al., 2015; Olsson et al., 2022). Because of the importance of reasoning about sustainability issues, its four main aspects (complexity of SSIs, multiple perspectives, ongoing inquiry, and scepticism) should be present in an assessment tool for EC (Table 4.1). Since complexity is uncovered by the Ten Dam et al. categorization, it is added to our model as the fifth main construct (Figure 4.1). Finally, an assessment tool for EC that focusses on opinion-forming and decision-making should take into account common competencies that are labelled essential for sustainable decision-making and action-taking. Wiek et al.'s (2011) five key sustainability competences (systems thinking competence,

anticipatory competence, normative competence, strategic competence, and interpersonal competence) relate to reasoning about sustainability issues, discussion and dialogue, values, discussing sustainability with others, and inquiry skills. The items for our assessment tool were therefore designed to cover these five key competences (Table 4.1).

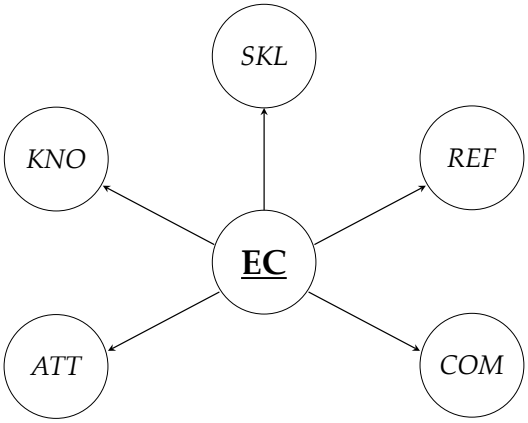

FIGURE 4.1 | The overarching construct of Environmental Citizenship (EC) and its five main second order constructs of our assessment tool: knowledge (KNO) about EC; attitudes (ATT) towards EC; EC skills (SKL); reflection (REF) about EC; and complexity (COM) of EC.

TABLE 4.1 | The five subconstructs from our factor model of the assessment tool, with connections to the four main components of citizenship competence (Ten Dam et al., 2011), the five key sustainability competences (Wiek et al., 2011), and the four Socio-Scientific Reasoning aspects (Sadler et al., 2007).

Subconstruct	Citizenship competence components	Key sustainability competences	Socio-Scientific Reasoning dimensions
Knowledge	Knowledge	Normative competence	Perspectives
Attitudes	Attitudes	Anticipatory competence, Strategic competence	Attitudes
Skills	Skills	Normative competence, Strategic competence	Skills
Reflection	Reflection	Normative competence, Strategic competence	Complexity, Perspectives, Ongoing inquiry
Complexity	n/a	Systems thinking competence, Anticipatory competence, Strategic competence	Complexity, Ongoing inquiry

For an assessment tool for EC to be effective in measuring learning gains related to opinion-forming and decision-making, it should unite Ten Dam et al.'s (2011) citizenship competence components, for these strongly focus on opinion-forming as a pivotal competence in citizenship. Furthermore, Wiek et al.'s (2011) sustainability competences are important aspects

for such a tool, since they cover commonly pursued competences for effective sustainable decision-making and action-taking. Finally, Sadler et al.'s (2007) Socio-Scientific Reasoning dimensions are important to include since they inherently feature two central requirements of effective education for EC, holism and pluralism, while covering the broader scope of reasoning and opinion-forming regarding complex and controversial issues such as those related to sustainability. An assessment tool that focusses on measuring EC opinion-forming and decision-making should unite these three models into a coherent whole. This important area of EC competence is as of yet uncovered by existing assessment instruments, despite its widely acknowledged societal value and worldwide prevalence as curricular aim. Our model unites these three dimensions in its five main constructs: EC Knowledge, EC Attitudes, EC Skills, EC Reflection and EC Complexity. With this study we aim to develop a validated assessment tool for opinion-forming and decision-making aspects of EC at lower secondary level.

4.3 Method

Initial version and pilot study

In a first step, we designed a pilot version of the Environmental Citizenship Opinions (ECO) questionnaire in which we included an items battery drawn from existing surveys. About a quarter of the pilot items was based on the instruments of Ten Dam et al. (2011), Gericke et al. (2018), Milfont and Duckitt (2010), and Schreiner and Sjøberg (2004). The rest of the items we constructed ourselves during the design process, based on the theoretical underpinning described in the theoretical framework. The instrument was developed and administered in Dutch. To ensure translation accuracy, backtranslation was used whenever items were originally written in English. The tool's items offer 5-point Likert-scale response options, in either a Strongly disagree, Disagree, Neutral, Agree, Strongly agree format or, for the Reflection subscales, a Never, Occasionally, Sometimes, Often, Very often format. Several items adopted inverted scales in order to check for response bias.

The pilot version of the questionnaire was discussed in one-on-one setting with several independent experts (Figure 4.2), after which they provided written feedback (Marissen, 2019). The consulted experts included a science teacher who commented on the applicability of the questionnaire for the target group, a psychology professor with experience with developing questionnaires commented on the questions and wording, and an assistant professor specializing in sustainability discussed its inclusion of the topic of sustainability. This resulted in minor but meaningful changes in wording. Subsequently, think aloud interviews with four lower secondary students were carried out, during which the questionnaire's cognitive validity was tested. This again led to some formulation changes. A small-scale test with a class of 27 students followed, which was aimed mainly at testing the platform and the process of online administration. Finalizing the pilot phase, the initial questionnaire of 65 items was tested

in a large-scale data collection round with 758 lower secondary students. The data for this pilot round were analysed with IBM SPSS (version 25) during several rounds of exploratory factor analysis (Principal Axis Factoring). Based on this pilot phase, a second version of the questionnaire was developed. Some items were adapted, new items were added, ultimately leading to 73 items. Most adaptations were based on results from the EFA, to improve item loadings whilst ensuring theoretical coverage of the items would remain sufficiently high. For example, new items were designed for the knowledge and complexity subscales in order to improve their quality.

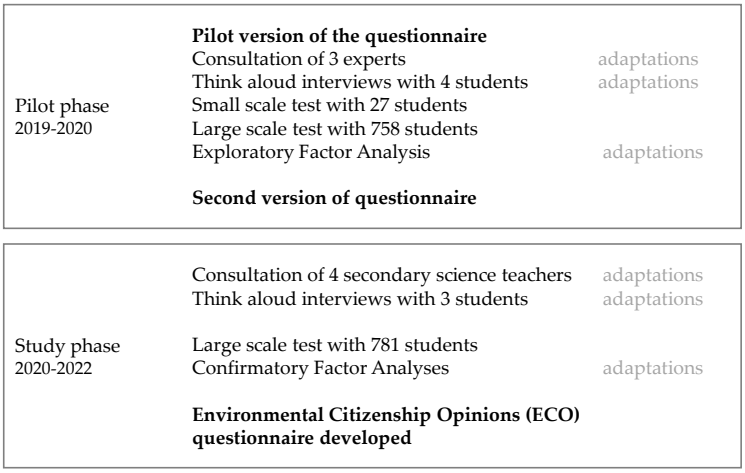

FIGURE 4.2 | Summary of the pilot phase and the study phase, and the steps taken during the development of the assessment tool for EC.

The first part of the study phase (Figure 4.2) again started with expert consultation. The questionnaire was discussed with four secondary school teachers and during think aloud interviews with three lower secondary students. Some small changes were made regarding wording of several items. The resulting version of the questionnaire was subsequently tested during a round of large-scale data.

Participants

Participants for the large-scale test during the study phase were sought through teachers from the researchers' network. Purposive sampling was used, selection of schools was based on ensuring representational spread of urban and rural areas. Ultimately, 894 students from 11 schools throughout the Netherlands took part in the study. 113 responses were excluded from analysis because they featured 80% or higher in one answer category or judging by the inverted items that were included as a check for social-desirability bias. The final dataset contained fully filled in questionnaires of 781 lower secondary students (female: 399; male: 363; neither female nor male: 19; average age 13.5; median age 13).

Data collection

Data were collected from January 2020 till June 2022. The questionnaire was administered online using FormDesk software. Participants either filled in the questionnaire during school hours in a regular science lesson or at home in their own time. Data collection took place within ethical boundaries set by Utrecht University.

Data analysis

The collected data were used to test the fit of our theoretical model to the dataset. To that end we conducted a series of Confirmatory Factor Analyses (CFAs) using the Mplus software package, version 8.8 (Muthén & Muthén, 2010). First, we checked for normality by looking at the skewness and kurtosis calculations of the individual items. Several rounds of CFA followed. In each round, the model fit parameters were checked as a reference for applicability of the model. We considered dropping items if very low factor loadings occurred and if this improved the model fit in subsequent CFAs. Multiple fit indices were used to evaluate the model, with the recommended values of .95 for the comparative fit index (CFI) and Tucker-Lewis index (TLI). For the root mean square error of approximation (RMSEA) we used values of .06 (Tabachnick & Fidell, 2007). Where necessary, modification indices based on meaningful error co-variances between items were used to further improve the model (Byrne, 2012), based on insights from theory and based on suggestions from Mplus that lowered the overall Chi Squared by more than 50 whilst being sensible from a theoretical point of view.

Finally, Cronbach's alpha was calculated using IBM SPSS Statistics (version 82.0.1.1) for each second- and third order construct to explore their reliability as an indication of their internal consistency. This combination of factor analysis, which models single-construct scales, and Cronbach's alpha, which indicates equivalence of items within these single scales, provides relevant information about reliability of scales (Taber, 2018).

4.4 Results

Several rounds of confirmatory factor analysis (CFA) were carried out to test the hypothetical model, which was based on the theoretical underpinning of our instrument. We set out to confirm that the construct of EC is composed of five latent psychometric constructs: knowledge, attitudes, skills and reflection, with the addition of complexity of EC issues (Figure 4.1).

For the first round of CFA, we included 46 of the initial 73 items. The item pool from the pilot study was narrowed down to improve usability of the instrument whilst simultaneously ensuring theoretical coverage of the instrument was not diminished. This first selection of items was based on factor loadings and creating a balanced distribution of items across the subconstructs. The first CFA showed a promising yet unacceptable model fit to the data, with the Root Mean Square Error Of Approximation (RMSEA) being 0.048, a Comparative fit index

(CFI) of 0.84, and a Tucker-Lewis Index (TLI) of 0.83. This indicated the need for modifications to improve the model. Modification indices in Mplus showed possible improvements, but none would improve model fit indices above unacceptable levels (CFI = 0.89, TLI = 0.88, and RMSEA = 0.039). Error covariances that were suggested and applied include all six covariances present in the final model, with the addition of six further covariances. None of the covariances were between items in different latent constructs.

During the second round of CFA we decided to drop items with very low loadings from the model with the aim to improve model fit. This led to exclusion of items 42 and 43 from the Attitudes subscale and 48 and 51 from the Skills subscale, meaning the second round model included 42 items. One more error covariance was included, between 64 and 61. Removing error covariances that were included in the first CFA round would not lead to improvements in model fit, which made us decide to keep the six covariances from the first round of CFA. Adaptations to our base model improved model fit indices, but CFI and TLI maxed out at 0.92 and 0.91, respectively, with an RMSEA of 0.036, which indicates an almost acceptable fit of our model to the data.

A third and final round of CFA followed (Figure 4.3), for which the model from round two was used as a base. This third round was furthermore informed by looking at a CFA which included all 73 original items. This 73 item model suggested to us to base the Knowledge subscale solely on social and human rights items (those being 8, 9, 10, and 11). The Knowledge subscale was therefore adapted accordingly. Furthermore, the Complexity subscale was adapted by excluding 61 and 64 because of low factor loadings, whilst 62 was included again to keep the number of items in the subscale in balance with the other subscales. Finally, 69 and 70 were excluded to further improve the Complexity subscale.

The final model thus included 38 items that cover the broad scope of EC theory that we initially set out to include in our model. These adaptations improved the model fit values, leading to a final model fit of RMSEA = 0.036, CFI = 0.93, and TLI = 0.93, with the Standardised Root Mean Square Residual being 0.05, indicating near excellent model fit. The SRMR acts as an approximation of model fit that combines the standardised residual covariances into one overall statistic (Maydeu-Olivares & Shi, 2017). The final list of items, including their standardised factor weight, mean scores and standard deviations, is provided in Table 4.2. This table also shows the Cronbach's alpha values that were calculated for each of the subscales as an estimation for their reliability. All alpha values are above the level of acceptable, ranging from 0.61 for the Knowledge subscale to 0.86 for the Reflection subscale.

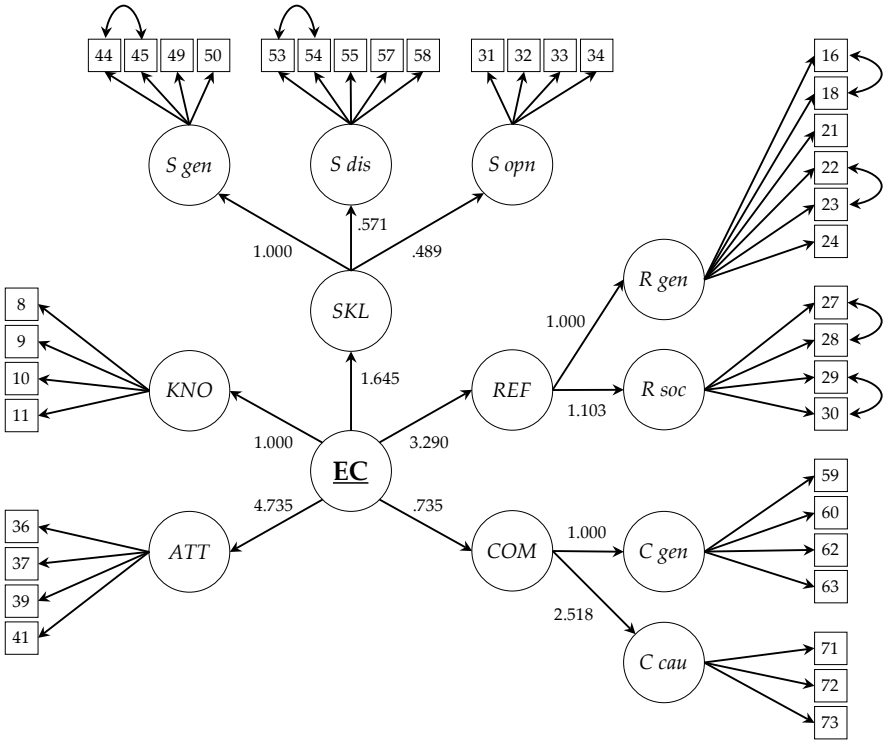

FIGURE 4.3 | The final higher order factor structure of the ECO-questionnaire. EC = Environmental Citizenship, KNO = Knowledge, ATT = Attitudes, SKL = Skills, REF = Reflection, COM = Complexity. Subconstructs include general skills (S gen), discussion skills (S dis), opinion skills (S opn), general reflection (R gen), social reflection (R soc), general complexity (C gen), and causes complexity (C cau). Estimates for the structural parameters based on the final Confirmatory Factor Analysis are shown. Estimates for the residual errors, error covariances and measurement errors available in Appendix 4.1: supplementary materials.

TABLE 4.2 | Final version of the Environmental Citizenship Opinions (ECO) questionnaire, showing Cronbach's alpha (α) for each (sub)construct, and standardised factor weight, mean (M) and standard deviation (SD) for each item. All subscales feature a five-point Likert scale, ranging from 'Strongly disagree' (1) to 'Strongly agree' (5), with the Reflection subscales ranging from 'Never' (1) to 'Very often' (5).

ECO-questionnaire		Factor weight	M	SD
Knowledge (α = 0.61)			3.03	1.03
8	Respect for human rights is part of sustainability. *	0.698	3.13	0.94
9	Companies that treat their employees badly are unsustainable. *	0.679	3.12	1.05
10	In a sustainable world, goods and means are distributed fairly across people. *	0.382	3.19	1.12
11	In a sustainable world, poverty does not exist. *	0.355	2.67	1.03

Table 4.2 (continued)

ECO-questionnaire		Factor weight	M	SD
Attitudes (α = 0.82)			3.05	1.12
36	I would like to learn how problems related to sustainability originate.	0.791	2.70	1.07
37	I would like to be involved in finding solutions for environmental problems.	0.800	2.71	1.23
39	I would like to learn how I can live more sustainably.	0.773	3.11	1.02
41	People should worry more about protecting the environment.	0.578	3.68	1.07
Skills (α = 0.79)			3.59	1.00
General skills (α = 0.70)			3.00	0.94
44	When I hear something about sustainability, I know how to find out whether it is true or not.	0.477	2.67	0.85
45	I can make an estimate whether a source with information about sustainability is trustworthy.	0.481	2.98	0.86
49	I am able to empathize with opinions about sustainability that are different from my own.	0.661	3.20	0.81
50	I am able to explain why groups of people have a certain opinion about sustainability.	0.681	3.15	0.88
Discussion skills (α = 0.73)			3.71	0.93
53	I am able to let someone finish speaking. †	0.413	3.96	0.76
54	I am able to listen to reasons why others choose something else. †	0.516	3.98	0.62
55	If I sense that I am wrong, I can admit this. †	0.501	3.49	0.94
57	In a discussion, I would like to find out where we agree and where we disagree. †	0.672	3.40	0.91
58	In a discussion, I am prepared to find a solution with which we can both agree. †	0.666	3.70	0.83
Opinion skills (α = 0.85)			4.03	0.82
31	I am able to defend my opinion if I am truly right. †	0.740	4.06	0.72
32	I am able to stand my ground for my opinion. †	0.824	4.05	0.66
33	In a discussion, I am able to explain what my opinion is. †	0.798	4.03	0.64
34	I am able to explain what my opinion is.	0.696	3.96	0.64
Reflection (α = 0.86)			2.58	1.13
General reflection (α = 0.82)			2.90	1.09
16	How I can ensure that something concerning sustainability changes in the world. †	0.620	2.61	1.08
18	How I can ensure that something concerning sustainability changes in the Netherlands. †	0.648	2.49	1.03
21	Environmental issues.	0.752	3.25	1.04
22	Inequality in the world.	0.531	3.29	1.18
23	Human rights.	0.524	3.09	1.12
24	How sustainable my life style is.	0.679	2.68	1.05
Social reflection (α = 0.82)			2.10	1.02

Table 4.2 (continued)

ECO-questionnaire		Factor weight	M	SD
27	With my friends I ... talk about sustainability.	0.591	1.62	0.67
28	With my friends I ... talk about our impact on the environment.	0.651	1.79	0.82
29	At home we ... talk about our impact on the environment.	0.710	2.49	1.01
30	At home we ... talk about sustainability.	0.689	2.51	1.04
Complexity (α = 0.64)			3.48	0.88
General complexity (α = 0.64)			3.50	0.89
59	Environmental problems are difficult.	0.707	3.68	0.85
60	Environmental problems are complex.	0.719	3.47	0.74
62	Problems related to sustainability do not have an easy solution.	0.379	3.51	0.80
63	Problems associated with the distribution of food are difficult.	0.429	3.34	0.72
Causes complexity (α = 0.66)			3.45	0.87
71	Sustainability issues are caused by people being egoistic.	0.615	3.38	0.81
72	Sustainability issues still exist because people do not want to change.	0.710	3.55	0.71
73	Sustainability issues still exist because the government does not do enough about them.	0.566	3.43	0.75

4.5 Discussion

In this study we set out to describe the development and validation of the Environmental Citizenship Opinions (ECO) questionnaire. Based on the results of the different steps in our analyses we will first discuss the ECO-questionnaire's quality. We then describe underlying relationships between the different constructs of EC in our instrument, and finally we reflect on implications for teachers.

As can be seen from the results of our analyses, the ECO-questionnaire offers a valid and reliable way to assess EC of students in lower secondary education. For the first time, opinion-forming and decision-making aspects are integrated in a single validated EC assessment tool. The overall structure of the model was based on Ten Dam et al.'s (2011) four main components of citizenship competence. Two of the third-order subconstructs are entirely made up from items of their measurement tool for citizenship, those being Discussion skills (items 53-55, 57, 58) and Opinion skills (31-34). The fifth subconstruct in our model, Complexity, was included because of its importance in Sadler et al.'s (2007) Socio-Scientific Reasoning model, one of the main constituents of the ECO-questionnaire. Other Socio-Scientific Reasoning items in our assessment tool are for instance 'I can assess whether a source with information about sustainability is trustworthy' (item 45, representing 'scepticism'). Wiek et al.'s (2011) key sustainability competences are covered by such items as 'In a discussion I am prepared to find a solution with which we can both agree' (item 58, a strategic competence item) and 'I am able to empathize with opinions about sustainability that are different from my own' (item

49, Normative competence). With this, the ECO-questionnaire covers the theoretical concepts which we set out to unite in one assessment tool.

Model fit indices and Cronbach's alpha estimates indicate that our assessment tool is both valid and reliable. The final model fit indices fall well within range of excellent quality (Tabachnick & Fidell, 2007). Furthermore, all subconstructs have acceptable to excellent Cronbach's alpha estimates. Since these alphas were calculated on single-construct scales, as modelled during factor analysis, these values are assumed to indicate that items within these constructs are interrelated (Taber, 2018). Four subconstructs have alpha values between .6 and .7. Since the items in these subconstructs are related given their performance in our model during the rounds of Confirmatory Factor Analysis, and since the generally assumed level of satisfactory alpha is an arbitrary one (Taber, 2018), the reliability of these subscales is considered to be satisfactorily high to use them as a measure for their corresponding subconstructs of EC.

Looking at the items scores, there is no occurrence of a ceiling effect, which indicates that our tool is not prone to elicit favourable answering modes from students. Furthermore, a large spread of student scores between respondents can be found, with standard deviations of individual items frequently being greater than one. Taken together, these findings show the instrument is sensitive to measure differences between individuals in a valid and reliable manner.

Environmental citizenship and relationships between its subconstructs

This novel tool in itself is an important outcome of our study, but the results also allow us to explore the interrelations of subconstructs of EC included in the questionnaire. When looking at the factor structure and the estimates for its structural parameters, a clear difference in relative weight of the subconstructs can be seen (Figure 4.3). The Attitudes and Reflection subconstructs for instance have a relative weight that is three to four times higher than the the other second order constructs. We know from literature that attitudes and other affective constructs are an important constituent for one's pro-environmental behaviour (e.g., Böhme et al., 2018). In redefining action competence for sustainable development, Sass et al. (2020) for instance included the attitudinal construct of 'Willingness to take action' as one of the driving forces behind taking action. We also know from research that affective variables such as emotions and intuitions, like attitudes, strongly influence decision-making (Haidt, 2001; Ojala, 2013). Since we cannot distinguish between fruitful and unfruitful emotions for environmental citizens, the emotional aspect was beyond the scope of our assessment tool for EC. Yet development of our model once more underscores the relatively strong weight of affective variables on EC compared to for instance the cognitive subscale.

Just like in our model, previous studies show that knowledge does not always play an equally important role in this process: "Even for the most engaged citizens, automatic unconscious intuitions are generally responsible of final political decisions, which are often resistant to any information that confronts those emotional insights" (Estellés & Fischman, 2021, p. 224).

Similarly, in their model for pro-environmental competences for adolescents, Roczen et al. (2014) found that different knowledge subscales had a lower impact on general ecological behaviour than attitudinal factors. Likewise, our model further emphasizes this relatively low weight effect of knowledge on EC and the relatively stronger relationship of Attitudes and EC.

Going one step beyond this previously identified relationship, our results point at Reflection about sustainability as being in the same range of importance as affective constructs for one's EC. Although the relevance of reflection as a subconstruct for citizenship competence (Ten Dam et al., 2011) or Socio-Scientific Reasoning (Sadler et al., 2007) has previously been acknowledged within the research community, our findings provide further empirical basis for underscoring its importance as one of the key constituents of EC. This has several implications for education. If one for example wishes to promote EC, learning aims related to reflecting on sustainability are recommended. Education could be tailored towards increasing the frequency of these reflective moments.

The Knowledge subconstruct could not be composed of items representing both environment themed items on the one hand and human rights or socio-economic items on the other with satisfactory model fit indices and reliability estimates. This tells us something about the participating students' interpretation of sustainability. It shows that the consulted students do not equally consider the environmental and the social or economic dimension of sustainability. Although further research is needed to check conceptual understanding of the target group, previous studies provide similar results. This was for instance shown by an overemphasis of the environmental or planet dimension of sustainability in student understanding of the concept (Benninghaus et al., 2018; Sass, Quintelier, et al., 2021; Walshe, 2008) or of underrepresentation of the economic dimension in student summaries of sustainability issues (Berglund & Gericke, 2018; van Harskamp et al., 2022). It is furthermore known that science teachers have narrow views of sustainability. An interview study on teachers' EC practice showed that the ecological dimension is overemphasised in science teachers' definitions of sustainability (Van Harskamp et al., 2021). With teachers having this overly ecological interpretation of what sustainability entails, it comes as no surprise that their students hold similar views. The relationship of teacher and student interpretation of sustainability as a concept could be explored further in subsequent studies. For our assessment instrument, however, it is important to focus on aspects of sustainability knowledge that would otherwise be underrepresented, those being the people and prosperity dimensions. These are therefore strongly represented in the current items of the Knowledge subconstruct as well as throughout other subconstructs, for instance in Reflection (e.g., inequality and human rights).

The relatively low overall score for the Social reflection subconstruct in our sample (a 2.1 average) indicates that the participating students hardly ever discuss sustainability with friends or their family. This contrasts with the students' interpretation of their own Discussion and Opinion skills (3.7 and 4.0, respectively), which is relatively high. The students in our sample

feel confident in their abilities to discuss their sustainability opinions, but they simultaneously mention hardly bringing these skills in practice at home or with friends. Since our sample does not represent spread across educational levels in the Netherlands, these results cannot be easily generalised. In our sample, the vocational level was underrepresented. There is no reason to assume that this has an effect on the structure of the model, but it does possibly influence the overall scores of the subconstructs. The Ten Dam et al. (2011) items, for instance, have been found to lead to higher averages for pre-university students than for those of other educational levels (Ten Dam et al., 2014). A mitigating factor here could be that the aforementioned means of the Skills subscales in our study closely resemble the means of the original instrument from which these items were taken, for which a representative sample was used (Ten Dam et al., 2011). However, caution needs to be taken when interpreting mean scores from our study, since our sample was selected with the eye on high quality instrument development rather than on representation of the Dutch population of students.

Implications for use in practice

Our assessment tool can be used by researchers to monitor EC opinion-forming and decision-making learning outcomes at lower secondary level, for instance by pre-post-test design. To make our instrument usable by (science) teachers, several steps need to be taken. First, guidelines need to be provided for teachers to ensure data collection conditions are appropriate. Second, instructions need to be written which describe how to calculate scores for first, second, and third order constructs. An (online) tool to perform these calculations would be helpful. Finally, an explanation needs to be given for how to interpret the results and for drawing conclusions and understanding implications for teaching practice. The clear and straightforward structure of our instrument, mainly when considering the five second order constructs, might facilitate this process. Furthermore, with 38 items, our assessment tool is relatively short, which enhances usability in a field where time is a scarce commodity.

Limitations

As with every questionnaire, choices were made during the development process which must be considered before implementation. Our instrument was validated in a Dutch context, and was developed with the specific age group of lower secondary level in mind. General higher and pre university level were overrepresented in the final dataset. Its validity and reliability have not been explored in other contexts, which means applying the questionnaire in other countries or using it for other age groups should be done with caution. Further studies of the ECO-questionnaire in other contexts would be a valuable addition to our understanding of its broader applicability. These studies could also explore specifications of the general subscales in the current version (e.g., General skills, General reflection). Despite the high quality of the current version of the instrument, these aspects could be improved in subsequent developmental rounds.

Apart from these limitations, the instrument behaves satisfactorily and offers valuable insight in students' EC. Of course, our model does not cover the theoretical constructs of EC in all of its broadness. However, taken together, our assessment tool is able to assess learning outcomes that were previously excluded from validated assessment tools. This provides insight in key characteristics of opinion-forming and decision-making regarding the elusive construct of EC.

Conclusion

We set out to develop an assessment tool for EC of lower secondary students. The ECO-questionnaire and all of its lower order constructs form a broad and meaningful overview of one's level of EC. Judging by its performance through rigorous testing, it measures EC in a valid and reliable way. The tool therefore offers opportunities for teachers to assess students' levels of EC in the classroom. This could help them understand what areas of EC are sufficiently developed, and which EC aspects demand further nourishment. Additionally, it could provide science education researchers with valuable information on where students currently stand concerning EC.

The added value of this new tool to the existing pool of instruments is threefold. First, it is the first time that these three dimensions of EC, the general citizenship components of Ten Dam et al. (2011), the key sustainability competences of Wiek et al. (2011), and the Socio-Scientific Reasoning aspects from Sadler et al. (2007), are unified in one coherent tool. Our effort to unify these EC elements thus fills a gap in the availability of tools. It enables teachers to assess learning aims other than those related to behaviours or knowledge. It also allowed us to explore the different constituents of EC and their underlying relationships which improved our understanding of EC in general. Second, the scores from our assessment tool show a large spread and there is no ceiling effect among the data. Our tool therefore is sensitive enough to discern differences between individual students. Finally, our instrument was aimed at lower secondary students, age 11-15. This specific target group has not yet been selected as main target group for previously developed EC assessment tools. With the development of the Environmental Citizenship Opinions questionnaire, we have filled several gaps in availability of EC assessment tools. In doing so, we hope to contribute to effective teaching for EC in the (science) classroom for lower secondary education and beyond.

Conflict of interest: The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Author contributions: M.v.H., M.C.P.J.K. and W.R.v.J. contributed to study conception, material preparation, and data collection. M.v.H., M.C.P.J.K., J.N.A.B.d.P. and W.R.v.J. contributed to study design, data analysis and the writing process. The first draft of the manuscript was written by M.v.H., M.C.P.J.K., J.N.A.B.d.P. and W.R.v.J. commented on the different versions of the manuscript. All authors read and approved the final manuscript.

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Data availability statement: The anonymised dataset for this study is publicly available at DANS, at https://doi.org/10.17026/dans-xra-buzx.

Appendix 4.1 | Supplementary materials

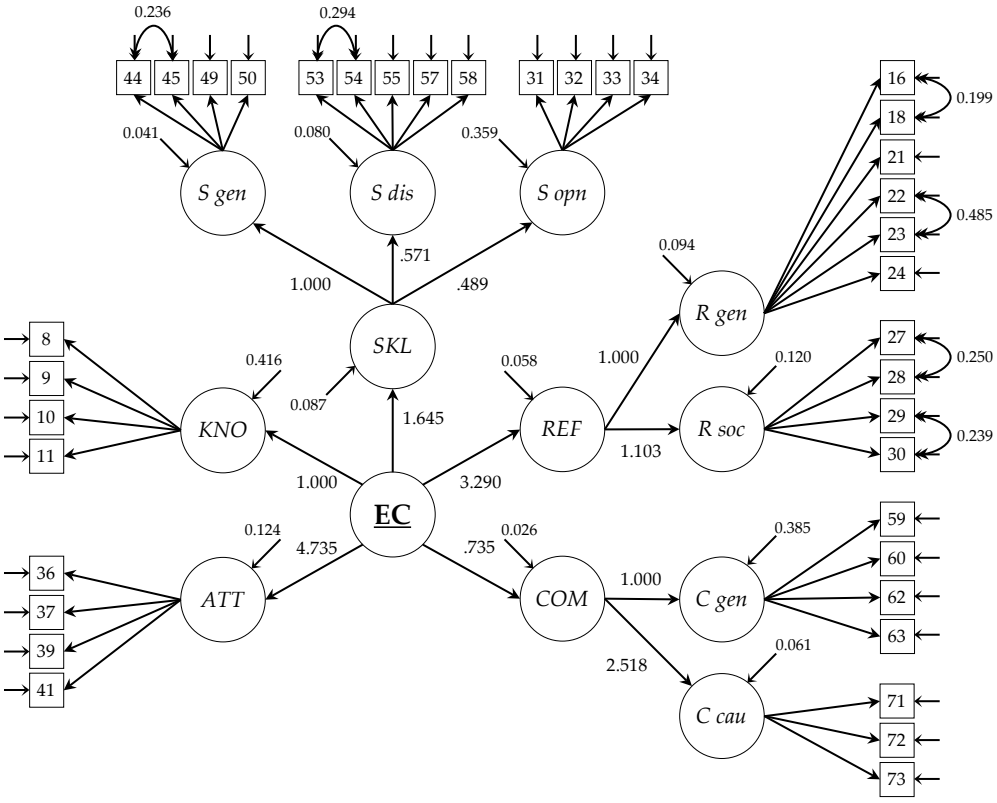


FIGURE S4.1 | The final higher order factor structure of the Environmental Citizenship Opinions (ECO) questionnaire. EC = Environmental Citizenship, KNO = Knowledge, ATT = Attitudes, SKL = Skills, REF = Reflection, COM = Complexity. Subconstructs include general skills (S gen), discussion skills (S dis), opinion skills (S opn), general reflection (R gen), social reflection (R soc), general complexity (C gen), and causes complexity (C cau). Estimates for the structural parameters, residual errors, and error covariances are shown. Measurement errors are provided in Table S4.1.

TABLE S4.1 | Final version of the Environmental Citizenship Opinions (ECO) questionnaire, showing Cronbach's alpha (α) for each (sub)concept, and standardised factor weight, measurement error, mean (M) and standard deviation (SD) for each item. All subscales feature a five-point Likert scale, ranging from 'Strongly disagree' (1) to 'Strongly agree' (5), with the Reflection subscales ranging from 'Never' (1) to 'Very often' (5).

ECO-questionnaire		Factor weight	Measurement error	M	SD
Knowledge (α = 0.61)				3.03	1.03
8	Respect for human rights is part of sustainability.*	0.698	0.463	3.13	0.94
9	Companies that treat their employees badly are unsustainable.*	0.679	0.568	3.12	1.05
10	In a sustainable world, goods and means are distributed fairly across people.*	0.382	0.956	3.19	1.12
11	In a sustainable world, poverty does not exist.*	0.355	0.898	2.67	1.03
Attitudes (α = 0.82)				3.05	1.12
36	I would like to learn how problems related to sustainability originate.	0.791	0.398	2.70	1.07
37	I would like to be involved in finding solutions for environmental problems.	0.800	0.440	2.71	1.23
39	I would like to learn how I can live more sustainably.	0.773	0.410	3.11	1.02
41	People should worry more about protecting the environment.	0.578	0.713	3.68	1.07
Skills (α = 0.79)				3.59	1.00
General skills (α = 0.70)				3.00	0.94
44	When I hear something about sustainability, I know how to find out whether it is true or not.	0.477	0.656	2.67	0.85
45	I can make an estimate whether a source with information about sustainability is trustworthy.	0.481	0.661	2.98	0.86
49	I am able to empathize with opinions about sustainability that are different from my own.	0.661	0.454	3.20	0.81
50	I am able to explain why groups of people have a certain opinion about sustainability.	0.681	0.472	3.15	0.88
Discussion skills (α = 0.73)				3.71	0.93
53	I am able to let someone finish speaking.†	0.413	0.630	3.96	0.76
54	I am able to listen to reasons why others choose something else.†	0.516	0.456	3.98	0.62
55	If I sense that I am wrong, I can admit this.†	0.501	0.701	3.49	0.94
57	In a discussion, I would like to find out where we agree and where we disagree.†	0.672	0.498	3.40	0.91
58	In a discussion, I am prepared to find a solution with which we can both agree.†	0.666	0.463	3.70	0.83
Opinion skills (α = 0.85)				4.03	0.82
31	I am able to defend my opinion if I am truly right.†	0.740	0.326	4.06	0.72
32	I am able to stand my ground for my opinion.†	0.824	0.212	4.05	0.66
33	In a discussion, I am able to explain what my opinion is.†	0.798	0.233	4.03	0.64
34	I am able to explain what my opinion is.	0.696	0.332	3.96	0.64

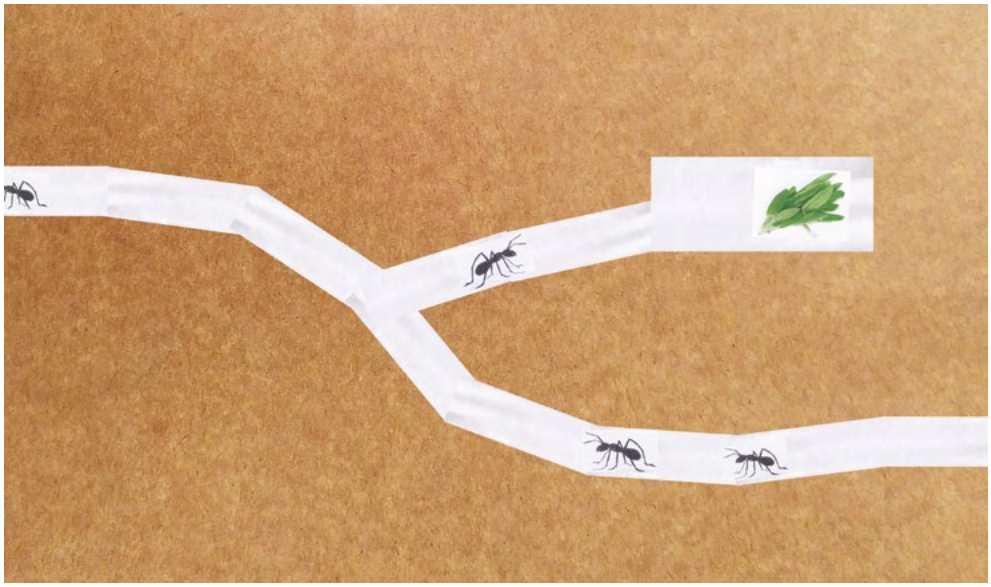
Table S4.1 (continued)

ECO-questionnaire		Factor weight	Measurement error	M	SD
Reflection (α = 0.86)				2.58	1.13
General reflection (α = 0.82)				2.90	1.09
16	How I can ensure that something concerning sustainability changes in the world.†	0.620	0.661	2.61	1.08
18	How I can ensure that something concerning sustainability changes in the Netherlands.†	0.648	0.595	2.49	1.03
21	Environmental issues.	0.752	0.452	3.25	1.04
22	Inequality in the world.	0.531	0.849	3.29	1.18
23	Human rights.	0.524	0.815	3.09	1.12
24	How sustainable my life style is.	0.679	0.567	2.68	1.05
Social reflection (α = 0.82)				2.10	1.02
27	With my friends I ... talk about sustainability.	0.591	0.439	1.62	0.67
28	With my friends I ... talk about our impact on the environment.	0.651	0.471	1.79	0.82
29	At home we ... talk about our impact on the environment.	0.710	0.503	2.49	1.01
30	At home we ... talk about sustainability.	0.689	0.544	2.51	1.04
Complexity (α = 0.64)				3.48	0.88
General complexity (α = 0.64)				3.50	0.89
59	Environmental problems are difficult.	0.707	0.424	3.68	0.85
60	Environmental problems are complex.	0.719	0.359	3.47	0.74
62	Problems related to sustainability do not have an easy solution.	0.379	0.686	3.51	0.80
63	Problems associated with the distribution of food are difficult.	0.429	0.587	3.34	0.72
Causes complexity (α = 0.66)				3.45	0.87
71	Sustainability issues are caused by people being egoistic.	0.615	0.505	3.38	0.81
72	Sustainability issues still exist because people do not want to change.	0.710	0.350	3.55	0.71
73	Sustainability issues still exist because the government does not do enough about them.	0.566	0.507	3.43	0.75

* Item derived from Gericke et al. (2018).
† Item derived from Ten Dam et al. (2011).

5

Sustainability issues in lower secondary science education: a socio-scientific, inquiry-based approach



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Abstract

Environmental Citizenship (EC) has the potential to mitigate current unsustainable processes. However, science teachers experience a lack of suitable teaching approaches for implementing EC in classroom practice, thus preventing students from developing the necessary competences for EC. Socio-Scientific Inquiry-Based Learning (SSIBL) has the potential to promote the key competences necessary for EC. However, SSIBL has not been extensively tested in classroom practice. Therefore, the aim of this study is to explore SSIBL's potential for developing Environmental Citizenship in lower secondary students. In order to reach this aim, a Lesson Study (LS) with six science teachers and three educational researchers was carried out. A lesson module about the mining of elements for smartphones was developed and tested in two classes (average age 14.6). Audio recordings of the lessons, of student interviews, of development and reflection discussions with the teachers, and written educational materials were collected. Results show that the module enables students to appreciate the complexity of the issue by using multiple perspectives. Opinion-forming and decision-making are stimulated too, but students struggle to use findings from their inquiry to develop solutions. Concluding, SSIBL has potential to promote aspects of EC in classroom practice.

Keywords: environmental citizenship, socio-scientific issues, inquiry-based learning, science education

5.1 Introduction

Sustainability issues such as pollution and the energy transition demand a suitable response from society. For this response to be effective, it is instrumental that both collective, organised action and individual, personal actions are taken (Dobson, 2007). These two compounds of Environmental Citizenship (EC) are essential to mitigate adverse effects of current unsustainable processes and for preventing new issues (Dobson, 2007; ENEC, 2018). Sustainability issues are open-ended, difficult to solve, and have personal and global implications. Further increasing their complexity, sustainability issues consist of ecological, economical, and societal aspects. Finally, because of their open-ended nature and since they have repercussions on both scientific and societal fields, they can be typified as Socio-Scientific Issues (SSIs; Kolstø, 2001).

For people to be change agents, transition managers, or problem solvers for sustainability issues, people need a specific set of competences. Wiek et al. (2011) constructed a framework that synthesizes the five most commonly listed competences for sustainability graduates, at university level. These competences are i) Systems thinking competence, across multiple domains such as people, planet, and prosperity; ii) Anticipatory competence, dealing with possibilities, probability, and risk; iii) Normative competence, about justice, fairness, and sustainable targets; iv) Strategic competence, dealing with actions, transition strategies, and solutions; and v) Interpersonal competence, for instance collaboration, leadership, and empathy.

Specific educational approaches need to be employed to develop these kinds of competences. Teaching approaches should offer ample opportunities to engage actively with authentic, real-world problems, in order to help learners in approaching dilemmas from different viewpoints and perspectives and develop higher order thinking skills (Sadler et al., 2016). Socio-Scientific Inquiry-Based Learning (SSIBL) is an educational approach that potentially fulfils these prerequisites (Levinson, 2018). SSIBL combines Socio-Scientific Issues-based education with Inquiry-Based Learning and aims to foster Citizenship through science education. It provides teaching and learning in three phases (Ask, Find out, and Act) during which learners examine authentic dilemmas and explore solution strategies that they subsequently implement. In this way, SSIBL can be used to create opportunities to develop the five key competences necessary for effective EC. Although science teachers see the added value of SSIBL for their teaching repertoire (Knippels & Van Harskamp, 2018), its practical implementation in the classroom and its applicability for sustainability education has not yet been extensively tested.

Science teachers struggle with the social and personal sides of SSIs, for instance with guiding discussions and covering the ethical implications of science, and other normative aspects of EC (Tidemand & Nielsen, 2017; Van Harskamp et al., 2021). These social and personal aspects have been shown to be of equal importance as the scientific content during SSI based education, for together they form a holistic image of sustainability issues (Sinakou et al., 2019). Science teachers experience a lack of competence with regard to citizenship education and therefore

students lack opportunities to intensely think through their own and their peers' feelings and opinions about SSIs (Day & Bryce, 2011). Since SSIBL offers opportunities for students to develop aspects of EC, it could be a valuable tool for science teachers. The aim of this study is to explore SSIBL's potential for developing Environmental Citizenship in lower secondary students.

For this purpose an exploratory Lesson Study (LS) was carried out. During a LS, teachers collaborate with researchers to research educational practice. The current LS could offer illustrative examples of effective education for EC, which are labelled as 'missing' by Sinakou et al. (2019). This chapter first describes the study approach, including a description of the lesson design. After that, the main findings are discussed. Finally, we draw conclusions and discuss implications for research and classroom practice.

5.2 Study approach: lesson study

To look into SSIBL's potential of fostering EC, an exploratory Lesson Study was carried out (Fernandez & Yoshida, 2004). During a LS, teachers and educational researchers collaborate to develop and test teaching strategies, focusing on student learning of specifically selected case students who are observed in classroom practice. The research question for this LS was: What potential does SSIBL have to develop Environmental Citizenship in lower secondary students?

The LS-team consisted of four biology teachers, two chemistry teachers, and three educational researchers. Six design sessions of 2.5 hours each were organised. After these design sessions, one of the teachers taught the lesson module, during which the rest of the LS-team observed specifically selected case students. Case students were selected from the group based on their ability to work independently, since this is an important skill when learning about open-ended issues. In each group, two very independent students (who hardly need any teacher guidance at all), two averagely independent students (who sometimes need teacher guidance, but otherwise are able to work on their own), and two more dependent students (who almost always need teacher guidance, because they struggle with most tasks) were selected. Afterwards, these six case students were interviewed. Experiences of the teacher and of the observers were shared during the post-lesson discussion. This discussion led to some minor adaptations of the module, after which the module was taught by another teacher with a new group of students. After the second post-lesson discussion, findings were discussed in the team.

The teachers who taught the lessons were both members of the Lesson Study team. This means they were involved in codesigning the lesson materials, which gave them a deep understanding of the teaching and learning activities, the decisions made during the design process, and the underlying assumptions and theoretical underpinning. Both teachers were male chemistry teachers, with Teacher 1 being 59 years old with 20 years of teaching experience, and Teacher 2 being 55 years old with 18 years of teaching experience.

Participants

In total, the lesson module contained one lesson of 50 minutes and one lesson of 100 minutes, which were taught to two classes (n=45 students total, one group pre-university level, the other higher general education, F:23, M:21, average age 14.6) of lower secondary students in the Netherlands. Informed consent of parents and guardians was sought before the study.

Data collection and analysis

During the LS, data was collected from several sources (Table 5.1). Design sessions were audio recorded, which enabled us to look back on decisions made during the design process. Audio recordings were made of the lesson and of the case-student interviews after the lesson (see Appendix 5.1: interview scheme for the interview scheme). Student materials were collected after the lessons, including their booklets and their summary schemes of the selected SSI. Observation sheets of the observers were collected and the post-lesson discussions were audio recorded to provide an entry point into the data and to look back on first impressions of the observers. Together, these data sources provide a rich and detailed image of the learning processes of the students during the lesson module.

TABLE 5.1 | Lesson Study phases, collected data sources during those phases, and their analytic purpose.

Lesson Study phases	Data sources	Analysed for
Design sessions (six, 2.5h each)	Audio recordings of design sessions	Choices made during design process
Teaching (two classes, 3 lessons per group)	Student materials (booklets, schemes)	Reaching learning aims
	Observation forms	Key moments during the lessons
	Audio recordings of lessons	Student reasoning
	Post-lesson student interviews	Reaching learning aims
Post-lesson discussions (two, 1.5h each)	Audio recordings of discussions	Reaching learning aims, effectiveness of lesson design, key moments during the lesson

The audio recordings of the design sessions and the post-lesson discussion were analysed for key moments in the decision-making process and for exemplary remarks by teachers and observers. The student summary posters were analysed using the three main dimensions of sustainability, people, planet and prosperity, and their occurrence. Answers in their booklets were categorised by the main researcher and analysed for the sustainability dimensions, the main sustainability competences, and problem context, subject matter information, and mentions of complexity of sustainability issues, since these were learning aims of the module (see Appendix 5.2: coding scheme for coding scheme). Audio recordings of the lesson were analysed for student reasoning, and the student interviews were transcribed verbatim and analysed for the different learning aims.

Lesson design

The LS-team based the design choices for the lesson module on experiences from the teachers and on research. This section discusses the design choices, the sources they were based on, and the resulting lesson module.

First, the central goal for the students was defined. Based on experiences from the teachers, we decided to look into how to support students when meaningfully and thoroughly forming an opinion on sustainability issues. Selection of this central theme led to formulation of the following learning aims for the students:

- The student is able to describe that sustainability issues are complex, multifaceted and open-ended;
- The student is able to form a scientifically and socially funded opinion about sustainability issues.

These learning aims implicitly contain elements of the five key competences. Mapping controversies and realizing complexity requires systems thinking and normative competence. Forming a scientifically and socially funded opinion requires normative competence (desirability of opinion), systems thinking (mapping the issue), anticipatory competence (futureproofing the opinion), and strategic competence (dealing with the action aspect of the opinion). Interpersonal competence is included in the lesson design by the choice for collaborative teaching activities. The lesson module was designed in such a way that it includes activities aimed to foster all of these five key competences for EC.

After discussion with the LS teachers, issues related to the production and use of smartphones was selected as the theme for the module. Based on previous experiences of the teachers, this topic was thought to be closely linked to the students' daily lives, and would be both recognizable and appealing to them. This personal connection is an important requirement when discussing sustainability issues (Blatt, 2014).

SSIBL was selected as the educational approach for the lesson module. SSIBL-based educational materials generally consist of three phases: Ask, Find out, and Act (Levinson, 2018). During the Ask-phase, the SSI is introduced, creating a need-to-know for the students. This way, the lesson prompts students to ask questions about the SSI. They try to find answers to these questions in the Find out-phase, during which students map the controversy, and perform scientific (experiments, measurements) or social sciences (questionnaires, interviews) research. Finally, during the Act-phase, students make decisions based on their inquiry and take action accordingly.

The Ask-phase of the developed lesson module starts with a commercial video of a new smartphone model. To record their primal reaction to the subject, students are asked whether they would buy this model, and why (Table 5.2). The teacher then deconstructs a smartphone, while the students pass around the parts. The LS-team thought this hands-on approach would

elicit a stronger enthusiastic response from the students. Subsequently, the teacher shortly introduces an adapted version of the periodic table, which shows what elements are present in smartphones, their availability, and whether they are mined in conflict areas (European Chemical Society, 2019). Taken together, this introduction is expected to raise questions and provoke an emotional response. First steps towards developing systems thinking, anticipatory, and normative competence are made (Table 5.2). Students individually write down this first reaction, noting what questions they have and what emotions they felt during the intro. Paying explicit attention to emotions and intuitive reactions is pivotal during moral reasoning, since they often show underlying values and form the basis of moral reasoning (Haidt, 2001). Thinking through an SSI individually before discussing it in small groups is desirable too, to ensure safety and stimulate reasoning for each student (Waarlo, 2014).

TABLE 5.2 | Description of the lesson elements of the smartphone lesson, with links to the three SSIBL-phases and the five key-competencies for sustainability (Wiek et al., 2011).

Lesson module element	SSIBL-phase	Key sustainability competences*
1. Smartphone commercial video, followed by smartphone deconstruction	Ask	Sy
2. Introduction on adapted periodic table of elements, showing which elements are present in smartphones, their availability, and which elements are from conflict areas		Sy, A
3. Writing down initial reaction to the dilemma, including questions raised and emotional response		N
4. Group work: each group looks into mining and its effects for one particular smartphone element; finding sources for the inquiry phase, checking their reliability, and listing stakeholders	Find out	N
5. Mapping the controversy: summarizing initial findings about mining, looking into people, planet and prosperity aspects, effects in the Netherlands and elsewhere, and effects now and in the future		Sy, A, N
6. Lesson two: forming new groups with members from all four elements, discussing findings from lesson one		Sy, I
7. Summarizing information from element schemes into a simplified life cycle scheme, with attention for influence of time and possibilities for change		Sy, A, St
8. Starting with individually thinking of the most desirable option for change, then discussing this in the small groups, then formulating one clear statement about the developed strategy	Act	A, N, St, I
9. Arguments in motion activity with the whole class, discussing the different statements, students take a position in the classroom, indicating whether they are for or against, and whether they based this on ratio or gut-feeling		A, N, St, I
10. Evaluation questions and looking back on initial reaction to dilemma, thinking about what has potentially changed		N, St

* Key competence codes: Sy – Systems thinking competence; A – Anticipatory competence; N – Normative competence; St – Strategic competence; I – Interpersonal competence

During the Find out-phase, students work in small groups (Table 5.2). Each group performs inquiry into one of four elements: cobalt, copper, tantalum, and tin. These elements were selected for their diverse environmental, social, and economic impacts, the backgrounds of areas where the raw materials are mined, and the diverse processes of acquiring these elements. The students look up information about the elements, think about the different stakeholders, and summarise their information in an element scheme. This process is guided by questions which are aimed to broaden their scope, for instance making them explicate implications in their surroundings and elsewhere, and on different time scales.

The following teaching and learning activity takes place during the following lesson. Groups are mixed so that each new group at least covers all four elements. Students perform a stripped-down version of a life cycle analysis based on the element schemes from the previous lesson. With constructing these schemes, students have strived to form a holistic overview of the issues associated to mining smartphone elements. Holism in the case of sustainability entails the three different dimensions of people, planet, and prosperity, effects in the past, the present, and the future, and a focus on local, regional, and global effects (Öhman, 2008). Employing a focus on holism during sustainability education can promote student knowingness of the complexity of sustainability issues (Boeve-de Pauw et al., 2015). Additionally, offering opportunities to discuss multiple sides of environmental dilemmas is important for students, since this makes them feel taken seriously (Blatt, 2014). Overall, the Find out-phase aims to make students realize how complex their sustainability issue is through performing inquiry. This combination of inquiry and explicating complexity is one of the main driving forces behind SSI-based reasoning (Sadler et al., 2007). The Find out-phase contains elements of all five key competences for EC (Table 5.2).

The Act-phase of the lesson module started with individual opinion-forming, this time asking students to pinpoint the most desirable option for change in their life cycle schemes (Table 5.2). Students discussed their ideas in small groups, and prepared one single statement about what they as a group would change in the system. These statements were used during the arguments in motion activity (Van Der Zande, 2011). During this activity, students position themselves in the classroom, according to what they think about a statement. One wall represents for, the one facing it represents against. After taking place on this line, the teacher introduces the other axis, with one wall representing their ratio, and the other their intuition. Students move along this axis accordingly, showing their principal motivation behind their choice. Subsequently, the teacher asks students to provide reasons for their position, to take another position in the room and imagine why people would stand there, and other questions that might show empathy and diversity of opinions. Explicitly showing different perspectives is essential for fostering SSI-based reasoning (Sadler et al., 2007).

After the arguments in motion activity, students answered a set of evaluative and reflective questions, referring back to their initial reaction at the start of the first lesson. Would they for

instance buy the smartphone from the commercial of the first lesson after the module? Again, the Act-phase contains links to all five key competences for EC (Table 5.2).

After the first round, some minor adaptations were made to the lesson module. The main difference was that we provided a filled in example of the element scheme for the element gold. This was deemed necessary because students struggled with deciding what to write down, and we expected this example to speed up the process. We also decided to provide the students with information sources a bit earlier than during the first cycle, since this process too took more time than expected or desired. Despite these small changes, the lesson module remained virtually identical during the first and second round of classroom testing.

5.3 Findings

Analysis of the data led to the following findings. They are ordered along the different learning aims of the lesson module: fostering EC in general, raising awareness of the complexity of sustainability issues, and student decision-making.

Fostering EC in general

The module's potential to foster EC was analysed based on different data sources. In the booklet, we asked the students what they had learned and what was new for them during the lesson. The most common answers here fell in the category of the problem context (Figure 5.1). These answers dealt with elements becoming scarce or running out entirely in the near future. Subject matter related answers were popular as well, related for instance to all the elements that are used for smartphone production. The third most common category was a bigger appreciation for how complex the issue was.

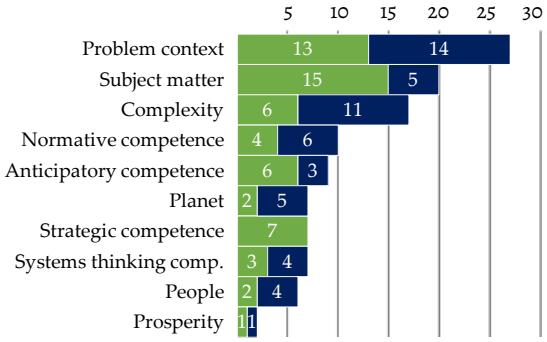

FIGURE 5.1 | Main categories found in written answers from student booklets (n=45), in response to a question asking what they have learnt during the lesson module. Categories represent the general learning outcomes, developments in the five key competences for sustainability, and the three dimensions of sustainable development. Green bars represent group 1, blue bars represent group 2, with numbers in the bars representing the number of students whose answer fell in the corresponding categories.

In their answers, students occasionally mentioned aspects of sustainability competences as learning outcomes. Normative and anticipatory competences were the most common among these. These for instance included students being surprised by the variation of opinions about the issues among their peers, and worries about the future. Strategic competences were only mentioned in the first group, with common comments revolving around recycling their used phones. One student shows signs of anticipatory and strategic competence when they strongly remember "That elements are running out and that people have to find new ways to replace them" (Student 14). Commenting on the strategic competences of the students, during the post-lesson discussion the teacher from group 1 said:

> "What also stands out to me is that they [the students] do go deeper at a certain point, most of them, not all of them, and that they then think through the issue more thoroughly. But when I then look at the statements, I think yeah, I had expected a little more from that. These are the kind of things you could have come up with after fifteen minutes as well. And not after three lessons." (Teacher 1)

According to the teacher, the discussion during the lesson was surprisingly deep for what he expected from his students. According to him, this was one of the key moments. However, this deeper level of insight in the issue did not end up in the statements that the students formulated. It appears students experience difficulty with converting their findings into practical ideas, or, in other words, their strategic competence was still lacking. Examples of systems thinking competence in student answers usually referred to the summaries that they made of the issue, for instance from their element scheme or life cycle analysis. Students did not mention learning anything that could be interpreted as interpersonal competence.

Concerning the three dimensions of sustainability, planet and people aspects were by far the most common in student answers in the booklet (Figure 5.1). Examples of these include effects on the environment, child labour involved in mining operations, and rising CO_2 emissions. Prosperity elements were mentioned only by one student from each group, which shows that these are among the least recognizable for the students.

The post-lesson interviews with the case-students showed many of these same trends. The problem context, about the elements running out, was similarly commented on, as this example illustrates:

> "Well, I have learned more about which elements are used in phones, how you can use your phone sustainably, and how you can improve that, how you can use it more sustainably, and what the government can do about that as well." (Student 2)

This quote also illustrates that some students were able to think about these issues in both private sphere behaviour as well as in public or collective action-taking. These are clear signs of students developing EC competences, where private and collective actions are important. Another student also commented on action-taking after the lesson:

> "I think this is a very relevant subject, because actually nobody knew anything about this before, and what I said, it is very much something that happens now, very relevant, this way we will know for the future, what we can do, of course not exactly how we can do everything, what we can change ourselves, but we do know now what the government can change, and when we are allowed to vote later on, if somebody then has an opinion about this, and then we can see do I agree with that, then you could vote for this person." (Student 45)

Other students specifically referred to different sustainability competences they developed, comparing this lesson with their regular chemistry lessons:

> "Yeah I think that this is a little more important than just stupidly knowing how molecules are formed or something, because this is actually the future, and it has, it concerns the future of the planet, and of course, molecules are also important for the planet, but this is the future and what is happening now […], I did not really think before that this would be covered during chemistry, I know it really has to do with chemistry, but on my own, I did not think it would have that much, impact." (Student 34)

Despite this clear appreciation for discussing EC during science lessons, a sentiment that should not be ignored is the one voiced by this student:

> "It is perhaps something that can be done once every while. Yeah because you hear so much about it all the time, and sometimes I am like, can you for one minute stop whining about how bad everything is for the environment?" (Student 39)

Complexity of sustainability issues

One of the main learning aims of the module was showing students how complex sustainability issues can be. All but one of the observers said during the post-lesson discussions that the module was effective in making their observed students aware of this complexity. Similar to the observers, the student booklets also showed students appreciated the complexity of the issue. As can be seen from Figure 5.1 from the previous section, 17 students mentioned complexity of the issue around the production of smartphones as main learning outcome of the lesson series. Elaborating on this, one student writes:

> "[I have learned] That the problem is way more difficult than you maybe think, because there are more effects caused by smartphone production and there are so many problems in the phone industry to begin with." (Student 27)

The lesson module prompted students to use the three dimensions of sustainability during the Find out-phase. From their element and life cycle schemes it follows that the people perspective is the most prominent, followed by the planet perspective (Table 5.3). Despite it being explicitly asked for in the assignment, the prosperity perspective was used only occasionally, and then

mainly by the second group. Overall, the second group used overwhelmingly more dimensions of sustainability than the first.

TABLE 5.3 | Occurrence of people, planet, and prosperity aspects in student summaries of smartphone production (the element scheme and the life cycle) for group 1 and group 2.

	People	Planet	Prosperity
Element scheme group 1	9	4	4
Life cycle group 1	6	7	0
Element scheme group 2	17	19	13
Life cycle group 2	36	30	16
Total	68	59	33

During the twelve post-lesson interviews (six per group), some students mentioned an increased appreciation for the complexity of the issues around the smartphone as a result of the lesson module. This was mainly caused by students seeing how complex a device such as a smartphone is, as this student describes:

> "I have mainly learnt that phones are way more than I previously thought, that there is way more behind them, and that you can look at them from totally different ways, more than just this is an electronic device." (Student 17)

Sometimes, students perceiving the complexity of the smartphone issue could be inferred from what they thought was important about the lesson module. For instance, this student says:

> "That you could reflect on, that there is a shortage of some elements and that we really are forced to think of a solution or something, otherwise […] we cannot produce anything anymore. And that there are some elements that, when mining for them, this causes extreme environmental damage, and for the people who live there, there is no nice living environment anymore because we want smartphones. […] We need to think about what it is made out of, which elements or something, and if it can be recycled, if it is good for the environment. Yes I think that it is important, that we, we want to keep the world as beautiful as possible for our, for the generation after us, and we have to think about this from our youth onward, that we can do something about this ourselves." (Student 7)

This student also commented on intergenerational effects of our behaviour. One other student mentioned this in their interview.

As can be seen from student 7's quote, students explicitly referred to the three sustainability dimensions of people, planet, and prosperity during the post-lesson interviews. For instance, this student says:

> "Yes, I thought it was pretty informative actually, because I did not know there was so much pollution, and so much child labour also, involved during the production of smartphones, that is pretty interesting." (Student 34)

During the interviews, planet aspects were the most commonly used of the three sustainability dimensions (occurring 12 times), closely followed by people aspects (10 times). Prosperity elements were only used 3 times in all the student interviews, further solidifying the image painted by the student posters and answers to the questions in the booklets that prosperity is the least immediate dimension of sustainability for these students.

Opinion-forming about sustainability issues

Fostering meaningful opinion-forming, ultimately leading to decision-making, was one of the main learning aims of the lesson module. After the lesson, the observers felt that students did not yet make enough progress during this module in developing their meaningful decision-making skills. During the first group's post-lesson discussion, Teacher 1 comments:

> "It occurs to me that they [the students], actually very quickly, I even have to pull the breaks on them, are going head first into drawing conclusions, without going [...] really much deeper into it. They very quickly know, well, polluting, and we are running out, and that is so early on in the process, [...] they are very quickly occupied with conclusions." (Teacher 1)

One moment later, this same teacher said:

> "And then, yeah, the opinion-forming, I think that, yes I have a good feeling about it actually, the difference between answering something individually, and then in a group, and then in the class, the way this was structured, and I think that they did think about it very well, [...] they did think about it, but not about their own impact, it is, they think only about what others should do about it, such as governments." (Teacher 1)

Judging from these quotes, the teacher felt that his students made progress in their decision-making skills, but there was still a way to go before they truly reach this learning aim. The observers and teachers still felt students did make progress during the lesson in developing their opinion-forming and decision-making skills. These developments were mainly due to the arguments in motion activity, one of the clear key moments in the lesson design. The teacher of the second group explains:

> "Well, I think it is amazing to hear that, the arguments in motion, that students think this is useful, and that they enjoy it, that something happens there after all." (Teacher 2)

Other data sources show the importance of this key activity as well. In the booklets, students overwhelmingly pinpointed the arguments in motion activity as the most useful during the lessons (22/45 students), only behind the element and life cycle schemes (23/45 students). During the discussion about the statement 'A maximum yearly tin production is set for each mine', students use different dimensions, as this excerpt illustrates:

> Student 13: "Yeah, there is less pollution because of this."
> […]
> Student 12: "It is better for the people, because they have to work less in the mines."
> […]
> Teacher 2: "Why are you standing here?"
> Student 14: "Because I don't want phones to become more expensive!"
> […]
> Student 16: "If there is less tin available, then it stimulates companies to become better in recycling, so there is more tin available this way and we stimulate reuse."

Answers from the student booklets paint a similar picture. Opinion-forming related learning outcomes were among the most commonly mentioned in the booklets (Normative competence, Figure 5.1). One student writes: "During the statements activity, there were opinions from students that I did not expect" (Student 32). To them, this was the most lasting impression of the module overall.

Looking at student reasoning about the issue, some students paid explicit attention to the three dimensions of sustainable development. For instance, in one of the student interviews, when describing their decision-making process, one student says:

> "With that statement, if we have to start spending a lot of money on waste processing, then you can maybe you can spend that money first on improving the working conditions first, before you start working on recycling and those kinds of things." (Student 39)

This student is using different dimensions of sustainability when forming their opinion, in this case the prosperity and the people dimension. They are thinking strategically about their preferred solution to issues related to smartphone production. Going further, students also reasoned using future generations and their needs, as this quote illustrates:

> "It is also important for our future, because the elements are running out, and how are we going to solve this in a few decades? Our children, our grandchildren will be left behind with this, so how can we solve this, what are the possibilities? What materials will we use then? So yeah, I think this is something to think about, and to come up with new things." (Student 1)

However, some aspects of decision-making remain difficult for students. For instance, during the post-lesson interviews, we asked the students what steps they think they take when forming an opinion. It becomes apparent that most students are not aware of specific steps they take when forming an opinion. The most common answer related to thinking about the question, and forming an initial reaction in their heads. One student describes:

> "I think that you should always first think about what sounds like the most logical, and then you have to think about can you ask the question in another way in your head, because

you will then see if you are for or against different aspects of the issue, because sometimes it sounds very much like you are for or against, but that you of course also think for a while if that is actually the case." (Student 43)

At the start and at the end of the lesson, the student booklet asked what students would do with their old phone when they buy a new model. Twelve out of the 45 students said they would do something else than before the lesson, with most of them responding that they would now recycle their old phones. Doing good for the environment was the only reason given for this change of strategy, still showing a relatively shallow argumentation, discarding all the people and prosperity arguments used during the lesson.

5.4 Discussion and concluding remarks

The lesson module we developed aimed to foster EC by making lower secondary students see the complexity of sustainability issues on the one hand, and by enabling them to make well-funded decisions about issues on the other. SSIBL's phases of Ask, Find out, and Act were used as an educational framework for the module.

Judging from the data, it becomes clear that some of the main competences of sustainability were at least partially developed by the module. Students learned about the problem context and the subject matter, elements becoming scarce and what elements are used in a smartphone. Mainly their normative competence, related to the opinion-forming elements in the module, and their anticipatory competence, dealing with possible future effects of the issue, were stimulated by the module. Students were highly motivated during the lessons, with multiple students wanting to continue even during the break. Some students were still discussing issues on taxes on smartphones during the breaks, entirely without teacher interference. Multiple students mentioned they truly enjoyed discussing real world issues, they felt it was important what they were doing. It seems SSIBL does indeed create moments of genuine enthusiasm in students.

Based on previous studies, the image arises that students strongly focus on the planet dimension of sustainability issues (Benninghaus et al., 2018; Sinakou et al., 2019). Furthermore, the intergenerational view is most commonly found, with students mostly looking into effects on future generations instead of effects on their own generation (Benninghaus et al., 2018; Sinakou et al., 2019). Surprisingly, in our study we found that people aspects were used at least equally as often as planet aspects, with some sources even showing a stronger representation of the people dimension in student answers. In addition, participants in our study more commonly use the intragenerational view as opposed to the intergenerational view. This inclusion of an intragenerational view is a clear sign of EC development (Benninghaus et al., 2018; ENEC, 2018). In contrast, what is in line with previous findings is that in most of our data sources, prosperity aspects were hardly mentioned at all.

An explanation for the shift in student focus might come from the smartphone context, which clearly features examples of child labour and adverse working conditions in our present time. This could have led to an overemphasis of the people dimension, and thus promote an intragenerational view as well. However, mining also causes severe ecological damage, which means that planet aspects were not underrepresented in the context. We do not know why these planet aspects were less impressive to the students, and why the people aspects were overrepresented in their answers.

One of the teachers commented on the fact that many students in our study placed their solutions not on the individual, at home level, but looked towards governments and other large institutions for solutions. This was a common finding across the various data sources and indicates anticipatory and strategic competence development. Contrary to the usual neoliberalist view on individual actions that some researchers describe (Schindel Dimick, 2015), our students show that SSIBL has the potential to enrich their action-taking, with a shift towards more collective or public sphere actions. A focus on both individual and collective action-taking is a strong sign of true EC (Dobson, 2007; ENEC, 2018). SSIBL seems effective in promoting that aspect.

Concerning the learning aims of the module, student appreciation for complexity of sustainability issues was fostered. This required students to develop both normative and systems thinking competence. Time and time again, students showed this both in their written and spoken form. Observers and teachers also felt this learning aim was reached. A difference was noticeable between the first and second group, mainly in the richness of their element and life-cycle schemes. The adaptation between group 1 and group 2 might have added to this, by strengthening ties between the first and second lessons. Additionally, the second group was pre-university level, whereas the first group was higher general education level, which might explain this difference.

The decision-making learning aim was only partially met at best. The arguments in motion activity, and other activities during which the students discussed their opinions and ideas together, were among the highlights of the lesson for many students. The actual decision-making process was less smooth. One of the teachers mentioned that he had to stop students from drawing conclusions immediately, making them consider multiple sides before making decisions. Furthermore, although students did manage to develop a relatively rich overview of the sustainability issues during the Find out-phase, this richness was not found in their strategies towards a more desirable situation. This indicates a lack of strategic competence in the students. Teacher guidance seems pivotal during these processes.

Another point that should be explored further is the decision-making process itself. Students are unaware of the specific steps they take when forming their opinion about sustainability SSIs. Paying explicit attention to these steps might make them realize what is important during opinion-forming and decision-making, perhaps simultaneously enriching their conclusions.

What can be seen from these results is that the phases of Ask, Find out, and Act have potential to foster student appreciation of the complexity of sustainability issues on the one hand, and can provide a starting point to develop their opinion-forming skills on the other. In doing so, SSIBL can support students during development of EC competence at lower secondary level. Student EC most strongly flourished during those phases in the lesson design where they approached the dilemma from multiple different perspectives, during activities where they could formulate their own opinion but also when they had the ability to hear the opinion of their classmates. Following studies should explore SSIBL's EC fostering potential more in-depth.

Taken together, this lesson was a step in developing EC competences through science education. Of course, developing higher order thinking skills takes time (Guérin et al., 2013). It would be too much to expect students to become problem solvers after this three-lesson module alone. Despite this, the steps that the students took in developing the competences needed for solving sustainability issues can still be seen as successful. With this, our study identified an educational approach for teaching EC through science education at lower secondary level.

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Appendix 5.1 | Interview scheme

Interview questions for the individual student interviews after completion of the entire lesson module.

1. What do you think of these lessons? What aspect(s) did you like/dislike?
2. Can you succinctly summarise what you have learnt from these lessons?
3. What are the most important steps you take when you form an opinion about an issue?
4. How do you know if a source of information/something you hear is trustworthy? Is this something you think about?
5. Would you say it is important to discuss these issues during chemistry lessons? Why or why not?
6. We will teach this lesson again with another class at another school. What would you change?

Appendix 5.2 | Coding scheme

What have you learnt during the module?	
Problem context	Elements running out, resources, aspects of the problem situation
Subject matter	Subject-related, for instance elements that are used in smartphones
Complexity	Student mentions complexity of issue, of phones, difficulty of situation
Normative competence	Desirability, ethics, opinions of other students, statements
Anticipatory competence	Mentions effects on the future, future generations
Planet	Refers to environment, ecology, animals, deforestation, pollution
Strategic competence	Referring to solutions, strategies, aspects of plans or ideas
System thinking competence	Mentions element and life cycle schemes or related topics
People	Refers to people, working conditions, social security, health
Prosperity	Refers to economic aspects, wages, child labour

6

Socio-scientific inquiry-based learning for environmental citizenship

Abstract

We have looked into Socio-Scientific Inquiry-Based Learning (SSIBL) and its potential to foster Environmental Citizenship (EC) through science education at lower secondary level. This approach can support science teachers in orienting their educational practice towards EC competences such as opinion-forming, decision-making and action-taking regarding sustainability issues. To do so, we carried out several cycles of Lesson Study (LS). The LS-team of four science teachers and three science education researchers collectively developed, tested, observed, redesigned, and reimplemented five lessons, based on SSIBL's phases of Ask, Find out, and Act. Data was collected from two classes of different schools, with sources including audio recordings of student group discussions, post-lesson interviews with students, and collected student booklets. SSIBL was successful in fostering EC competences such as systems thinking, normative competences, skills related to the students' own opinion-forming, Socio-Scientific Reasoning aspects, and developing student action knowledge and action skills. Challenges remain with fostering student action competence aspects such as positive outcome expectancy and willingness to act, although data sources show conflicting evidence on this regard. Overall, SSIBL has been identified as a suitable approach for implementing EC in science education at lower secondary level.

Keywords: environmental citizenship, action-orientation, lesson study

6.1 Introduction

Decision-making on sustainability issues and taking appropriate action is high on the agenda of educational institutions across the globe. For instance, the EU recently published their GreenComp framework, focussing on Green Competences that are essential for taking responsible action on sustainability issues (Bianchi et al., 2022). Similarly, the UN adopted the Education for Sustainable Development (ESD) Goals in 2017, incorporating action-taking as a primary outcome (UNESCO, 2017). These examples illustrate that action-taking is among the most prominent learning aims for ESD. This focus on competences that facilitate action-taking regarding sustainability issues on an individual and in a collective manner, while taking into account local, national and global situations, underscores the importance of Environmental Citizenship (EC) for science education (ENEC, 2018). Many national science curricula feature (aspects of) EC (A. C. Hadjichambis et al., 2019).

Despite this widespread attention for EC on educational agendas worldwide, science teachers experience difficulty with teaching EC (Borg et al., 2012; Taylor et al., 2019; Tidemand & Nielsen, 2017; Van Harskamp et al., 2021). Sustainability issues share characteristics with Socio-Scientific Issues (SSIs). They are open-ended, controversial, concern multiple stakeholders, and have societal and scientific implications (Ratcliffe & Grace, 2003). This controversial nature of SSIs places emphasis on skills such as opinion-forming and perspective-taking, which science teachers experience as challenging to incorporate in their teaching (Oulton et al., 2004; Van Harskamp et al., 2021; Yacoubian, 2018). Furthermore, because of these characteristics, education for EC requires a holistic and pluralistic educational approach (Boeve-de Pauw et al., 2015). Holism entails considering multiple dimensions of sustainability issues, including ecological, social, economic, temporal, and spatial aspects (Öhman, 2008). Pluralism, on the other hand, acknowledges the importance of using diverse perspectives, of norms and values, and of other normative considerations (Öhman, 2008). When these conditions are met, it is more likely that education for EC can be effective (Boeve-de Pauw et al., 2015), yet science teachers experience challenges with implementing holism and pluralism in their teaching (Boeve-de Pauw et al., 2022).

One teaching approach that features a focus on taking action and that adopts a holistic and pluralistic approach is Socio-Scientific Inquiry-Based Learning (SSIBL). The goal of SSIBL is fostering citizenship through science education by stimulating students to interact with SSIs in an inquiry-based manner (Ariza, Christodoulou, et al., 2021). SSIBL thus combines SSI and Inquiry-Based Learning in an integrated whole, and does so across three interconnected phases. It promotes students to ask personally relevant, authentic questions during the Ask-phase. Students then perform inquiry to these questions during the Find out-phase, through both natural- and social scientific means. During the Act-phase, students develop an action strategy and take action based on their findings.

SSIBL has many characteristics that make it suitable for fostering EC through science education (Ariza, Christodoulou, et al., 2021; van Harskamp et al., 2022). It is founded on the pluralistic teaching tradition, which states that for sustainable decision-making, we need to draw on insights from science, from ethics, personal values, politics, the arts and humanities (Ariza, Christodoulou, et al., 2021). Pluralism deals with reflecting on different ways of action instead of teaching about the correct way of action, principally because this predefined right answer does not exist (Boeve-de Pauw et al., 2015). SSIBL offers students the opportunity to view sustainability issues from multiple perspectives, a well-documented prerequisite of effective ESD (e.g., Boeve-de Pauw et al., 2015). SSIBL furthermore urges students to put into words their own views and ideas about the issue and discuss these with their peers, to map the complexity of the issue, and to collectively explore alternatives and their desirability (van Harskamp et al., 2022).

Since EC competences are complex and benefit from practice over longer periods of time, it is desirable to investigate an extended SSIBL-based lesson module for its potential to foster EC competences through science education (van Harskamp et al., 2022). Furthermore, since an adolescent dip of sustainability competences has been found, with lower levels for 15-16 year olds being reported than their younger and older peers (Olsson & Gericke, 2016), it is desirable to study EC development for this age group. The research question for this study therefore is: what is the educational potential of an extended SSIBL-based science lesson series on lower secondary student EC development? The following section explores the relationships between SSIBL's three main phases and their connection to important aspects of EC, which will feature as our analytical framework for this study.

SSIBL for EC: the Ask-phase

The aim of the Ask-phase in SSIBL is to create a need to know in students (Knippels & Van Harskamp, 2018). The initial reaction to being confronted with an issue raises authentic questions about scientific content, affective aspects, and normative considerations. Questions in action-oriented ESD should take into account four dimensions to ensure broad coverage of the issue and to refrain from overfocussing on despair and hopelessness (Jensen, 2002). First, they need to be oriented towards causes of the issue. Second, effects of the issue are relevant. Third, questions need to be raised that concern sustainability visions, exploring where we want to go. Finally, they concern change strategies, dealing with the way we reach this desired future. Taken together, these four question dimensions offer a rich overview of sustainability issues.

In a review study, five sustainability competences have been identified as being instrumental for an individual to make meaningful and informed decisions regarding sustainability issues (Wiek et al., 2011). These are systems thinking competence, which concerns mapping the issue and its different components; anticipatory competence, which deals with possible future scenarios and alternatives; normative competence, concerning desirability of current

and future situations and allowing for multiple perspectives; strategic competence, involving possible ways to take action and to reach desirable futures; and interpersonal competence, dealing with working together, consensus and empathy. Questions during SSIBL's Ask-phase can thus be related to the system overall and how the issue works; to potential, desirable, or undesirable futures; to norms, values, and desirability of current and future situations; to strategies for change; and to ways of collaboration.

SSIBL for EC: the Find out-phase

During the Find out-phase of SSIBL, students map the issue through doing research, for instance with experiments, interviews, and surveys (Knippels & Van Harskamp, 2018). The aim of this phase is providing an overview of the issue. This aim closely resembles Sadler et al.'s (2007) Socio-Scientific Reasoning. For this, students need to i) look from multiple perspectives, ii) use critical thinking, iii) appreciate the issue's complexity, and iv) appreciate that issues are open-ended and subject to ongoing inquiry. These four dimensions of Socio-Scientific Inquiry are instrumental during SSIBL-lessons that aim to foster EC.

In the competence framework of Wiek et al. (2011), SSIBL's Find out-phase most strongly overlaps with Systems thinking competence. This competence deals with relations between variables, loops and feedback in systems, scale, cascading effects, and a diversity of stakeholders. Systems thinking competence allows for thorough mapping of the problem, which is an important aspect of SSIBL's Find out-phase.

SSIBL for EC: the Act-phase

The aim of the Act-phase of a SSIBL-activity is developing an action strategy and carrying out appropriate action informed by the Find out-phase (Knippels & Van Harskamp, 2018). Action-taking as a goal of ESD has been extensively mapped and researched. Influential recent work on this was done by Sass et al. (2020), who redefined action competence for sustainability. According to their work, an action competent individual: i) has knowledge about the issue and about action possibilities; ii) has skills such as critical reflection and a positive stance to action possibilities; iii) has willingness insofar as a commitment and passion to contribute to action; iv) has confidence in their own influencing possibilities; and v) has confidence in their own skills and capacities for change. These five aspects of action competence are central in SSIBL's Act-phase.

SSIBL's Act-phase furthermore links to Wiek et al.'s (2011) Strategic competence. This competence deals with developing an action plan and taking action, through concepts such as barriers and carriers of action, feasibility and intentions of strategies, alliances with diverse stakeholders, and societal norm changes. During a SSIBL-lesson, students need to consider these aspects for their strategies to be effective.

EC development of SSIBL-lessons can therefore be linked to Jensen's (2002) dimensions of action-oriented knowledge, Sadler et al.'s (2007) Socio-Scientific Reasoning, Sass et al.'s (2020) Action competence and Wiek et al.'s (2011) key sustainability competences. This theoretical framework is summarised in Table 6.1.

TABLE 6.1 | The SSIBL-phases of Ask, Find out, and Act, in combination with associated theoretical context relating to Environmental Citizenship.

SSIBL phase	Theoretical context	
Ask	Action-oriented knowledge (Jensen, 2002)	Causes, effects, visions, change strategies
	Key sustainability competences (Wiek et al., 2011)	Systems thinking competence, anticipatory competence, normative competence, strategic competence, interpersonal competence
Find out	Socio-Scientific Reasoning (Sadler et al., 2007)	Multiple perspectives, critical thinking, appreciating complexity, ongoing inquiry
	Systems thinking competence (Wiek et al., 2011)	Relations, loops, scale, cascading effects, stakeholders
Act	Action competence (Sass et al., 2020)	Knowledge, skills, willingness, outcome expectancy, efficacy expectancy
	Strategic competence (Wiek et al., 2011)	Barriers, carriers, effectivity, intentions, alliances, side effects, norm changes

6.2 Method

We set out to explore SSIBL's potential to foster Environmental Citizenship competences through lower secondary science education. To do so, we performed the following study.

6

Study outline and lesson design

To answer the research question, we performed three interconnected cycles of Lesson Study (LS; Goei et al., 2021). In each LS-cycle, the LS-team, consisting of four teachers and two researchers, designs a research lesson, tests this lesson while observing case-students, redesigns the lesson based on insights from the first test run, and subsequently tests the lesson in another class, again while observing case-students.

The LS-team spent 12 sessions during the 2021-2022 school year on lesson design. Three of these lasted 2.5 hours and were in a face-to-face setting, the other 9 took place online and lasted an hour each. The decision was made to design one Ask-Lesson on the fashion industry, one Act-Lesson on collecting smartphones for recycling, and a Lesson Series featuring all SSIBL-stages related to food in the school canteen. This way, the students would spend more time to practice individual sustainability competences, which was one of the main conclusions from a previous LS-cycle by the same team (van Harskamp et al., 2022).

Lesson 1 focussed on asking questions about sustainability issues in the fashion industry. Students selected a clothing item and discussed in small groups whether this item was OK. Three video intermezzos were shown during the discussion phase to introduce a broader scope of stakeholders (e.g., factory workers, fashion companies, vegan leather engineers). Students then formulated a statement about what they wanted to change in the fashion industry, which they then collectively explored in the arguments in motion activity. During this activity, the classroom is divided in for and against on two opposing walls, and with rational and emotional on the other two walls. Students walk through the classroom, representing their opinion regarding statements and what they based their position on. The lesson ended with individually answering reflective questions from the lesson booklet.

Lesson 2 concerned action-taking, by asking students to set up a strategy for collecting unused smartphones for recycling. The lesson started with a short discussion about an infographic explaining the main details of the problem. Students worked in groups and had to pay attention to how they planned to collect phones, how they could pursue people to participate, and what they would do with the collected phones. They pitched their ideas to the other groups. They then had the opportunity to voice interest in actually carrying out a plan based on the pitches, after which they individually answered reflective questions in the lesson booklet.

Lessons 3, 4, and 5 were about making food from the school canteen more sustainable, with students going through all three phases of the SSIBL-approach. Students first practiced with systems thinking by analysing a recognisable issue: the COVID-19 pandemic. They created a system of variables, indicating whether there were 'same' or 'opposite' relations between them. Relation circles in their schemes were categorised as 'balancing' or 'reinforcing'. After practicing with systems thinking, they applied the approach to issues related to a Dutch school canteen staple, a '*broodje gezond*' (a so-called 'healthy sandwich' with ham, cheese, tomato, egg, and cucumber). After mapping their system, students developed plans to turn reinforcing loops into balancing loops, which they transformed into a statement. Opinions regarding these statements were explored during arguments in motion. The lesson ended with each group coming up with a pitch for a new sandwich, which they shared with the group and visiting canteen personnel. Students answered a set of reflective questions individually.

Participants

The lessons were taught to two classes from two schools from the Utrecht area in the Netherlands (Table 6.2). They were selected from Utrecht University's secondary education network. The two teachers who taught the lessons had previous experience with LS, since they participated in a four-year LS project together with staff from the university. 36 of the participating students said they had prior experience with sustainability in a school context, whereas two said they did not. The other 10 were uncertain about this. Perceived prior experience with sustainability was spread equally among the two classes. Since this study concerned underage students, informed consent of parents or guardians was collected beforehand.

TABLE 6.2 | Background data of the study participants, including gender, age, and, for the teachers, teaching experience.

	Class 1	Class 2
Gender	Female 7 Other/I'd rather not say - Male 18	Female 11 Other/I'd rather not say 2 Male 13
Age (average)	13.2	14.3
Teacher	Male, age 62, teaching experience 23 years	Male, age 58, teaching experience 21 years

Data collection

Data was collection during Spring 2022. Audio recordings of groups of students (4 or 5 per group) form the main data source of this study (six for each lesson of class 1, 5 for each lesson of class 2). They are complemented with individual post-lesson student interviews, which were performed by the lesson observers (six for each lesson of class 1 and the first lesson of class 2, 5 for the other lessons of class 2). These observers observed groups of students during the lesson, paying attention to their learning process. These interviews were semi-structured (for the interview schemes, see Appendix 6.1: interview schemes) and audio recorded. They provide further information for how successful the lessons were in fostering EC. The student booklets contained open-ended and close-ended reflective questions which provide information on progress made on specific aspects of EC (25 for all lessons of class 1 and the second lesson of class 2, 23 for the other lessons of class 2).

In addition to these data, we conducted a pre-post-test for the first class by means of the ECO-questionnaire, a validated 5-point Likert-scale questionnaire on EC competences (Van Harskamp et al., 2023). It was applied before the first lesson and again after fully completing the five lessons. Due to unforeseen circumstances this questionnaire could not be completed by the second class. Comparison of the pre-post-test answers can lead to insight in EC development of the first class.

Data analysis

The recordings of the student group discussions were annotated in NVivo (version 1.7), after which annotated sections were transcribed for analysis in Microsoft Excel (Office 2019, version 2304). Open coding was used to quantify development of EC of the participants. For the Ask-Lesson, these related to the questions students asked, which were categorised by Jensen's (2002) four domains, complemented with the categories truthfulness and background knowledge, and by which of Wiek et al.'s (2011) five sustainability competences they corresponded (see Appendix 6.2: coding schemes). The group discussions of the Act-Lesson were analysed for their action competence elements as defined by Sass et al. (2020) and elements of Wiek et al.'s (2011) Strategic competence for the Knowledge and Skills aspects (see Appendix 6.2: coding

schemes). Analysis of the lesson series' group discussion recordings, which had students move through Ask, Find out, and Act, focussed on the same aspects as used in the separate Ask and Act-Lesson, with the addition of Socio-Scientific Reasoning (Sadler et al., 2007) and Systems thinking competence (Wiek et al., 2011) in the Find out-section (see Appendix 6.2: coding schemes). An independent researcher individually coded 4/11 of the audio recordings of the student group discussions for each lesson. After discussion, 100% agreement was reached between the authors and the second coder.

The student interviews were transcribed verbatim, omitting vocalised pauses. Open coding was used to analyse the transcripts for gaining further insight in development of EC competences targeted by the different lessons as a means of triangulation. For the Ask-Lesson, the questions that students asked during the interview were coded using the same coding scheme as the group discussion. For the Act-Lesson, the interviews were analysed for signs of Action competence (Sass et al., 2020). For the lesson series, students were asked what they had learnt during the systems thinking activity. Open coding was used to analyse this question.

The collected student booklets provide an overview of learning processes in the entire class, since these were available from all students. For Lesson 1 they were analysed for the type of questions that were raised using the same coding scheme as for the group discussions. For Lesson 2 analysis focussed on whether students felt it was important to think about making the world more sustainable, which shows willingness and commitment to act, again using the coding scheme from the group discussions. For Lesson 3, booklets asked students whether they felt they developed their assessment skills of the sustainability of processes and products. Open coding was used to analyse this question.

The questionnaire data for class 1 was used to visualise general learning outcomes after the LS-cycles. A comparison of the scores from the questionnaire was made between the pre- and the post-test by a two-tailed t-test. Developments in EC and its different subconstructs could therefore be made explicit, triangulating the qualitative data sources.

6.3 Results

Lesson 1: Ask – the fashion industry

The first lesson concerned students discussing the fashion industry. Jensen's (2002) four areas of action-oriented knowledge, with the addition of two new categories, were used to categorize questions that students asked during group discussions (Table 6.3). The questions were then coupled to a subsequent coding of Wiek et al.'s (2011) five key sustainability competences.

TABLE 6.3 | Number of questions asked by students (two classes combined, n=51) during the group discussions (11 small groups) during the lesson on the Fashion industry, categorised by Jensen's (2002) environmental action-oriented knowledge and the additional categories of truthfulness and background knowledge, and coupled to Wiek et al.'s (2011) key sustainability competences. Size of the circles corresponds one on one with frequency.

	Causes	Effects	Visions	Strategies	Truthfulness	Background knowledge
Systems thinking competence	14	5	2	1	3	3
Anticipatory competence			2	3		
Normative competence	2	3	18			
Strategic competence	9		2	8		
Interpersonal competence			5			1

An average of 7 questions was asked per small group during the lesson. Questions about Causes connected most strongly to either Systems thinking competence (e.g., "What even is the problem, people haven't worn these clothes right?", c2g2) or to Strategic competence (e.g., "Why wouldn't they sell it again?", c1g3). Students most often wondered about causes of the current situation and about persistence of unsustainable processes in the fashion industry.

Vision questions were most often connected to Normative competence (e.g., "But is that even OK, that they throw it away like that?, c1g2). These questions concerned desirability of current practices, and, on a more meta level, what qualifies as acceptable clothing. Occasionally, these questions related to Interpersonal competence, which then mainly concerned ensuring everyone was heard (e.g., "Do you have an opinion about this?", c2g1).

Seven questions could not be placed in Jensen's (2002) dimensions. These relate to background knowledge of the issue that is neither causes nor effects related (for instance "Is that [brand name] manufactured in Bangladesh?", c1g2), and to truthfulness of information students discussed (e.g., "How do you know this?", c2g5).

The student interviews also show a diversity of questions which were raised during the lesson. The combination of Causes and Strategic competence was most prevalent here (e.g., "Well, with the silk, and making that with spiders, why is that not yet being used a lot?", c2sB3). Strategic

competence and Strategies was a common combination as well (e.g., "Does the brand get all the money, or should it be used to make things more sustainable?", c1sA1). Questions also often combined Effects and Systems thinking competence (e.g., "If I buy something from far away it's cheap, but aren't there extra costs for transport, making it more expensive again?", c2sB*4). Students did not ask questions related to the Visions category or to Normative or Interpersonal competence during the interviews.

At the end of the lesson, the student booklets prompted students to write down remain questions about this issue. 28/48 students wrote down a question. System thinking competence questions were by far the most common, with 20 questions falling in this category. They most often connected to Causes (e.g., "Why are returned clothes being burnt?", c2s42), and Effects (e.g., "What kind of clothing is the most harmful?", c1s23). Seven students asked Strategic questions, often relating to Strategies (e.g., "Does it help the industry in Bangladesh/Asia to make prices higher?", c1s18). Background knowledge questions were also asked, most commonly related to System thinking competence (e.g., "How much clothing is being produced outside of Asia?", c2s38).

Lesson 2: Act – collecting smartphones

The second lesson had students design a strategy for collecting unused (smart)phones for recycling. Group discussions and written answers were analysed for signs of EC Action competence development as defined by Sass et al. (2020) in connection to Wiek et al.'s (2011) Strategic competence.

During the student group discussions, the Action competence aspects Skills and Knowledge were by far the most common themes (Table 6.4). Critical thinking was the most numerous Action Skill during the group discussions, with a typical example being "OK, but do you know that for certain? That they are worth one to three euro?" (c1g3). Critical thinking mainly occurred when students collaboratively refined action plans. Students often showed the ability to think of alternatives (31) for the current situation. Carriers (53) was the most common Wiek et al. (2011) aspect associated with Action competence Skills, with Barriers, Alliances, and Feasibility being less common.

Background problem knowledge that was relevant for student action strategies was the most common Action Knowledge aspect (22). One student for instance explains: "That isn't realistic. You do not buy a small old phone for a hundred euro. They will not give you twenty euro, the components aren't worth that much" (c2g1). Knowledge about action strategies was also common (19), with students often drawing parallels between possible action strategies and examples from daily life, as this example illustrates: "Every supermarket has these bins to collect batteries, maybe we should make a centralised collection point at each supermarket or something" (c2g4). The most common aspects of Strategic competence as defined by Wiek et al. (2011) that were present in the Skills-related student discussions were carriers (16), barriers

(14), alliances (7), and intentions (6).

TABLE 6.4 | Action Competence (Sass et al., 2020) and Strategic Competence (Wiek et al., 2011) aspects found in student discussions during the lesson on smartphone recycling.

Action competence aspects		Strategic competence aspects
Knowledge	22 Problem knowledge	16 Carriers
	19 Action strategies	14 Barriers
	6 Norms and values	7 Alliances
		6 Intentions
		1 Norm change
Skills	33 Critical thinking	53 Carriers
	31 Ability to think of alternatives	31 Barriers
	17 Positive stance to alternatives	11 Alliances
	8 Negative stance to alternatives	8 Feasibility
		6 Intentions
		2 Norm change
Willingness	7 Low	
	3 Conditional	
	2 High	
Confidence:	14 Positive	
Outcome expectancy	12 Negative	
	5 Conditions	
Confidence:	4 Positive	
Efficacy expectations	2 Negative	

Confidence in Outcome Expectancy was the third most discussed aspect of Action Competence. Students were about equally positive (14) and negative (12) about their expected outcome of their strategies. Five times a condition was placed on their expectations of how well their plans would work in practice. A common theme here concerned the necessity of a reward for handing in phones, with people not cooperating otherwise. The Action Competence elements Willingness and Efficacy Expectations were much less commonly discussed during this lesson. They were discussed occasionally, with students most often displaying low willingness.

Interviews show that the knowledge component of Action competence is multifaceted for these students. Knowledge was one of the most common learning outcomes which students experienced (12), for instance related to knowing the problem existed, its scale, and what possibilities for change there were. Some students felt they needed more knowledge about the issue to enhance their plans (2). Another aspect that was mentioned by students in the interview was their confidence in their own influencing possibilities (3), or Confidence in Outcome expectancy. This for instance relates to getting companies on board for their strategies (supermarkets, big tech), which students deemed difficult. Efficacy expectations were mentioned less, but when they were, students thought they were unable to make a difference (4). One student explains:

> "I think nothing will happen with this anyway. The ideas were good, and good promotion is made for our generation, that our generation is also busy with this instead of adults, because now I have the idea it usually are the adults who organise things, and that we will listen to them, because I learn from that. But I do not know whether for once the adults will learn from me." (c1sA2)

Skills that were mentioned in the interviews mainly related to combining ideas into one plan through group discussion. Uniting the plans of the different groups was seen as less of a challenge (11). Willingness was usually positive (6). Students wanted to change the current situation, thinking the issue is important. They wanted to improve the world or show that their generation was thinking about these kinds of issues, too.

In the student booklet, which was filled in by 50 students, we asked whether the students agreed with the statement 'I think it is important to think about how we can make the world more sustainable' on a 5-point Likert scale. The mean Likert score from the student answers was 3.62, showing general agreement. Students had to write down the reason for their score in an open question format. Reasons include a general sense of this being important (6), which shows Willingness. Knowledge is another common reason, for instance relating to ensuring own quality of life (8), for students think we are currently destroying the world (6). A negative Confidence related to Outcome expectancy (5) and Efficacy expectancy (2) was also common, with answers such as "Because I think it is important that it changes, but I also find it difficult to contribute to that" (c1s13) or "Although I think it is important that young people are informed about possible consequences, I think this explanation needs to be given to people who actually have influence" (c2s49). The lowest rating is a 2, which was given by one student. He says he thinks it is unimportant because "There are people who do want this and are able to do this" (c1s4). The highest rating, a 5, was also given by one student, who said "We are slowly destroying the Earth, which has to stop" (c2s33).

Lessons 3, 4, & 5: Ask, Find out, Act – the school canteen

The lesson series had students go through all three SSIBL-phases as they explored the sustainability of a common sandwich found in all school canteens in the Netherlands. Students asked questions throughout the entire lesson series, with Systems thinking competence questions being by far the most numerous (Table 6.5). Most of these related to Causes of the issue (25, e.g., "Is there something else that causes methane?", c2g3), followed by Effects (18). Many of these questions were related to the system building exercise that was the central activity of the first part of the lesson series, for instance when seeking the nature of relationships between variables:

> Student 1: "That is an S [from Same, a relationship between variables], right?"
>
> Student 2: "An S, yes, and the number of greenhouses also affects the amount of CO_2

emissions, so that is an S too" (c1g3).

The combination of Strategic competence and Jensen's (2002) Strategies also occurred often (13, e.g., "You say cucumbers need to be transported sustainably, how should they go and organise that?", c1g3).

TABLE 6.5 | Number of questions asked by students (two classes combined, n=51) during the group discussions (11 small groups) during the lesson series on the school canteen, categorised by Jensen's (2002) environmental action-oriented knowledge and the additional categories of truthfulness and background knowledge, and coupled to Wiek et al.'s (2011) key sustainability competences. Size of the circles corresponds one on one with frequency.

	Causes	Effects	Visions	Strategies	Truthfulness	Background knowledge
Systems thinking competence	25	18			5	41
Anticipatory competence						
Normative competence	1	1	5			
Strategic competence	2	2	1	13		
Interpersonal competence	1	3			2	1

A further 41 questions were asked about background information that was not related to Jensen's (2002) action-oriented knowledge, but did contain Systems thinking competence elements. A typical example is: "Well, does it come from abroad or not, cheese?" (c1g6). A less common category was students questioning the truthfulness of statements made by peers or information they read (5, e.g., "Yes, but who knows if that is true?", c1g2).

During the section of the lesson series that focussed on the Find out-phase of SSIBL, Perspectives was the most common aspect of Socio-Scientific Reasoning (Sadler et al., 2007) in the group discussions (42, Table 6.6). A typical example would be "Cows only produce milk when they are pregnant, or if they have just gotten a calf" (c2g3), showing reasoning from the perspective of cows in the dairy industry. Critical thinking (30, e.g., "No, we have just seen one video, that doesn't mean that it is like that in all of Italy!", c2g3) was also commonly present in their discussions. Complexity (20) and uncertainty about information (17) were less common but still occasionally discussed aspect of SSR.

TABLE 6.6 | Number of times students used aspects of Socio-Scientific Reasoning (Sadler et al., 2007) and aspects of Systems thinking competence (Wiek et al., 2011) during the lesson series on the school canteen.

	Socio-Scientific Reasoning aspects	**Systems thinking competence aspects**
Group discussions	42 Perspectives	145 Relations
	30 Critical thinking	35 Stakeholders
	20 Complexity	29 Loops
	17 Uncertainty	25 Cascading effects
		23 Scale
Arguments in motion	4 Complexity	9 Relations
	3 Perspectives	4 Stakeholders
	3 Critical thinking	1 Loops
	3 Uncertainty	1 Scale
		1 Cascading effects

Concerning Systems thinking competence components, Relations (145) were by far the most common. These concern the effect one variable has on the other, for instance: "The higher the wages, the lower the profit, so yeah then it is Opposite" (c1g6). Other common aspects of Systems thinking competence were Stakeholders (35, e.g., "A farmer only makes 3% profit on tomatoes", c1g3), Loops (29, e.g., "Price of a product is more profit, is a higher salary, we have a second causal loop", c2g4), Cascading effects (25, e.g., "Look, synthetic fertilizer goes back to animal feed, and that goes back to pigs, and more pigs is more manure", c2g2), and Scale (23), which was related to regional and global processes. Both Loops and Cascading effects show deepened understanding of the complexity of systems, since they go beyond one on one relationships.

During the group discussions of the Act-phase of the lesson module, Knowledge about the problem was the most commonly discussed Action competence aspect (49, Table 6.7). Knowledge about action strategies was also regularly discussed (28): "Yeah but I think, why would supermarkets not just, go with the seasons you know, why would the grapes come from Mexico?" (c1g3). Concerning Strategic competence aspects, Intentions was the most commonly discussed (31) during the lesson series, with Barriers (18) and Carriers (9) being less regular.

The next most common aspect of Action competence (Sass et al., 2020) that students discussed in their small groups was Skills, with the ability to think of alternatives being fairly common (16, e.g.: "Greenhouses should use electric energy from water!", c1g6). Critical thinking was also present during these group discussions (10, e.g., Student 1: "We should use more natural fertilizer instead of synthetic fertilizer", Student 2: "But is natural fertilizer better?", c1g2). Barriers (9) and Carriers (7) were the most common Strategic competence aspects related to Action competence Skills.

Students did not show much Confidence, either in their Outcome expectancy (1 positive versus 6 negative) or regarding Efficacy expectations (1 positive versus 2 negative). Willingness to commit to action was also low (2), with no positive signs shown.

TABLE 6.7 | Action Competence (Sass et al., 2020) and Strategic Competence (Wiek et al., 2011) aspects found in student discussions during the lesson series on the school canteen.

Action competence aspects		**Strategic competence aspects**
Knowledge	49 Problem knowledge	31 Intentions
	28 Action strategies	18 Barriers
	7 Norms and values	9 Carriers
		1 Alliance
Skills	16 Ability to think of alternatives	9 Barriers
	10 Critical thinking	7 Carriers
	2 Positive stance to alternatives	2 Feasibility
	1 Negative stance to alternatives	1 Intentions
		1 Norm change
Willingness	2 Low	
	0 Conditional	
	0 High	
Confidence:	6 Negative	
Outcome expectancy	1 Positive	
Confidence:	2 Negative	
Efficacy expectations	1 Positive	

During the student interviews, we asked about learning outcomes and what students thought about the systems thinking exercise. Students most often mention general information about sustainability and what it entails (5), general problem knowledge (4), and the skill of systems thinking (4) as main learning outcomes. One student explains: "I have learnt how you can perform research, how you can see if something is sustainable, and with those arrows [the system]" (c1sC1). Students liked creating the system during the Find out-phase. They thought it was interesting to see relationships between variables and how everything is connected (4). One student for instance says: "I thought it was interesting because for many things you learn what the causes and the effects of many things are […] and you can see that if there is one action, then this changes, and maybe over there some other things change, so everything has an effect on itself" (c1sC1). Some students thought the systems thinking activity was challenging (6) or uninteresting (1).

In the student booklets, we asked whether students agreed with the statement 'After this lesson series, I am better able to judge whether something is sustainable or not'. A 5-point Likert-scale response option was added, in combination with an open question where students could explain their reasons. In general, students agreed with this statement (average of 3.65; lowest score 2, highest score 5). The most common reason for agreeing with this was receiving new information (8 students). Examples of (un)sustainable practices (5 students) and research (3

students) were other common reasons for agreeing. Six students felt they could already assess sustainability of processes before the lesson, so they did not make any progress. The most common thing students felt they learnt from the lesson was knowledge about sustainability in general (12 students). Knowledge about their ingredient (9 students), an improved appreciation of complexity of sustainability issues (8 students), insight in new solutions (4 students) and information about the environment (4 students) were also common. For both questions, knowledge seems to be the prevailing learning outcome perceived by students.

For the first class, the ECO-questionnaire was applied as a pre-post-test (Table 6.8). Results show no large shifts in Environmental Citizenship as a whole after the five lessons. Three significant differences ($p < .05$) for subconstructs between the pre- and the post-test were found. Knowledge and Own opinion skills increased, while Attitudes decreased.

TABLE 6.8 | Pre-post-test results of the ECO-questionnaire (Van Harskamp et al., 2023) for one of the classes of students (n=25). Significance was calculated with a two-tailed t-test, * and bold font indicates significant differences ($p < .05$).

	Before	**After**	**Difference**	***p***
Environmental Citizenship	3.16	3.05	-.11	.808
Knowledge	2.96	3.17	**.21***	**.040**
Attitudes	3.35	3.06	**-.29***	**.001**
Skills	3.73	3.80	.07	.234
General	3.38	3.51	.13	.107
Discussion	3.89	3.87	-.10	.129
Own opinion	4.14	4.30	**.16***	**.013**
Reflection	2.57	2.51	-.07	.105
General	2.87	2.77	-.10	.140
Social	2.31	2.27	-.04	.495
Complexity	3.51	3.55	.05	.642
General	3.84	3.84	.00	1.00
Causes	3.37	3.44	.07	.488

6.4 Discussion

With this study, we explored SSIBL's potential to foster EC through science education at lower secondary level. Despite EC being a widespread aim in educational policy and curricula, it poses challenges for science teachers. SSIBL might fill a need for more effective teaching approaches for science teachers when incorporating EC in their teaching. With its two cases, our LS study provides an in-depth view of using SSIBL in science education over a longer period of time. In this section, we will first explore what aspects of EC were successfully developed during these SSIBL-lessons. Next, we will discuss which EC aspects remain challenging based on our results, including suggestions further research. Finally, we offer recommendations for science education practice.

SSIBL's successes in EC development through science education

Our data show that many aspects of EC can be developed by using SSIBL in science education. Concerning the Wiek et al. (2011) key sustainability competences, an operationalisation has been made that distinguishes between the novice, the intermediate and the advanced level (Wiek et al., 2015). The current study includes many examples of the novice level for the five key sustainability competences. This is considered a success of the SSIBL-lessons, since these mastery levels were designed for graduate students, whereas the students from our sample are still three to four years away from higher education. Despite them being so young, we for instance see examples for developing novice level Normative competence during the Ask-Lesson, while they explore their own values and reason using values from stakeholders; examples of Strategic competence during the Act-Lesson, for instance when discussing intentionality, barriers and effectiveness; and Systems thinking competence during the lesson series, which can be seen from their system diagrams and them mentioning adverse effects of their strategies. SSIBL seems to be a suitable approach for practicing these aspects of EC competences at lower secondary level, preparing students for deeper EC development at graduate level.

Analysis of the Ask-Phases shows that students are triggered to ask a diversity of questions. All of Jensen's (2002) action oriented knowledge categories are covered. Furthermore, the question profiles of the different lessons, linking the categories of Jensen (2002) and the additional categories of truthfulness and background knowledge to the five key sustainability competences of Wiek et al. (2011), differ between lessons. During the first lesson for instance, students mainly ask questions related to sustainability Visions, whereas this category was underrepresented in the lesson series, which contained more Causes and Effects questions. These differences show that, depending on the goal of the lesson, SSIBL creates chances to raise specific student questions, thus showing flexibility for educational designers. It furthermore shows that students were free to pursue personally relevant interests associated with the topic. This openness for a diversity of opinions and interests lies at the core of pluralistic education (Öhman, 2008), and therefore forms an important prerequisite for effective science education for EC. With this, the Ask-phases show SSIBL is a suitable approach for pluralistic science education.

For Socio-Scientific Reasoning, which was mainly stimulated during the Find out-phase of the lesson series, a mastery level scale is available too (Sadler et al., 2007). Regarding complexity, the students in our sample mostly display quasireflective skills: they recognise complexity of issues, and deal with multiple information sources relativistically, yet they do not adopt rational strategies for evaluating these conflicting sources. For perspective taking, our students show signs of advanced practice, which for instance includes analysing SSIs from diverse perspectives and acknowledging that these differ from their own view. Concerning inquiry, we saw students raise questions of both scientific and social nature. Students occasionally acknowledged that there was a need for further information, but plans to establish answers were hardly discussed.

This means that the inquiry mastery level for these students is somewhere between the upper echelons of Sadler et al.'s (2007) less advanced and the lower levels of advanced. Finally, regarding scepticism, the SSIBL-lessons prompted students to question information shared by peers and from online information sources. Examples for this include the truthfulness questions that students asked during the Ask-phases of the lessons. This suggests advanced scepticism levels were present for at least some of the students. This is a notable outcome, since previous studies show lacking scepticism (Karahan & Roehrig, 2017), and perspectives (Cian, 2020) being common in student reasoning on sustainability SSIs. Taken together, during the SSIBL-lessons we find promising levels of student mastery for SSR, especially considering their age.

Action competence aspects of Sass et al. (2020) were identified in both the Act-Lesson and the lesson series. Especially the dedicated Act-Lesson seemed successful, for instance in its frequent display of developments in aspects such as Knowledge and Skills. These were often linked to Wiek et al.'s (2011) Strategic competence aspects such as Carriers, Effectivity and Barriers. Oftentimes, students discussed Knowledge of the issue and potential Action strategies in combination with Intentions or Carriers, as this representative example from the group discussions illustrates:

> "They miss raw materials, and they want to recycle the raw materials from old phones, so they will for instance offer three euro for this. So, we collect phones and we hand them in to [name of electronics retailer], you will get paid for that, and they can recycle the phone and make some money from it." (c2g4)

The pre-post-test results also show student knowledge about EC significantly increased after the lesson.

The student interviews also show Willingness to be involved in strategy development. During the student group discussions, students discussed indirect actions, collective actions, and showed that they felt the need for well-orchestrated actions. Jensen (2002) describes that education focussed on behavioural change often shows pitfalls in neglecting these aspects. The fact that students discussed these on their own accord is an indication that our SSIBL-based lessons were effective in their action-oriented focus, going beyond pure behavioural change towards the more internalised and intentional concept of Action competence. The occurrence of collective actions is an encouraging sign, for shifting away from purely individual, private sphere actions prevents feelings of hopelessness among teens (Ojala, 2020).

As far as teaching and learning activities go, SSIBL-based science education inherently offers students the chance to share experiences with and opinions on sustainability issues. This is achieved by the collaborative nature that most typical SSIBL-activities have. Students mentioned they appreciated collaborating with peers when developing strategies for change and during for instance the systems thinking and discussion activities. During the interview after the Act-Lesson, one student explained:

> "I liked it that we did this in groups, since you then hear ideas from others, and if you do it alone, you have to think about everything on your own, and the way it was now, you can discuss with each other about what is the most effective […] and each group member can share their opinion and then we collectively think about a shared solution, which includes the strengths of each individual idea." (c1sA1)

With its focus on collaborative activities, SSIBL offers these students ample opportunity to share views, opinions, and discuss ideas with peers. Our data shows that students greatly appreciate collaborating with peers that they did not select on their own. Illustrating this, students mention "learning to collaborate with everyone" (c1sB2) and "collaborating was something I enjoyed, especially with people with whom I do not normally do this" (c2sB3) during the interviews. Examples of novice level Interpersonal competence (Wiek et al., 2015), for instance relating to negotiation, team work, and stakeholder identification, are paramount. Collaboration and sharing opinions, views and ideas has been singled out as an important feature of effective education concerning moral issues surrounding sustainability, especially when there is space for both rational arguments and emotional reactions (Öhman, 2008). Our data shows, for instance with the many normative questions raised during the Ask-Lesson, and the conversations during the arguments in motion activity, that SSIBL offers opportunities for discussing both these emotional and rational reactions to sustainability issues. As seen from the pre-post-test results, students self-reported skills related to their own opinions increased significantly after the lessons. This stronger focus on collaborative and dialogue driven teaching and learning activities, where students express their values and perspectives and test them against each other, is considered a valuable step towards promoting EC through science education (Ojala, 2020).

Challenges with EC development during SSIBL-based science lessons

One of the main challenges with these SSIBL-lessons is related to student Action competence. On multiple occasions, students stated that they thought it was important to discuss sustainability issues and strategies for change. Despite this, Action competence aspects Willingness and Efficacy expectations are often low in our student sample during both the Act-Lesson and the lesson series. It seems that the current SSIBL-lessons have not fully succeeded in creating a sense of achievement in this regard. In for instance the student interviews, multiple students commented on this, saying "It is not like we children can do anything about this" (c2sA3, Ask-Lesson), "It is a nice project, because I think about this a lot, but I do not think I will have a lot of influence, […] I'm not that special, I'm only a girl" (c1sA2, Act-Lesson), and "I cannot do anything about this as a 15 year old" (c2sA3, lesson series). Similarly, low Willingness, Outcome expectancy, and Efficacy expectations were found during the group discussions of the Act-Lesson and the lesson series.

This lack of Efficacy and Outcome expectations among youths has been reported in other studies as well. In a survey study on Action competence of Swedish 17-19 year olds (Olsson et al., 2022), Confidence expectations were lagging behind the other core aspects of Action

competence, just like in our sample. Olsson et al. (2022) reason that this might be caused by action-taking not usually being practiced in a school context, and students might therefore not feel their strategies are going to be taken seriously. Another reason might be that students explicitly state that the responsibility to act does not lie with them, but with bigger and more influential entities such as companies and policy makers. To mitigate low Outcome expectations, researchers often recommend education to focus on using multiple perspectives (Öhman, 2008) and collaborative actions and emotions (Ojala, 2020) and incorporating other kinds of information besides effects (Jensen, 2002), including visions, change strategies and causes. In our lessons, we have seen ample evidence of students using these aspects in their reasoning, showing these processes were indeed in place. Yet, despite that, low Outcome expectations persist. Further research is needed, for instance through interviews, to explore the causes behind this widespread lack of Outcome expectations among young people.

Another challenge remaining for SSIBL-based education for EC is using the information from the Find out-phase during the Act-phase. Judging by our data, it remains difficult for students to use for instance their systems during their strategy development. Examples of this type of reasoning do occur, for instance with one student explaining their strategy in the interview:

> "Well, as you can see, pigs use animal feed and then, for animal feed and everything, you need a lot of stuff, and that is made in Brazil, and that causes deforestation, and pigs they also, they emit methane, so the statement is to not use pigs anymore." (c2sC3)

Although examples of this type of reasoning exist, often students do not explicitly link their strategies to their systems. A related phenomenon that our data show is that very often, students do not consider potential side-effects of strategies that involve quitting using certain goods. They for instance propose to stop using synthetic fertiliser, since they have found it is bad for the environment, but they do not think about the effects of alternatives for synthetic fertiliser on the environment. In these instances, they do use their systems to explain their reasoning, yet they do not go one step beyond this. During the interview after the lesson series, one student commented on seeing this exact kind of shallow reasoning in her peers: "Well, for instance with bread, they claim it is bad, but the same could be true for its alternative." (c2sC4). It is worthwhile to further investigate how to facilitate the transition from the Find out-phase into the Act-phase.

From the pre-post-test data, a significant decrease in EC Attitudes can be found for the students as a result of these lessons. Since the Attitudes subconstruct contains items aimed at whether students want to learn more about sustainability, and since these students just experienced five sustainability lessons, it might not come as a surprise that they have lower attitudes after this extensive lesson series. However, according to the pre-post-test, overall EC of students did not change significantly as a result of the lessons. While other data sources from this study, such as the student discussions and interviews, place these findings in perspective, it remains challenging to significantly improve self-reported EC with a five-lesson SSIBL-module.

Recommendations for science education practice

Our study adds to the existing knowledge base that advocates the inclusion of real world sustainability issues in science education for EC (e.g., Boeve-de Pauw et al., 2015). Through asking authentic questions about these issues, systemically exploring them, and by developing strategies for change, students develop vital aspects of EC competences. Students appreciate exploring these issues in a holistic and pluralistic manner. They furthermore wish for more collaborative activities such as those typical for SSIBL in science education, and appreciated sharing views and ideas with their peers, activities that they do not often encounter in current science education practice. Judging from our data, SSIBL seems to be an approach which naturally includes ample opportunity for students to experience action-taking, including dialogue with peers and exploration of real world issues, two themes that are pivotal when fostering EC competences (Olsson et al., 2022). SSIBL therefore is a valuable approach for science teachers who wish to enrich their practice and align it with the aims of EC.

Conclusion

With this study, we show that science education based on SSIBL has the potential to foster a diverse set of aspects of EC at lower secondary level. No previous studies have explored SSIBL's potential to foster these aspects in such detail. Our study therefore offers valuable insights in the workings of SSIBL during science education for EC. Through its holistic and pluralistic approach, and by its action-orientation, SSIBL is indeed a tool for science teachers who want to effectively implement EC in their teaching. While it is no panacea, the phases of Ask, Find out, and Act offer lower secondary students ample opportunity to practice pivotal EC competences. Its successes in fostering aspects of EC are particularly relevant in light of previously documented dips in EC competence of this age group. SSIBL can therefore be used by science teachers to develop effective EC based education at lower secondary level. In doing so, SSIBL-based science education which focusses on EC development prepares students for later stages in education, and equips them with competences that they benefit from throughout their lives.

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Data availability statement: No data were made publicly available for this study, in line with ethical guidelines.

Appendix 6.1 | Interview schemes

The following three questions were asked in **each** of the post-lesson interviews:

1. What do you think of the lesson as a whole? What did you like/which question/which part?
2. Can you shortly summarise what you have learnt from this lesson?
   [Lesson specific questions, see below.]
6. We will teach this lesson again with another class. What would you change?

These questions were specific to the **Ask-Lesson** interview:

3. Did the intermezzos make you think? Did they raise questions for you?
4. Which statement did you find most interesting? Can you shortly summarise what you thought and why?
5. Did students come with new insights for you during the arguments in motion activity? If yes, can you give an example?

These questions were specific to the **Act-Lesson** interview:

3. Did you think it was difficult or easy to come up with your plan? Why?
4. Do you think one plan could be made from the pitches from all groups? Why? Would this plan be feasible?
5. How did the collaboration go in your group? What was your role? And what were the roles of your peers?

These questions were specific to the **lesson series** interview:

3. What did you think of developing the system? Can you elaborate on that?
4. Can you shortly elaborate on what your advice was? How did you come to this advice?
5. Did you use or hear different perspectives during this lesson? Can you give examples?

Appendix 6.2 | Coding schemes

Coding scheme for the Ask-Lesson and the Ask-phase of the lesson series

Every SSIBL-question (showing a need to know) is coded, also when questions are asked non-linguistically, e.g., in the form of showing a need to know ("I do not understand why…"). Code exactly one Jensen+ category and one Wiek category for each question.

Jensen's (2002) Action-oriented knowledge + two additional categories	
Causes	Questions regarding causes of problems, reasons for existence of problems, the 'why'
Effects	Questions regarding effects of actions, of alternatives, 'Is that sustainable?', effects of situations/problems, can also be negative the 'what'
Visions	Questions regarding opinions, values, ethics, 'Is this OK?', desirability, also the 'where', as in: 'where do we want to go?'
Change strategies	Questions regarding strategies, solutions, aspects of actions, the 'how'
Truthfulness	Questions regarding if something is true, if it is correct, how somebody knows this
Background knowledge	Questions about background knowledge that is unrelated to causes or effects, 'Is this coming from there?', 'Where is that?'
Wiek et al.'s (2011) Sustainability competences	
System thinking competence	Questions about how something is caused or how something works, 'What causes this?', reasons, 'How does this work?', also related to where something is from
Anticipatory competence	Questions about processes in the future, alternatives and how desirable they are, which scenarios are desirable
Normative competence	Questions about normativity, desirability, 'What do we want?', opinions, 'What do you think?'
Strategic competence	Questions about solutions, possible ways to act, 'Why can't they…?', alternatives, 'Why do they…?'
Interpersonal competence	Questions about their peers' input, ideas, 'Do you still have…?'

Coding scheme for the Act-Lesson and the Act-phase of the lesson series

Sass et al.'s (2020) Action competence: Knowledge component	
Problem knowledge	Knowledge about the problem, problem size/scale, aspects of the problem, causes/effects of the problem, background knowledge
Action knowledge	Knowledge about possibilities for change, alternatives, examples, requirements for strategies/plans, legislation
Norms and values	Knowledge about what people think is acceptable, both of strategies and of the problem
Sass et al.'s (2020) Action competence: Skills component	
Alternatives	Think of alternatives, aspects/parts of a plan, possibilities to intervene
Critical thinking	Student clearly has criticism about what others (group members, authors/sources) say, 'Well, but,', 'That is not true, because,'
Negative	Do not have faith in effectiveness of the plan/strategy
Positive	Have faith in effectiveness of the plan/strategy
Sass et al.'s (2020) Action competence: Willingness component	
Positive	Shows commitment/passion to come up with a plan/carry out a plan
Negative	Shows lack of commitment/passion to come up with a plan/carry out a plan
Conditions	Places conditions on commitment/passion to come up with a plan/carry out a plan
Sass et al.'s (2020) Action competence: Outcome expectancy component	
Positive	Has faith in effectivity of their plan, thinks their plan works
Negative	Does not have faith in effectivity of their plan, does not think their plan works
Conditions	Has some conditions for which they think their plan works, but some for which it does not work
Sass et al.'s (2020) Action competence: Efficacy expectations component	
Positive	Shows they think they could have an impact
Negative	Shows they do not think they could have an impact
Wiek et al.'s (2011) Strategic competence	

Coded for Sass et al.'s (2020) Knowledge and Skills sections of the transcripts, but not for Willingness and the Outcome and Efficacy expectations.

Carriers	Success factors for the plan, aspects that improve effectiveness of the plan, plusses, positive sides for the plan
Barriers	Negative factors for the plan, aspects that hinder effectiveness of the plan, minuses, unintended effects, obstacles
Alliances	Collaborations with companies/individuals, possible partners for the plan
Feasibility	Student literally mentions whether a plan is feasible or not
Intentions	Goals of the plan, what do they want to achieve
Norm change	Effects on ideas/opinions of people, normalising, changing public opinion

Coding scheme for the Find out-phase of the lesson series

Sadler et al.'s (2007) Socio-Scientific Reasoning	
Perspectives	Student empathises with point of view from somebody else (group member, stakeholder, etc.), view from stakeholders' point of view, use different view on issue
Complexity	Discuss non-linear relations, complications, mention many different things that affect an issue, dichotomy, mention it being complicated
Critical	Sceptical to sources of information (peers or other sources), 'Is that so?', critical to others and what they read/hear/see
Uncertainty	Students stress they miss information, does not know enough, uncertainty of knowledge, 'You do not know that (for certain)'
Wiek et al.'s (2011) Systems thinking competence	
Stakeholders	Student mentions stakeholders, involved parties
Relations	Cause-effect relations, between two variables, 'This leads to this', also when student identifies there are no relations between two variables, S (same) and O (opposite)
Loops	Circles in their cause-effect-chains, 'This is a loop', B (balancing) and R (reinforcing)
Scale	Local/regional/global effects, source of products, area/region
Cascades	Effects that go beyond two variables (but include three, four, or even more), non-circular

7

General discussion

Throughout the previous five chapters, we have looked at the concept of Environmental Citizenship (EC) through the lens of science education. The main research question of this dissertation is

How to foster environmental citizenship in lower secondary science education?

In this chapter, we discuss overarching themes that lead to an answer to this central research question. In line with the sub-questions, we first sketch an overall view of Dutch science teachers' and students' views on EC. We then move on to a general discussing of the assessment of EC. Finally, we discuss experiences with using Socio-Scientific Inquiry-Based Learning (SSIBL) to foster EC through science education. We explore avenues for future research, summarise implications for research and practice, and draw final conclusions.

7.1 EC and teachers

Views of Dutch science teachers regarding EC in education were the central research theme in Chapter 2. Overall, most teachers interviewed in that study think sustainability and EC are important aims for science education. These findings correspond to work done with upper secondary school teachers in Sweden (Borg et al., 2012). Many of the interviewed teachers aim to raise student awareness of sustainability issues and unsustainable behaviour with their lessons. They hereby shift the focus from knowledge-based learning aims that are prevalent during lower secondary science education to more affective learning aims. The interviewed teachers' views show that the current Dutch national science curriculum does not align with their preferred focus during education for EC, which causes challenges for teachers. We found that they disapprove of the overtly knowledge and fact-based representation of sustainability in the national curriculum and in school text books, and often call for a stronger inclusion of sustainability issues throughout the curriculum. In a Danish interview study with biology teachers, researchers found that teachers often tended to only superficially incorporate SSIs in their teaching practice, mainly focussing on the science content of the issues (Tidemand & Nielsen, 2017). In their case, too, the curriculum was perceived as being a challenge to uptake of more holistic socio-scientific teaching.

This experienced sporadic and shallow representation of sustainability in the science curriculum causes severe time-restraints on the way teachers can implement EC in their everyday practice. Similar findings have been recorded in for instance an international review study on science teachers' views on teaching sustainability issues (Taylor et al., 2019), and a theoretical paper exploring uptake of decision-making in science education (Yacoubian, 2018). Of course, not all science teachers see this knowledge driven curriculum as a hindrance. Some teachers employ a fact-based outlook on their subject in general, avoiding emotional, social, or other implications of subject-related issues in their teaching (Borg et al., 2012; Chen & Xiao, 2021; Tidemand & Nielsen, 2017). A purely knowledge-based take on sustainability

can lead to feelings of hopelessness and fear in students (Ardoin et al., 2018; Jensen, 2002). With this outlook, teachers furthermore run the risk of oversimplifying inherently complex sustainability issues, turning them into unrepresentative fact-based problems. A lack of holism and pluralism in this sense is not beneficial for fostering opinion-forming, decision-making, and action-taking aspects of EC (Boeve-de Pauw et al., 2015). Furthermore, in a study on climate change and associated emotions from the UK, it was found that teachers paying attention to both hope and anxiety is most beneficial for student action competence (Finnegan, 2022).

Our results once more show that many science teachers mainly see the ecological dimension of sustainability issues. The interviewed Dutch science teachers are not unique in this aspect, since this planet-focus has often been reported (e.g., Borg et al., 2012; Clément & Caravita, 2014; Sinakou et al., 2019; Summers & Childs, 2007). As in the results from our study, teachers often mention private sphere and individual behaviours when discussing actions students can undertake (see also Georgiou et al., 2021). They thereby promote a neoliberal view, placing most of the responsibility of taking action on the individual, which is contradictory to EC and its broader focus, also including collective and public actions (Schindel Dimick, 2015).

Next to the curriculum and teachers' interpretations of sustainability issues, teachers experience difficulties with activities such as guiding dialogue and opinion-forming. Our interviews show that dealing with normative aspects of sustainability issues, such as emotions, values, and other affective reactions from students to sustainability issues, has been identified as particularly challenging. Many teachers mention feeling unequipped with the necessary knowledge and skills to teach these aspects of EC through science education. In previous studies, just like in our study, this has been linked to the many perspectives of different stakeholders (Owens et al., 2019), to guiding discussion and dialogue (Tidemand & Nielsen, 2017), to fostering opinion-forming (Clément & Caravita, 2014) and decision-making (Yacoubian, 2018), or lack of knowledge (Chen & Xiao, 2021) or lack of inspiring examples of how to incorporate this in their lessons (Borg et al., 2012). These same themes are present in our teacher interviews. Our study furthermore shows that teachers believe interest of lower secondary students for sustainability is low. About equal groups of the interviewed teachers think students are very interested or very uninterested in this topic. With this, our study provides a view on the Dutch context, and further solidifying our understanding of the challenges science teachers face when incorporating EC in their teaching practice.

7.2 EC and students

Looking at the results from the previous five chapters, the image of student EC in the Netherlands is a complicated one. Many contrasts exist, between groups of students but also often within single individuals. We found that students' affective relationship with

sustainability for instance has many different faces. On the one hand, students jokingly discuss hopelessness of sustainability issues during conversations in small groups. On the other hand, during one-on-one interviews students share their feelings of worry and sometimes fear more upfront. These emotions are important to take seriously in education aimed at fostering EC, for instance because they prevent development of action competence and willingness to take action (Ojala, 2020). In a recent British study with 16-18 year olds, student feelings of hope regarding climate change were correlated with self-perceived action competence, showing that the more hope students had regarding climate change, the higher the chance they also had high action-competence self-efficacy (Finnegan, 2022). On the other hand, the same study showed that distress and fear for climate change are also fuelling climate action in students.

Similar contrasts can be found for the social contexts in which students choose to discuss sustainability issues. Most students discuss these issues at school or at home, whereas almost none of the students discuss these issues with friends. This image arises both in the interview study (Chapter 3) and in the development of the assessment instrument for EC (Chapter 4). It was also recently found that Dutch students from primary and secondary school hardly discuss sustainability and other SSIs with friends on their own initiative (Klaver et al., 2022). It appears that despite students often being worried about sustainability and the future of the planet, they do not discuss these worries with friends on their own accord.

Furthermore, almost all of the interviewed students think people elsewhere are already affected by sustainability issues, whereas there is a big group of students who mention not yet experiencing any effects of sustainability issues close to home. The severity of these issues differs too between regions, with students noticing different types of sustainability issues in their direct surroundings compared to issues they think are experienced by people elsewhere. According to the students, issues closer to home are less impactful (for instance concerning less snowfall in winter) and issues further away are more serious and already have a severe impact on living conditions of humans and other species (for instance species going extinct and heavy smog). Additionally, the sentiment of issues not becoming serious in the students' lifetime is shared by several students. It seems that for some of the interviewed students, sustainability issues could be typified as 'somebody else's problem', with the affected individuals either currently living somewhere else, or not yet being born. The temporal and spatial distance between consumers and sites of environmental degradation as discussed by Dutta and Chandareskhar (2017) seems to affect some of these students' judgement of the nature of sustainability issues.

A final contrast exists between the causes of issues on the one hand, which students attribute to large-scale societal processes, and the small-impact behaviours which students mention doing, such as not littering or conserving energy at home. Most students mention people not cooperating in solving issues as main reason for persistence of issues. In doing so, they again refer to behaviour of individuals. This is a contrast between a neoliberal view of action-

taking which many students in our studies have adopted (see also Jickling & Wals, 2008; Schindel Dimick, 2015), where there is a strong responsibility for the individual, versus their understanding of the bigger picture, with large-scale societal processes driving unsustainable practices. Many of these students therefore display private environmentalism as opposed to EC (Stern, 2000). Our findings correspond with findings from other studies. As in our interviews from Chapter 3, small-scale actions such as recycling were mentioned most often in a study on students' sustainability actions (Agirreazkuenaga & Martinez, 2021), whereas another study documented science teachers also thinking these processes are the most readily accessible to students (Aarnio-Linnanvuori, 2019). A hopeful sign here is that many students in our studies would like to learn more about what they can do to help advance sustainability, so there is a demand for action-oriented education.

On a knowledge-level, students from our studies often show a relatively narrow, ecology-centred view on sustainability issues. This same trend has been observed in other studies concerning students, with for instance political aspects lacking (Walshe, 2008), economic dimensions being underrepresented (Sinakou et al., 2019), and an overrepresentation of the ecological dimension (Benninghaus et al., 2018). It appears students do not have a holistic view of sustainability issues, which is a barrier for developing EC. The fact that science teachers do not employ a broad view of sustainability either (Chapter 2) might partially explain this narrow student view. Similarly, both in our studies as in studies elsewhere, intergenerational effects of sustainability issues are more obviously present in student descriptions, with less attention going to effects within the current generation (Benninghaus et al., 2018). This relates to findings from PISA (OECD, 2022), where students had more difficulty with finding short-term solutions to climate change than for long-term solutions.

Concerning EC competences, the interviewed students do not often adopt a critical stance to information sources on sustainability (Chapter 3). They are sceptical towards information from social media such as Instagram, or when they perceive sources as overtly sensationalist. This corresponds to findings from studies on student Socio-Scientific Reasoning, where a lack of scepticism and a critical attitude was found among American 14-18 year old students (Karahan & Roehrig, 2017; Kinslow et al., 2019). Additionally, an adolescent dip has been observed in EC competences such as sustainability behaviour, knowingness, and attitudes (Boeve-de Pauw et al., 2015; Cincera et al., 2022; Olsson et al., 2022; Olsson & Gericke, 2016), with students aged 14-15 showing less EC competence than their younger and older peers. Our student sample fell within this range, so any aspects of EC competence observed in our student sample could be interpreted as a promising sign.

7.3 Assessing EC

The Environmental Citizenship Opinions (ECO) questionnaire turned out to be a valid and reliable assessment instrument for EC competence. It focusses on opinion-forming since this central aspect of EC was previously uncovered by existing assessment instruments. With the development of the ECO-questionnaire, we therefore offer an alternative to the overtly fact-based assessment system that is currently in place for Education for Sustainable Development (ESD). This is a step towards enabling teachers to broaden their teaching repertoire, shifting from knowledge- and fact-based approaches towards incorporating more competence-driven education for EC, which they currently do not pursue due to insufficient support from curriculum and assessment (Tidemand & Nielsen, 2017). Assessment of learning in ESD has been singled out as a particular challenge for teachers, for instance caused by its complex learning aims and a requirement for non-traditional evaluation methods (Boeve-de Pauw et al., 2022). The ECO-questionnaire could be employed as one facet for assessment of this complex set of learning aims and EC competences.

With its development, we identified reflection about sustainability issues as a construct of particular importance for EC. According to the structural parameters, its effect on overall EC falls in the order of magnitude of sustainability attitudes, which has previously been attributed a central role as one of EC's strongest contributors (e.g., Gericke et al., 2018; Olsson et al., 2019; Roczen et al., 2014). Development of our assessment instrument points at reflection as having a similarly pivotal role for overall EC competence. In previous studies about general citizenship competence (Ten Dam & Volman, 2007) and moral reasoning (Wardekker, 2001), critical reflection has been attributed a central role already. A person who reflects critically on values and rules, according to Wardekker (2001), is able to challenge the status quo if they think this would lead to more desirable situations. It seems that further exploration of reflection's role in EC competence would be beneficial, since from a theoretical perspective, this combines well with what EC entails.

Concerning the composition of the ECO-questionnaire, the knowledge subscale could not be successfully constructed of items containing the three dimensions of sustainability. The current version includes items related to the social side of sustainability, without ecological or economical aspects. This phenomenon was observed in other studies as well, for in the student interviews (Chapter 3) and the Lesson Studies (Chapters 5 and 6) students did not interpret sustainability beyond the ecological dimension. This imbalance in interpretation of sustainability and its dimensions has been reported in other studies with students as well (e.g., Benninghaus et al., 2018; Sinakou et al., 2019).

7.4 SSIBL for EC in practice

Socio-Scientific Inquiry-Based Learning (SSIBL) formed the backbone of the Lesson Studies (LS) described in Chapters 5 and 6. These two studies show what aspects of EC SSIBL-based science lessons can foster at lower secondary level. The discussion is based around the three theoretical models which were central during lesson development and data analysis: the five key sustainability competences (Wiek et al., 2011), the four aspects of Socio-Scientific Reasoning (Sadler et al., 2007), and the concept of action competence (Sass et al., 2020).

The SSIBL-lessons offered students room to practice the five **key sustainability competences** as defined by Wiek et al. (2011). In both LS-cycles, many aspects of these key competences were observed. Both studies had students map the complexity of the issue to promote their Systems thinking competence. Students commented on enjoying these activities and teachers and observers were satisfied with the learning processes regarding systems thinking competence. Anticipatory competence was most pronounced in the first LS-cycle, the second LS-cycle focussed less strongly on this. Normative competence was central in both LS-cycles, with students appreciating being able talk about their opinions with peers. Strategic competence, too, was strongly present in both cycles. This was a conscious decision, since students appreciated an action-oriented approach, as can be seen from the student interview study (Chapter 3). Finally, interpersonal competence, including collaboration, was central to both LS-cycles and to SSIBL in general.

Students showed many aspects of **Socio-Scientific Reasoning (SSR)** during the SSIBL-lessons. Its four main components, appreciating complexity, taking perspectives, employing scepticism while assessing quality of information, and appreciating the ongoing inquiry regarding issues, were present during both LS-cycles. Students approached the issues with a holistic outlook, and often explicitly mentioned having a newfound appreciation for the complexity of issues. Concerning perspective taking, students engaged with stakeholders, adopted outside views on the issue next to empathising with insiders, and reflected on moral and ethical aspects of issues. These three components of perspective taking on SSIs were identified as instrumental (Kahn & Zeidler, 2019).

As discussed in the student interview section (Chapter 3), scepticism towards information sources of the interviewed students was generally low. This is in line with previous findings, for instance with American lower secondary level students (Karahan & Roehrig, 2017; Kinslow et al., 2019). Contrastingly, during the SSIBL-lessons, students clearly showed signs of critical thinking towards information in the small group discussions (Chapters 5 and 6). The lesson designs focussed student attention on considering reliability of data sources, which, according to the data, promoted student scepticism. Finally, the open-ended nature of these issues, and ongoing inquiry towards developing strategies for change was made less explicit to the students during the lessons. This aspect of SSR is one of the least developed and demands further attention in other research projects.

Concerning **action competence** (Sass et al., 2020) of students, the two Lesson Studies show many different aspects. It was particularly positive to see both private and public sphere actions being considered, and both individual and collective strategies being developed. It seems the overtly neoliberalist view of sustainability that both teachers (Chapter 2) and students (Chapter 3) have of solving these issues does not necessarily affect student Action competence. This is at least not the case for our student sample. Students were considering tackling the root causes of issues, not just taking care of the symptoms. These SSIBL-lessons therefore offered them opportunities to develop EC that shares similarities with Westheimers' (2008) Social-Justice Oriented citizenship, shifting their strategies from small, personal behaviours to address the mechanisms that cause sustainability issues on a grander scale. This is an encouraging finding, as overtly neoliberalist, individualist actions have relatively small impact (Courtenay-Hall & Rogers, 2002; Schindel Dimick, 2015), whereas public sphere actions might have larger effects (Schindel Dimick, 2015; Stern, 2000). A further benefit from students planning public and collective actions is helping them to avoid feelings of hopelessness (Ojala, 2020), and preventing the over-romanticised image of citizenship education "as a redemptive educational solution to global problems" (Estellés & Fischman, 2021, p. 231).

SSIBL is strongly founded on the pluralistic teaching tradition, for instance with its aim to offer room for students expressing their opinions, ideas, values, emotions, and other experiences with the issue at hand. This pluralistic approach was highly valued by the students who participated in the Lesson Studies. The SSIBL-lessons provided support for the students to develop dialogue, perspective, and argumentation skills, which has been identified as important for this age group (Blatt, 2014). The importance of providing room for discussing these normative aspects of issues has been stressed by scholars in the field of SSI (Cian, 2020; Day & Bryce, 2011; Zeidler et al., 2019), and in the context of sustainability education (Kater-Wettstädt, 2018; Ojala, 2013; Olsson et al., 2022). Sund and Öhman, for example, discuss the importance of pluralism in environmental and sustainability education:

> "Valuing and exchanging various ideas should thus be an important aspect of ESE practice because this makes it possible for students to make meaning of contradictory knowledge. It also increases their understanding of unfamiliar values and establishes certain views of environmental and sustainability issues in a pluralistic discussion." (2014, p. 653).

It was clear from the small group discussions, the collective exploration of opinions and ideas during 'arguments in motion', and the personally relevant aspects of the issues explored by for instance the diverse set of questions asked during the second LS (Chapter 6) that students had ample room to collectively discuss normative aspects of the issues. While the steps during the opinion-forming process did remain implicit for the students, this room for dialogue and exploration of values is of critical importance to developing EC competences.

Despite these successes, there still are some challenges associated with using SSIBL as a means to foster EC through science education. One such challenge arose in both Lesson Study chapters.

Students clearly experienced difficulty with incorporating their discussion themes, which were extensive, into their action strategies, which remained monodimensional. The strategies were not as well-developed as one would expect based on the depth of the Find out-phase. This conclusion has been drawn based on other studies, too, for instance when using Futures thinking at lower secondary level (Jones et al., 2012). A possible explanation for this could be students jumping to conclusions too soon, without taking a moment to critically think through what effects their strategies might have, or considering alternatives. For moral reasoning, it is known that people usually base their opinions and decisions on quick, automatic evaluations related to intuition and emotions (Haidt, 2001). This could be the case for our students too. Additionally, it is difficult and takes a lot of time to develop these critical thinking skills, which would benefit the quality of the student strategies (Guérin et al., 2013).

Another challenge were recurring signs of low confidence in outcome expectancy and efficacy expectations, two instrumental aspects of Action competence (Sass et al., 2020). Similar difficulties regarding these components have been found, for instance in Sweden (Olsson et al., 2022), and regarding action-taking in a large international comparison study (OECD, 2022). While there were several instances where a positive stance towards action-taking was indeed observed, for instance in the first LS (Chapter 5) and the lesson on smartphone recycling (Chapter 6), signs of negative confidence and willingness were frequently observed as well. These often related to students having little faith in their actions actually making an impact, that companies would not cooperate, that experts would be better in solving issues, or in low levels of conviction that adults would listen to their ideas.

The affordances discussed in the LS-cycles are to be viewed as successes of SSIBL, especially in light of the age group of the participating students. As previously discussed, an adolescent dip in EC competences such as behaviour and attitudes has been identified in previous studies in Sweden, Czechia, and Taiwan (Boeve-de Pauw et al., 2015; Cincera et al., 2022; Olsson et al., 2022; Olsson & Gericke, 2016). Despite the challenges associated with this age group, many aspects of EC competences were observed during the different SSIBL-lessons. With this, we have identified SSIBL as a suitable approach for EC development through science education at lower secondary level.

7.5 Lesson study as research approach

Lesson Study forms the central research approach during the studies which are discussed in this dissertation. Our work therefore falls in the category of science education research that use LS less as a teacher professional development tool, instead focussing on its potential for generating new educational insights. While LS was used in this way before, for instance in a study on biological meta-modelling knowledge (Jansen et al., 2021) and on systems thinking in biology education (Gilissen et al., 2022) this view on LS is relatively new (Jansen et al., 2021).

We will therefore shortly consider the benefits and remaining challenges of this outlook on LS as a research instrument.

First of all, one of the biggest affordances of LS as a research tool is its collaborative nature. Including teachers in the research process maximises usability of results. The teachers who participated in the LS-team had the opportunity to steer the research process in directions that directly benefited their teaching practice, hereby ensuring research relevance. Furthermore, the lessons were co-designed by the entire LS-team, which means the teachers had internalised the main aims and teaching activities, which ensured that the lessons were taught as planned. This co-design process had an additional benefit in the strong foundation of the lesson which resulted from inclusion of both theoretical insights brought in by the researchers and practical insights based on teachers' experiences. The participating teachers also mentioned they directly learned about integrating EC in their teaching practice from partaking in the LS-process.

A second benefit of using LS as a research approach is its potential for collecting many different data sources, providing detailed insight in lesson design and student learning. These include audio recordings of design sessions, of the lesson itself, of post-lesson student interviews, of the post-lesson discussion during which the observed learning processes are being discussed, of student materials, and of questionnaires or other pre-post-test data. This allows for a focus on student learning from many different perspectives, providing a deep and rich overview of learning processes that occurred during the lesson.

A challenge for using LS as a research instrument is the pressure it inherently puts on the participating teachers' time. The drawback of this necessary time-investment has been reported in the past (Jansen et al., 2021). It furthermore requires good alignment of both expectations and agreement of the research aims and question, and an understanding of the research-driven nature of the process (Jansen et al., 2021). If these conditions are met, however, LS can be a valuable tool for educational researchers and teachers for researching challenging aspects of educational practice.

7.6 Limitations

Despite care taken while designing and carrying out the research described in this dissertation, several limitations to the five studies can be identified. First of all, we describe processes associated with EC in the Netherlands, which differs from the situation in other countries. Educational contexts, attitudes and interests of the students, and experiences and vision of the teachers for instance differ between regions. Comparison of results therefore should be done with caution. Furthermore, many of these studies concern a relatively small sample of participants. This meant we could go into depth during data analysis, which one of the main affordances of LS as a research approach, but it might also restrict transferability of conclusions. Finally, while the data collection associated with the five main studies does not

include data from COVID-19 affected school years, the students who participated in the study in Chapter 6 did go through formative years of their education during the pandemic. This means these students followed unconventional lessons prior to our research lessons, possibly affecting their prior knowledge and experiences relevant to the concepts under study. Despite these limitations our studies paint a considerably broad picture of the current situation of EC in the Netherlands, of assessing EC competences that have previously been omitted from assessment instruments, and of SSIBL and its potential to foster EC during science education at lower secondary level.

7.7 Implications for science education practice

With this dissertation, SSIBL has been identified as a suitable approach to foster aspects of EC at lower secondary level. With its focus on dialogue about controversial sustainability issues, its holistic approach, its inherent inclusion of pluralism, and its action orientation, it offers ample opportunities for students to develop EC competences necessary for taking sustainable action. Looking at the results from the five studies that form the main body of this dissertation, and especially considering the final two chapters concerning the Lesson Studies, we can draw several conclusions regarding the SSIBL-phases of Ask, Find out, and Act that have implications for science education practice.

Concerning the **Ask-phase**, science teachers are advised to help students ask different types of questions (e.g., related to content, desirability, ethics). This ensures the issue is considered holistically, which has been identified as a driving force behind effective education for EC (Boeve-de Pauw et al., 2015). As a starting point for the lesson, this is best done in small groups, which creates a sense of safety (Knippels & Van Harskamp, 2018). Points of view could for instance include the three main dimensions of sustainability (ecological, social, economic) or the dimensions of action-oriented knowledge of Jensen (2002), which concern causes, effects, visions, and change strategies. Furthermore, the five key sustainability competences as defined by Wiek et al. (2011) could provide insight in coverage of the topic, showing if there are underappreciated aspects that need further exploration by the students. The five key competences for sustainability are systems thinking competence, about current and past processes that make up the issue; anticipatory competence, concerning possible and desirable future situations; normative competence, about values and desirability; strategic competence, regarding ways of reaching sustainability; and interpersonal competence, concerning collaboration and cooperation. We advise teachers to stimulate students to ask questions regarding these different dimensions and aspects of sustainability and sustainable action-taking.

Teachers are also encouraged to help students raise questions about actions that are not limited to the individual and private sphere, but also include the collective and public dimensions of

sustainable action-taking. We have seen many students focus on the private and the individual level (Chapters 3, 5 and 6), teachers could assist students to expand this rather limited view. From the student interviews (Chapter 3), we have seen many students wonder what they can do themselves to promote sustainable processes. This can be a good starting point for introducing sustainability and related issues, but ensuring issues are approached from a holistic perspective is key for EC development.

During the **Find out-phase**, two kinds of activities are important. First, it is important to include activities that allow students to map the issue, for instance through a systems thinking activity. When implementing systems thinking, for example focus on relationships, on feedback loops, on scale, on cascading effects, and on stakeholders (Wiek et al., 2011, see also Chapter 6). Next to this, the Find out-phase is about sharing and exploring points of view, for instance through dialogue or arguments in motion (Van Der Zande, 2011). During arguments in motion, students move through the classroom to display their stance regarding a statement: whether they are for or against (this axis consists of two opposite walls of the classroom), and whether they based this mainly on ratio or on intuition (the other two walls).

The two LS chapters (5 and 6) provide further evidence for the major importance of dialogue in education for EC. The moments when students were triggered to put their own opinions regarding issues into words, to share these with their peers, to exchange points of view, and to empathise with stakeholders of issues, we saw students flourish. Our data once more underscore the importance of dialogue, discussion, debate, and argumentation when dealing with SSI and other controversial issues with scientific ramifications, as previously discussed by other researchers (Day & Bryce, 2011; Zeidler et al., 2019). It should be noted here that we consider dialogue to be a more suitable form of developing and exchanging opinions. Dialogue is not aimed at convincing others of the truthfulness of one's own opinion or converting people to your 'side', as usually the case with a discussion or debate. Instead, dialogue is aimed at respectful exchange of visions, ideas, and opinions, which is more suitable as a pluralistic educational activity since this leaves room for opinions to coexist. This aligns with Öhman's view of the role of pluralism in science education: "pluralism is therefore not a question of including a multitude of theoretical perspectives, but rather one of not excluding human ways of reacting and certain forms of human life—that is, not excluding certain human beings from the democratic community" (Öhman, 2006, p. 160). Whereas discussion and debate have their own merit as teaching activities, the potential of dialogue in fostering EC cannot be overemphasised.

Next to these two activities, it is important during the Find out-phase to pay attention to student emotions associated with the sustainability issue. Throughout the student interviews from Chapter 3 and both LS chapters (5 and 6), we encountered students who were anxious about the future of the planet, afraid of living conditions deteriorating or of species going extinct. Teachers also commented on this in the teacher interviews (Chapter 2). Previous

studies already pointed at the pivotal role of emotions during the decision-making process on controversial issues (Roeser, 2006) and in risk-assessment (Roeser, 2012). Understanding the emotions that students have regarding these issues can help science teachers effectively implement EC in their teaching practice. Furthermore, there are downsides to ignoring negative emotions when teaching about sustainability issues. Doing so might induce a passive stance instead of promoting action-taking and therefore might hinder action-competence development (Finnegan, 2022; Ojala, 2020; Sass et al., 2020). Our studies included signs of hopelessness and anxiety (see for instance Chapters 3 and 6), leaving room for students to express these is instrumental for fostering EC.

The Find out-phase is instrumental in fostering Socio-Scientific Reasoning (SSR; Sadler et al., 2007). We have seen ample evidence of its four main components of perspective-taking, scepticism, appreciation of complexity, and appreciation of the need for ongoing inquiry during the SSIBL-LS-cycles (Chapters 5 and 6). Students used different perspectives to approach their sustainability issues, for instance related to stakeholders, which is beneficial for their EC development. They furthermore appreciated the complexity of issues, for instance by acknowledging the different dimensions of sustainability and temporal or spatial aspects of the issues. Developing a more critical outlook on information sources and statements by means of scepticism was a more difficult aspect of SSR to develop during the LS-cycles. This might need some extra teacher support during the SSIBL-phase of Find out.

Finally, the **Act-phase** can support students to develop their strategic competence, which deals with identifying carriers and barriers to plans, discussing possible alliances, feasibility of their strategies, intentions, and possible norm changes that are required to take action (Wiek et al., 2011). For teachers, it is once more important to help students develop action strategies that have collective and public sphere foundations as opposed to being limited to the individual and private sphere. During the final LS-cycles (Chapter 6), we encountered many students who had negative outcome expectancy and efficacy-expectations, two important aspects of Action competence (Sass et al., 2020). Students with these negative expectations usually felt that their own influencing possibilities were small and inadequate, or that adults would not pay attention to their ideas. By helping students explore collective and public sphere actions, teachers could assist students in promoting more positive outcome expectancy and willingness to act.

Another way to mitigate these negative aspects of Action competence is setting attainable goals for students instead of having them 'solve sustainability issues', which is unrealistic and beyond the scope of everyday science education lessons. In our lesson designs (Chapters 5 and 6), we purposefully did not include terminology such as 'solving issues' or 'solutions', opting for 'developing strategies' instead. This for instance related to having students indicate points in the systems they developed during the Find out-phase where they wanted to intervene. As previously discussed, we have seen ample evidence for hopelessness in students, regarding for instance their own efficacy- and outcome expectations for EC. It might be beneficial for

student outcome expectancy to be realistic about which targets are manageable, and which aims are set too high for students to reach. We advise teachers to be mindful about setting attainable targets for students during education for EC, which for instance relate to collectively changing unsustainable processes within their school or community.

Overall, the LS-cycles in this dissertation (Chapters 5 and 6) reinforce findings from previous studies, showing that developing EC and associated competences takes time (Olsson et al., 2022; Romine et al., 2017). We recommend practicing these competences in lessons or lesson series throughout the school year, during different subjects, and providing angles on EC development from different topics and contexts (e.g., food, water use, climate change). Doing so will give students the biggest chance to develop the complex competences of EC and transfer what they have learned to other contexts and settings.

The work related to this dissertation has led to several tools that might be of assistance for science teachers when implementing EC in their lessons. The assessment tool developed for Chapter 4 might support teachers when assessing student opinion-forming as a main concept of EC. The developed lesson materials for the LS-cycles are available online[3]. These could be used as exemplary lesson materials and could provide inspiration or form a starting point for science teachers when developing EC materials for their own context. Together with the phases described by Knippels and Van Harskamp (2018), these tools could support science teachers in developing SSIBL-based education for EC.

7.8 Future research directions

As a result of this dissertation, several avenues for further research were identified. A first possibility could be exploring the transition from SSIBL's Find out-phase into the Act-phase. During both LS-cycles (Chapters 5 and 6), students were able to construct overview schemes and systems that were of satisfactory quality. These systems showed an understanding of complexity of the sustainability issue that students were exploring. The actions that students subsequently proposed during the Act-phase did not represent the depth of the student discussions and the constructed systems. Students seem to experience difficulties with translating their systems into corresponding actions. They are challenged by explaining their strategies using their overview schemes, showing deep understanding of the issue they displayed during the Find out-phase. Further research could look into what students need to facilitate this transition.

Furthermore, concerning student action competence regarding sustainability issues, researchers could inquire into the common lack of student confidence in outcome and efficacy expectations that we encountered in both LS-cycles (Chapters 5 and 6). If we better understood

3 See https://www.uu.nl/onderzoek/freudenthal-instituut/lesmodules-burgerschapsvorming-rond-duurzaamheidsvraagstukken-in-het-betaonderwijs, in Dutch.

what drives students to experience low levels of confidence in these areas, educational approaches could be better aligned with supporting student action competence regarding EC. In our studies, we found examples of lack of trust that adults would listen to students, students not feeling equipped with the necessary knowledge and skills to come up with effective strategies, and students placing blame or responsibility of developing these strategies with experts. There is conflicting information about the effect of the perceived distance (both spatially and temporally) to environmental degradation in decreasing willingness to take sustainable action, also in Dutch mainstream media (Aan de Brug, 2023). Improving our understanding of this situation could be an interesting future research direction.

Finally, we could improve our understanding of how to support science teachers when teaching the broad and complex topic of EC. To do this, it would for instance be interesting to track teacher efficacy of education for EC across extended periods of time. The Lesson Study teachers were involved in the current research project for almost four years. We collected data through interviews, questionnaires, and from recording lesson design sessions. These sources could be analysed for learning processes that took place for the participating teachers. In a recent study, changes in self-efficacy of teachers regarding ESD as an effect of teacher professional development in Sweden were followed for a couple of years (Boeve-de Pauw et al., 2022). Findings show that these first were high, then showed a dip, when teachers first started to implement ESD, to finally grow again near the end of the teacher professional development course. It would be interesting to compare these findings with the data collected during the LS-cycles belonging to this dissertation.

7.9 Overall conclusion

The five studies that make up this dissertation all provided steps towards answering the main research question: *how to foster environmental citizenship in lower secondary science education*? They do so by describing three themes, corresponding with the three sub-questions:

- How can we characterise current Dutch teachers' and students' views on environmental citizenship?
- How can we validly and reliably assess environmental citizenship?
- What is the educational potential of Socio-Scientific Inquiry-Based Learning for fostering environmental citizenship?

The first sub-question was aimed at providing a characterisation of Dutch science teachers' and students' current views on EC. This work, described in Chapters 2 and 3, served as a starting point for developing the assessment instrument and for carrying out the Lesson Studies looking into EC in science education practice. Generally, while Dutch science teachers think sustainability and citizenship are important, they often feel restricted in their own capabilities regarding normative teaching methods and the narrowly formulated, knowledge-

transfer driven guide rails imposed by the national curriculum. To their dissatisfaction, this results in classroom practice that is less suitable for fostering Environmental Citizenship. Concerning their understanding of EC, they often overlook the social and economic side of sustainability issues. They furthermore commonly focus on individual, private sphere actions for their students. Many teachers seem to adopt a neoliberalist view on sustainability, which might hamper EC development of their students.

From the study described in Chapter 3, it follows that Dutch lower secondary students are a diverse group when considering their EC. Common trends can be discerned, however, for instance regarding their general interest in discussing real-world sustainability issues, their low outcome expectancy for their personally developed sustainability strategies, and a general sense of urgency regarding solving sustainability issues. A spatial and a temporal divide was observed for many students regarding occurrence and severity of sustainability issues, with many students feeling issues would only become serious somewhere else or sometime in the future. Most students do not discuss sustainability with friends, yet at school and at home, for many students it is a recurrent conversation topic. Just like their teachers, many students adopt narrow understanding of sustainability issues, overemphasising the ecological dimension and individual and private sphere actions.

The second sub-question concerned validly and reliably assessing EC at lower secondary level. With the development of the Environmental Citizenship Opinions (ECO) questionnaire, described in Chapter 4, we offer a valid and reliable way to assess EC competences. For the first time, opinion-forming has been given a central role in such an assessment instrument. The development process led to a new appreciation for the aspect of reflection and its major impact on EC. Its contribution to EC in the ECO-questionnaire is of the same order of magnitude as attitudes. Difficulties with creating a knowledge subscale that encompassed the three main dimensions of sustainability further underscore the skewered understanding of lower secondary students regarding the concept of sustainability.

Finally, the third sub-question was aimed at researching the educational potential of Socio-Scientific Inquiry-Based Learning (SSIBL) for fostering EC through science education at lower secondary level. During the LS-cycles, we saw students being triggered by authentic sustainability issues to ask questions, exploring scientific and normative aspects of these issues during the Find out-phase, and developing appropriate actions towards more desirable situations. SSIBL unites three dimensions that have been identified as important drivers of fostering EC in education: holism, pluralism, and action-orientation. The studies in Chapters 5 and 6 showed students developing key sustainability competences, Socio-Scientific Reasoning, and action competence. Whereas some aspects of these competences were relatively underdeveloped, for instance related to student confidence in their ability to act or scepticism towards information sources, promising signs of EC development were witnessed for a broad spectrum of EC competences.

This dissertation has identified many benefits of SSIBL as a teaching approach towards fostering EC through science education. During the four years of research discussed in this dissertation, several other studies have explored the potential of SSIBL in relation to EC development and SSI educational practice. Ariza et al. (2021) explored the potential of SSIBL for fostering EC and the way it assists pre-service teachers when developing and implementing SSIBL-based lesson plans in Cyprus, the Netherlands, Spain, and the UK. They concluded that SSIBL has benefits for teacher education, acquainting them with teaching controversial issues, normativity, and action-taking as important aspects of EC. Another study explored SSIBL and how it could be of assistance to science teachers in England, the Netherlands, and Sweden (Amos et al., 2020). This study showed that implementing short-term inquiries could help teachers deal with the overloaded curriculum that could otherwise be a hindrance towards implementing SSIBL (see also Chapter 2). In an Austrian context, SSIBL has shown promising results for teacher education and for students, for instance by its focus on real-world, authentic sustainability issues that students recognise from their surroundings (Rauch & Radmann, 2020). Finally, in a climate-change centred SSIBL-programme for 11-12 year old students in Korea, student morality and emotion competences were reported as the main learning outcomes for students, whereas teachers thought the approach was easy to implement, since it offered them phases for structuring SSI-based education around climate change (Baek et al., 2022). Taken together, there is ample evidence for SSIBL's potential for both teacher education and science education in developing EC competences in different national contexts. The current dissertation adds another layer to this evidence base.

The three phases of Ask, Find out, and Act that form the basis of SSIBL offer students an experience during which they can practice their EC competences in the context of science education. SSIBL therefore offers science teachers a framework which they can employ to embed a stronger competence-driven foundation in their teaching, something which many teachers feel is needed in the complex field of education for Environmental Citizenship. Taken together, the insights and findings from the work described in this dissertation provide directions for how to foster Environmental Citizenship through science education at lower secondary level. Equipping citizens with the competences to form opinions on sustainability issues, to make decisions, and take corresponding action is an important task of (science) education. Education for Environmental Citizenship therefore plays an important role in the transition from current unsustainable processes towards a greener future. With this dissertation, yet another step has been taken on the long road of progress.

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Samenvatting in het Nederlands

Wereldwijd groeit de behoefte om niet-duurzame processen te vervangen door groenere, duurzamere alternatieven. De noodzaak voor deze overgang brengt problemen met zich mee die wetenschappelijke en maatschappelijke implicaties hebben, verschillende belanghebbenden aangaan, vatbaar zijn voor controverse en risicobeoordeling met zich meebrengen, en waarvoor geen eenduidige oplossingen bestaan. Huidige curricula voor het voortgezet onderwijs leggen de verantwoordelijkheid bij het bètaonderwijs om leerlingen toe te rusten met de nodige competenties om een gefundeerde mening te vormen over deze vraagstukken, de juiste beslissingen te nemen en passende actie te ondernemen. Hiermee zijn de curricula afgestemd op de doelstellingen van Milieubewust burgerschap (EC, van *Environmental Citizenship*).

Tijdens het proces van meningsvorming, besluitvorming en actie ondernemen houdt een milieubewuste burger rekening met dimensies als tijd (verleden, heden en toekomst) en plaats (lokaal, regionaal, mondiaal), terwijl hij ook rekening houdt met ecologische, economische en sociale overwegingen. Vijf sleutelcompetenties voor duurzaamheid zijn voor EC van groot belang. Dit zijn: i) systeemdenkcompetentie, over het in kaart brengen van het vraagstuk en de verschillende componenten ervan; ii) toekomstgerichte competentie, die betrekking heeft op mogelijke toekomstscenario's en alternatieven; iii) normatieve competentie, aangaande de wenselijkheid van huidige en toekomstige situaties, daarbij rekening houdend met meerdere perspectieven; iv) strategische competentie, over mogelijke manieren om actie te ondernemen en deze wenselijke toekomsten te bereiken; en v) interpersoonlijke competentie, die betrekking heeft op samenwerken, consensus en empathie. Daarnaast beheerst een milieubewuste

burger het concept van *Socio-Scientific Reasoning* (SSR), wat het gebruik van verschillende perspectieven, kritisch denken, waardering voor complexiteit en waardering voor verder onderzoek van kwesties inhoudt. Tot slot brengt EC-actiecompetentie met zich mee, waarbij sprake is van actie-kennis, actie-vaardigheden, actiebereidheid en positieve resultaat- en *self-efficacy* verwachtingen.

Het bevorderen van deze EC-competenties en bijbehorende hogere-orde denkvaardigheden stelt wetenschapsdocenten voor uitdagingen. Dit geldt vooral voor het normatieve karakter van deze onderwerpen en hoe ze te implementeren in het wetenschapsonderwijs. Een mogelijke onderwijsaanpak die bètadocenten kan ondersteunen bij de implementatie van EC in hun onderwijspraktijk is *Socio-Scientific Inquiry-Based Learning* (SSIBL). Het bestaat uit drie fasen: i) Vraag, waarbij een '*need-to-know*' leerlingen aanzet tot het stellen van authentieke vragen over sociaalwetenschappelijke vraagstukken, ii) Zoek uit, waarbij leerlingen wetenschappelijk, persoonlijk en sociaal onderzoek doen naar het vraagstuk, en iii) Handel, waarbij leerlingen een actiestrategie ontwikkelen en overeenkomstige actie ondernemen. Ondanks het potentieel dat SSIBL heeft om EC te bevorderen, is het nog niet uitgebreid getest in de onderwijspraktijk.

De belangrijkste aanpak die we in dit proefschrift hebben gebruikt om het potentieel van SSIBL om EC te bevorderen te onderzoeken is Lesson Study (LS). Bij deze aanpak ontwerpt een team van docenten en onderwijsonderzoekers gezamenlijk een onderzoeksles, geeft deze les terwijl ze leerlingen en hun leerprocessen observeren, reflecteren op de observaties en ervaringen, voordat ze de les aanpassen en het proces met een andere klas doorlopen. In de loop van vier jaar zijn er verschillende cycli van LS uitgevoerd. Dit proefschrift beslaat vier van deze cycli, omdat de andere werden beïnvloed door de COVID-19 pandemie, waardoor de verzamelde data van onvoldoende kwaliteit was. Samen met drie voorbereidende studies vormen deze vier cycli het belangrijkste onderdeel van het onderzoek naar het operationaliseren van EC in de lespraktijk van het natuurwetenschappelijk onderwijs.

Hoofddoel en onderzoeksvragen

Het doel van dit proefschrift is drieledig. Ten eerste willen we het huidige Nederlandse EC-begrip en de EC-praktijk beschrijven door opvattingen en ervaringen van bètadocenten en leerlingen uit de onderbouw van het voortgezet onderwijs met betrekking tot EC te onderzoeken. Vervolgens hebben we een beoordelingsinstrument ontwikkeld en gevalideerd dat zich richt op meningsvorming over EC, een nog niet eerder ontdekt beoordelingsgebied. Tot slot onderzochten we het potentieel van SSIBL om EC te bevorderen via bètaonderwijs in de onderbouw van het vo. De belangrijkste onderzoeksvraag is:

Hoe bevorder je milieubewust burgerschap in de onderbouw van het voortgezet bètaonderwijs?

Deze onderzoeksvraag is onder te verdelen in drie deelvragen:

- Hoe kunnen we de huidige opvattingen van Nederlandse docenten en leerlingen over milieubewust burgerschap karakteriseren?
- Hoe kunnen we milieubewust burgerschap valide en betrouwbaar beoordelen?
- Wat is het educatieve potentieel van *Socio-Scientific Inquiry-Based Learning* voor het bevorderen van milieubewust burgerschap?

De vijf empirische hoofdstukken van dit proefschrift beschrijven het werk dat gedaan is om EC te operationaliseren door middel van SSIBL in het bètaonderwijs. Elk van deze hoofdstukken onderzoekt een ander aspect van onderwijs voor EC. Van de ervaringen van wetenschapsdocenten en leerlingen met EC, via het ontwikkelen van een beoordelingsinstrument, tot een praktische toepassing van SSIBL voor EC in de klas, bieden deze vijf hoofdstukken de empirische basis waarmee we de hoofdonderzoeksvraag van dit proefschrift beantwoorden.

Overzicht van de vijf studies

Als voorbereiding op de studies over de klassenpraktijk keken we eerst naar de opvattingen van Nederlandse bètadocenten over EC in hun onderwijspraktijk (**Hoofdstuk 2**). Het doel van deze studie was een diepgaande, kwalitatieve blik te werpen op de huidige onderwijspraktijk van EC in Nederland. De studie richtte zich op beschrijven wat docenten in het voortgezet onderwijs denken dat duurzaamheid en burgerschap inhouden, of ze het in het curriculum herkennen, wat hun positieve en negatieve ervaringen met onderwijs voor EC zijn, wat ze proberen te bereiken met dit type onderwijs, en hoe ze het integreren in de klas. Om deze beschrijving te kunnen geven, zijn 41 Nederlandse bètadocenten geïnterviewd in een individuele, offline setting.

Analyse van de gecodeerde transcripten laat zien dat de meeste docenten de toegevoegde waarde van EC zien, maar moeite hebben om het volledig te implementeren in hun lessen. Ze vinden dat het curriculum ongeschikt is om EC te bevorderen, omdat het te veel gericht is op kennisoverdracht en kennisleerdoelen, en te weinig kritisch denken en andere vaardigheid gerelateerde leerdoelen bevat die nodig zijn voor EC. Veel van de geïnterviewde docenten vinden deze meer affectieve en competentiegerichte leerdoelen geschikter en belangrijker in duurzaamheidsonderwijs. Ze willen bijvoorbeeld het bewustzijn van leerlingen bevorderen en hen toerusten met de juiste competenties om zinvolle beslissingen te nemen en actie te ondernemen voor een duurzamere wereld.

De geïnterviewde bètadocenten zien sommige aspecten van onderwijs voor EC als een uitdaging. Hieronder vallen het begeleiden van het meningsvormingsproces, het omgaan met waarden, eerdere ervaringen, emoties en meningen die leerlingen kunnen hebben met betrekking tot duurzaamheid, de door docenten ervaren desinteresse van leerlingen met betrekking tot duurzaamheid, en problemen met het definiëren van burgerschap en begrijpen

wat het zou kunnen betekenen om het op te nemen in hun lespraktijk. In het algemeen zijn de interpretaties van docenten van het concept duurzaamheid relatief beperkt, met een sterke focus op de milieudimensie en minder op de sociale en economische dimensies.

In het algemeen wijzen de resultaten van deze studie op een behoefte aan een geschikter curriculum met een sterkere focus op competentieontwikkeling met betrekking tot EC, naast de kenniscomponent die al aanwezig is. Bovendien blijkt er behoefte te zijn aan professionele ontwikkeling van docenten, waarbij de mogelijkheden van burgerschapsvorming en het omgaan met complexe affectieve componenten met betrekking tot EC in het bètaonderwijs worden verkend.

De tweede studie betrof Nederlandse leerlingen in de onderbouw van het voortgezet onderwijs, met als doel een diepgaande karakterisering te geven van de opvattingen van leerlingen over duurzaamheid (**Hoofdstuk 3**). Een dergelijke beschrijving kan gebruikt worden als input voor bètadocenten bij het ontwerpen van lessen die gericht zijn op het bevorderen van EC. In dit proefschrift hebben we de resultaten van dit onderzoek gebruikt in de twee *Lesson Studies* die beschreven zijn in Hoofdstuk 5 en 6. Om EC van leerlingen te beschrijven, hielden we individuele, semigestructureerde, offline interviews met 42 leerlingen uit de onderbouw van het vo. De vragen hadden betrekking op hun kennis over duurzaamheid, houdingen, gedrag en reflectie. Samen vormen deze componenten een beschrijving van het EC van leerlingen.

Data-analyse laat zien dat veel Nederlandse leerlingen zich zorgen maken over de toekomst van de planeet vanwege actuele duurzaamheidsvraagstukken zoals klimaatverandering. Hoewel alle leerlingen van mening zijn dat duurzaamheidsvraagstukken al invloed hebben op mensen elders, geeft slechts een kleine groep aan problemen in hun directe omgeving te ervaren. Bovendien zijn de problemen die leerlingen dicht bij huis ervaren minder ernstig dan de problemen die leerlingen denken dat mensen in andere delen van de wereld ervaren. Tot slot denken leerlingen dat problemen alleen negatieve gevolgen zullen hebben voor toekomstige generaties.

Leerlingen zijn geïnteresseerd in mogelijke oplossingen die ze zelf kunnen implementeren. Ze noemen kleine, lokaal georiënteerde duurzame acties zoals het oprapen van zwerfvuil en energiebesparing thuis, maar ze vinden dat er grotere acties nodig zijn om problemen op te lossen. Ze lijken vaak een vorm van EC aan te nemen die getypeerd kan worden als 'persoonlijk verantwoordelijk burgerschap', zonder collectieve en publieke acties. Ze bespreken duurzaamheid niet met vrienden, maar ongeveer de helft van hen bespreekt duurzaamheid thuis of op school.

Onze data geven nuanceringen en redenen achter conclusies uit kwantitatieve studies die voorheen ons begrip van EC bij leerlingen domineerden. Voor bètadocenten en -lerarenopleiders toont dit onderzoek aan dat het relevant is om te focussen op collectieve en publieke acties die leerlingen kunnen ontwerpen en waaraan ze kunnen deelnemen. Het erkennen van zorgen en problemen dicht bij huis is ook belangrijk voor onderwijs gericht op het bevorderen van EC.

Het volgende onderzoek, beschreven in **Hoofdstuk 4**, betreft de ontwikkeling en validatie van een beoordelingsinstrument gericht op het meten van EC, de *Environmental Citizenship Opinions* (ECO) vragenlijst. De ECO-vragenlijst richt zich op algemene burgerschapscomponenten, belangrijke duurzaamheidscompetenties zoals systeemdenkcompetentie en normatieve competentie, en aspecten van *Socio-Scientific Reasoning*. Door deze domeinen te combineren, biedt het een noodzakelijke innovatie, aangezien deze verschillende aspecten van EC tot nu toe niet in één gevalideerd meetinstrument zijn verwerkt. Het oorspronkelijke model bestaat uit EC-kennis, EC-attitudes, EC-vaardigheden, EC-reflectie en complexiteit van EC-vraagstukken, en legt de nadruk op meningsvorming als een hoofdcomponent van EC.

De ECO-vragenlijst werd gevalideerd door middel van een pilotronde (758 leerlingen) en een daaropvolgende grootschalige studie (781 leerlingen uit de onderbouw van het vo). Verschillende rondes van *Confirmatory Factor Analysis* resulteerden in een eindmodel van 38 items verdeeld in 7 eerste orde en 5 tweede orde constructen. De uiteindelijke *model fit indices* laten een bijna uitstekende kwaliteit van ons model zien. Berekeningen van de relatieve bijdrages van elk van de vijf hoofdconstructen aan EC tonen aan dat attitudes en reflectievaardigheden de belangrijkste bestanddelen zijn. Terwijl de centrale rol van attitudes voor EC al eerder beschreven is in de literatuur, is de vergelijkbare relevantie van reflectie als subconstruct van EC van leerlingen minder goed gedocumenteerd.

De resultaten van deze studie tonen aan dat de ECO-vragenlijst een waardevol, valide en betrouwbaar instrument is om EC van leerlingen te meten. Mogelijke toepassingen van de vragenlijst in de praktijk zijn onder andere het monitoren van de EC-ontwikkeling van leerlingen en het ondersteunen van docenten tijdens de uitdagende taak van effectief onderwijs voor EC in en buiten de klas. Zelf gebruiken we de vragenlijst tijdens de laatste LS-cyclus, die beschreven staat in Hoofdstuk 6.

Na de voorgaande achtergrondstudies richtten we ons op het bestuderen van de mogelijkheden van SSIBL als onderwijsaanpak om EC te bevorderen via het bètaonderwijs (**Hoofdstuk 5**). Dit hoofdstuk beschrijft de eerste Lesson Study-cyclus, die een klassikaal perspectief biedt op het bevorderen van EC-aspecten zoals belangrijke duurzaamheidscompetenties. Het LS-team bestond uit zes wetenschapsdocenten en drie onderwijsonderzoekers. Er werd een op SSIBL gebaseerde lesmodule over het delven van elementen voor smartphones ontwikkeld en getest in twee klassen van de onderbouw van het vo. De dataverzameling bestond uit audio-opnames van de lessen, interviews met leerlingen na de les, ontwikkel- en reflectiegesprekken met het LS-team en schriftelijk lesmateriaal van de leerlingen.

De resultaten laten zien dat de module leerlingen in staat stelt om de complexiteit van het onderwerp in te zien, bijvoorbeeld met betrekking tot de drie dimensies van duurzaamheid. De module stimuleert leerlingen bovendien om meerdere perspectieven op het vraagstuk te gebruiken, bijvoorbeeld van verschillende belanghebbenden. Deze waren het sterkst aanwezig in hun groepsdiscussies en tijdens 'beweegredeneren', waarbij leerlingen collectief een

vraagstuk verkennen door door het klaslokaal te bewegen. Meningsvorming en besluitvorming worden ook gestimuleerd, maar leerlingen zijn zich niet bewust van de stappen die ze nemen bij het vormen van een mening.

Deze studie identificeerde ook een aantal uitdagingen bij het implementeren van SSIBL om EC te bevorderen door middel van het bètaonderwijs. Leerlingen uit beide klassen hadden moeite om de bevindingen uit hun onderzoek te gebruiken om oplossingen te ontwikkelen, wat laat zien dat de stap van de Zoek uit-fase van SSIBL naar de Handel-fase meer ondersteuning vereist. Docenten vonden dat ze moesten voorkomen dat leerlingen snel conclusies trokken, maar eerst kritisch moesten reflecteren op hun ontwikkelde handelingsstrategieën.

Het in dit hoofdstuk beschreven werk laat zien dat SSIBL het potentieel heeft om bepaalde aspecten van EC te bevorderen, bijvoorbeeld aspecten die te maken hebben met het waarderen van de complexiteit van kwesties en het innemen van perspectieven. Hiermee vormt het een geschikte aanpak om bètadocenten te ondersteunen bij de uitdagende taak om EC in hun onderwijspraktijk te implementeren.

De studie beschreven in **Hoofdstuk 6** heeft opnieuw betrekking op LS-cycli gebaseerd op SSIBL, gericht op het bevorderen van EC door middel van bètaonderwijs. Deze studie gaat een stap verder dan de studie uit hoofdstuk 5 door de focus op opnames van leerlingdiscussies als primaire databron en door de langere periode die in de klas werd besteed aan het bevorderen van EC-competenties. EC-competenties zoals meningsvorming, besluitvorming en actie ondernemen met betrekking tot duurzaamheidsvraagstukken vormen het centrale onderzoeksthema. Het LS-team van vier bètadocenten en drie natuurwetenschappelijk vakdidactisch onderzoekers ontwikkelden, testten, observeerden, herontwierpen en herimplementeerden gezamenlijk vijf lessen, gebaseerd op de fasen Vraag, Zoek uit en Handel van SSIBL. De data werden verzameld in twee klassen van verschillende scholen, met bronnen als geluidsopnamen van groepsdiscussies met leerlingen, interviews met leerlingen na de les en verzamelde leerlingenboekjes.

Data-analyse toont aan dat SSIBL succesvol was in het bevorderen van aspecten van EC die gerelateerd zijn aan de belangrijkste duurzaamheidscompetenties, zoals systeemdenken, strategische competentie en normatieve competenties. Leerlingen stelden een grote verscheidenheid aan vragen, bijvoorbeeld over visies, oorzaken, gevolgen, systeemdenken en strategieën. De data tonen verder aan dat de lessen aspecten van SSR stimuleerden, zoals leerlingen die de complexiteit van de vraagstukken inzagen en leerlingen die perspectieven innamen. Componenten van actievaardigheid zoals kennis van actiemogelijkheden, probleemkennis, actievaardigheden en kritiek werden ook vaak waargenomen.

Ondanks deze successen blijven er uitdagingen bestaan bij het stimuleren van aspecten van actievaardigheid bij leerlingen, zoals positieve resultaatverwachting en actiebereidheid, hoewel de databronnen op dit vlak tegenstrijdige bewijzen laten zien. Terwijl resultaatverwachting en

bereidheid vaak negatief waren tijdens de interviews met leerlingen, laat één van de lessen positieve aspecten zien van deze componenten van actievaardigheid.

Over het geheel genomen bevestigt dit onderzoek de bevindingen uit Hoofdstuk 5, door opnieuw de geschiktheid van SSIBL als onderwijsaanpak voor het implementeren van EC in het bètaonderwijs in de onderbouw van het vo aan te tonen. Hoewel SSIBL niet succesvol is in het stimuleren van alle aspecten van EC, bevordert het wel een brede en diverse set van EC-aspecten die leerlingen uitrusten met noodzakelijke competenties voor effectieve meningsvorming over duurzaamheid, besluitvorming en het nemen van actie.

Slotopmerkingen

Dit proefschrift was gericht op het bestuderen van EC en opname van dit concept in de lespraktijk van het bètaonderwijs in de onderbouw van het vo. Door middel van vijf hoofdstudies zijn de opvattingen over EC van Nederlandse wetenschapsdocenten en leerlingen uit de onderbouw beschreven, is een beoordelingsinstrument voor EC ontwikkeld, en is het potentieel van SSIBL om EC te bevorderen door middel van bètaonderwijs onderzocht. Over deze thema's kunnen verschillende conclusies worden getrokken.

Ten eerste hebben we gezien dat hoewel de meeste docenten duurzaamheid en burgerschap belangrijk vinden, ze een gebrek aan ondersteuning vanuit het curriculum ervaren en zich minder voorbereid voelen met betrekking tot het opnemen van normatieve aspecten van EC in hun onderwijspraktijk. Hun leerlingen hebben een complexe relatie met duurzaamheid: aan de ene kant zijn ze bezorgd en willen ze weten wat ze kunnen doen om te helpen, aan de andere kant hebben ze het gevoel dat problemen pas ergens anders of ergens in de toekomst ernstig zullen worden en zijn ze beperkt in hun denken tot voornamelijk individuele acties en acties in de privésfeer.

SSIBL's fasen van Vraag, Zoek uit en Handel bieden docenten ondersteuning bij het implementeren van EC in de klas en bieden leerlingen de mogelijkheid om belangrijke EC-competenties te ontwikkelen. Centraal in de SSIBL-benadering staat de implementatie van de dialoog als een onderwijs- en leeractiviteit. Een open en inclusieve dialoog dwingt een normatieve dekking van het onderwerp af, wat een essentieel aspect is van effectieve SSIBL voor EC. Hoewel het een uitdaging kan zijn voor docenten, is het erkennen van emoties en andere affectieve componenten met betrekking tot duurzaamheidsvraagstukken belangrijk, bijvoorbeeld vanwege de rol die emoties spelen in sociaalwetenschappelijke besluitvorming en om pluralisme in de klas te waarborgen, door ervoor te zorgen dat alle stemmen worden gehoord. Het is van cruciaal belang voor het bevorderen van EC om een holistisch perspectief op het vraagstuk te bieden, door leerlingen te laten empathiseren met verschillende belanghebbenden, hun eigen standpunt naast dat van anderen te verkennen, verschillende waarden en perspectieven te erkennen en verschillende dimensies van het vraagstuk te verkennen (bv. tijd, plaats, ecologie, maatschappij, economie). Verder stellen we

voor om expliciet te focussen op de publieke sfeer en collectieve acties om het lage niveau van resultaatverwachting en effectiviteitsverwachtingen van leerlingen te verminderen. Tot slot is het belangrijk om ervoor te zorgen dat de doelen van de acties van leerlingen haalbaar zijn. Het is onwaarschijnlijk dat leerlingen klimaatverandering zullen oplossen, maar ze kunnen wel succesvol zijn in het vervangen van niet-duurzame processen binnen hun school of gemeente door duurzamere alternatieven.

Dit proefschrift leidde tot verschillende richtingen voor vervolgonderzoek. Ten eerste was de overgang van de Zoek uit-fase naar de Handel-fase van SSIBL moeilijk voor leerlingen. Een deel van de diepgang en nauwkeurigheid van de systemen die leerlingen van het probleem hadden gemaakt, ging verloren bij het vertalen ervan naar actiestrategieën. Het zou de moeite waard zijn om te onderzoeken hoe dit proces van actie ondernemen kan worden vergemakkelijkt. Ten tweede zouden de relatief lage niveaus van actiebereidheid en resultaatverwachting van de leerlingen onderzocht moeten worden. Wat veroorzaakt deze barrières voor de actievaardigheid van leerlingen? Hoe zou deze situatie verbeterd of zelfs voorkomen kunnen worden? Ten slotte zouden we het leerproces van de docenten tijdens de LS-cycli kunnen onderzoeken om te onderzoeken hoe we docenten kunnen ondersteunen bij het implementeren van SSIBL voor EC.

Met dit proefschrift is de geschiktheid van SSIBL aangetoond als onderwijsaanpak voor het bevorderen van EC middels het bètaonderwijs. We hebben hiermee een kleine maar belangrijke stap gezet in het toerusten van leerlingen met de benodigde competenties om actie te ondernemen met betrekking tot duurzaamheidsvraagstukken. Uiteindelijk is dit een voorwaarde voor de transitie naar een duurzamere toekomst voor iedereen.

Summary in English

There is a growing worldwide need to replace unsustainable processes with greener, more sustainable alternatives. This transition causes issues that involve scientific and societal implications, that concern different stakeholders, are prone to controversy and involve risk assessment, and do not have clear-cut solutions. Current secondary school curricula place a responsibility on science education to equip students with the necessary competences to form informed opinions regarding these issues, to make corresponding decisions, and take appropriate action. With this, curricula are aligned with the aims of Environmental Citizenship (EC).

During the opinion-forming, decision-making, and action-taking processes, an Environmental Citizen considers dimensions such as time (past, present, and future), and place (local, regional, global), whilst taking into account ecological, economic, and social considerations. Five key competences for sustainability have been singled out as being of particular importance for EC. These are: i) systems thinking competence, which concerns mapping the issue and its different components; ii) anticipatory competence, which deals with possible future scenarios and alternatives; iii) normative competence, concerning desirability of current and future situations and allowing for multiple perspectives; iv) strategic competence, involving possible ways to take action and to reach desirable futures; and v) interpersonal competence, dealing with working together, consensus and empathy. Additionally, an Environmental Citizen masters the concept of Socio-Scientific Reasoning (SSR), involving using different

perspectives, critical thinking, appreciation for complexity, and appreciation for ongoing inquiry of issues. Finally, EC entails Action Competence, involving action-knowledge, action-skills, willingness to take action, and positive outcome and self-efficacy expectations.

Fostering these EC competences and associated higher-order thinking skills poses challenges for science teachers. This is especially true for the normative character of these issues and how to implement them in science education. A possible teaching approach that can support science teachers during implementation of EC in their educational practice is Socio-Scientific Inquiry-Based Learning (SSIBL). It consists of three phases: i) Ask, during which a need-to-know prompts students to ask authentic questions regarding Socio-Scientific Issues, ii) Find out, during which students perform scientific, personal, and social inquiry into the issue, and iii) Act, during which students develop an action strategy and take corresponding action. Despite its promise for fostering EC, it has not been extensively tested in educational practice.

The main research approach that we used in this dissertation to investigate SSIBL's potential to foster EC is Lesson Study (LS). Through this approach, a team of science teachers and science educational researchers collectively designs a research lesson, teaches this lesson whilst observing students and their learning processes, reflecting on the observations and experiences, before adapting the lesson and going through the process with another class. Over the course of four years, several cycles of LS have been carried out. In this dissertation, we report on four of these cycles, since the others were affected by the COVID-19 pandemic, causing the collected data to be of insufficient quality. Together with three preparatory studies, these four LS-cycles form the main body of research on operationalising EC in science education practice.

Main aim and research questions

The aim of this dissertation is threefold. First, we aim to describe current Dutch EC understanding and practice by exploring views and experiences of science teachers and lower secondary students regarding EC. We followed this with the development and validation of an assessment instrument focussing on EC opinion-forming, a previously uncovered area of assessment. Finally, we explored the potential of SSIBL to foster EC through science education at lower secondary level. The main research question is:

How to foster environmental citizenship in lower secondary science education?

This research question is divided in three sub-questions:

- How can we characterise current Dutch teachers' and students' views on environmental citizenship?
- How can we validly and reliably assess environmental citizenship?
- What is the educational potential of Socio-Scientific Inquiry-Based Learning for fostering environmental citizenship?

The five empirical chapters of this dissertation describe the work done towards operationalizing EC through SSIBL in science education. Each of these chapters explores a different aspect of education for EC. From science teachers' and students' experiences with EC, via developing an assessment instrument, to a practical application of SSIBL for EC in the classroom, these five chapters provide the empirical basis with which we answer the main research question of this dissertation.

Overview of the five studies

To set the stage for the classroom studies, we first looked into Dutch science teachers' views regarding EC in their teaching practice (**Chapter 2**). This study aimed to provide an in-depth, qualitative view on current EC education practices in the Netherlands. It focussed on describing what secondary science teachers think sustainability and citizenship entail, whether they recognise it in the curriculum, what their positive and negative experiences with education for EC are, what they try to reach with this type of education, and how they incorporate it in the classroom. To provide this description, 41 Dutch science teachers were interviewed in an individual, face-to-face setting.

Analysis of the coded transcripts shows that most teachers see the added value of EC but struggle to fully implement it in their teaching. They think the curriculum is unsuitable to foster EC, since it focusses too much on knowledge transfer and knowledge learning aims, and does not include enough critical thinking and other skills-related learning aims that are necessary for EC. Many of the interviewed teachers think these more affective and competence driven learning aims are more suitable and more important in sustainability education. They for instance wish to foster student awareness and equip students with the appropriate competences to make meaningful decisions and take action for a more sustainable world.

The interviewed science teachers furthermore see some aspects of education for EC as challenging. These include guiding the opinion-forming process, dealing with values, previous experiences, emotions, and opinions students might have regarding sustainability, teacher perceived student disinterest regarding sustainability, and difficulties with defining citizenship and understanding what it might mean to include it in their teaching practice. In general, teacher interpretations of the concepts of sustainability are relatively narrow, focussing strongly on the environmental and less on the social and economic dimensions.

Overall, results from this study identify a need for a more suitable curriculum with a stronger focus on competence development regarding EC, next to the knowledge-component that is already present. Furthermore, it shows a need for teacher professional development that includes exploration of the possibilities with citizenship education and dealing with complex affective components regarding EC in science education.

The second study concerned Dutch lower secondary students, with its aim being to provide an in-depth characterisation of student views regarding sustainability (**Chapter 3**). Such a description can be used as input for science educators when designing lessons that aim to foster EC. In this dissertation, we used results from this study in the two Lesson Studies described in Chapters 5 and 6. To describe student EC, we conducted individual, semi-structured, face-to-face interviews with 42 lower secondary students. Questions related to their sustainability knowledge, attitudes, behaviour, and reflection. Together, these components form a description of student EC.

Data analysis shows that many Dutch students worry about the future of the planet because of current sustainability issues such as climate change. Whilst all students believe sustainability issues already affect people elsewhere, only a small group of students reports experiencing issues in their direct surroundings. Furthermore, issues students experience close to home are less severe than issues students think are felt by people in other parts of the world. Finally, students think issues will only negatively affect future generations.

Students are interested to learn possible solutions that they can implement themselves. They mention performing small, locally oriented sustainable behaviours such as picking up litter and conserving energy at home, yet they feel larger solutions are needed to solve issues. They often seem to adopt a form of EC that can be typified as personally responsible citizenship, without collective and public sphere actions. They do not discuss sustainability with friends, but about half of them discusses sustainability at home or at school.

Our data provide qualifiers and reasons behind conclusions drawn from quantitative studies that previously dominated our understanding of student EC. For science educators, this study shows it is relevant to focus on collective and public action-taking that students can develop and partake in. Acknowledging worry and issues close to home is also important for education aimed at fostering EC.

The next study, described in **Chapter 4**, concerns the development and validation of an assessment instrument aimed at measuring EC, the Environmental Citizenship Opinions (ECO) questionnaire. The ECO-questionnaire focusses on general citizenship components, key sustainability competences such as systems thinking competence and normative competence, and Socio-Scientific Reasoning aspects. By combining these domains, it provides a needed innovation as previously these different aspects of EC have not been covered in one single, balanced and validated measurement instrument. The initial model consists of EC knowledge, EC attitudes, EC skills, EC reflection and complexity of EC issues, and places an emphasis on opinion-forming as a main component of EC.

The ECO-questionnaire was validated through a pilot round (758 students) and a subsequent large-scale study (781 lower secondary students). Several rounds of Confirmatory Factor Analysis resulted in a final model of 38 items divided in 7 first order and 5 second order constructs. The final model fit statistics indicate near excellent quality of our model. Calculations on the

relative attribution of each of the five main constructs to overall EC highlight that attitudes and reflection skills are the most important constituents. Whereas the central role of attitudes for EC has been previously described in literature, the similar relevance of reflection as a subconstruct of student overall EC is less well-documented.

The results from this study show that the ECO-questionnaire is a valuable, valid and reliable tool to measure EC of students. Possible applications of the questionnaire in practice include monitoring student's EC development and as such supporting teachers during the challenging task of effective teaching for EC in and outside the classroom. We use the questionnaire in the final LS-cycle, described in Chapter 6.

After the previous background studies, we set out to study the potential of SSIBL as a teaching approach to foster EC through science education (**Chapter 5**). This chapter describes the first Lesson Study cycle, which provides a classroom perspective on fostering EC aspects such as key sustainability competences. The LS-team consisted of six science teachers and three educational researchers. A SSIBL-based science lesson module about the mining of elements for smartphones was developed and tested in two lower secondary classes. Data collection consisted of audio recordings of the lessons, of post-lesson student interviews, of development and reflection discussions with the LS-team, and written educational materials from the students.

Results show that the module enables students to appreciate the complexity of the issue, for instance related to the three dimensions of sustainability. The module furthermore stimulates students to use multiple perspectives on the issue, for instance of different stakeholders. These were most strongly present in their group discussions and during the arguments in motion activity, in which students collectively explore an issue by moving through the classroom. Opinion-forming and decision-making are stimulated too, yet students are not aware of the steps they take when forming an opinion.

This study also identified some challenges when implementing SSIBL to foster EC through science education. Students from both classes struggle to use findings from their inquiry to develop solutions, which shows the step from the Find out-phase of SSIBL to the Act-phase demands further support. Teachers felt they needed to prevent students from quickly jumping to conclusions, but first critically reflect on their developed action strategies.

The work described in this chapter shows that SSIBL has potential to foster certain aspects of EC, for instance those related to appreciating complexity of issues and perspective taking. It therefore could support science teachers during the challenging task of implementing EC in their teaching practice.

The study described in **Chapter 6** again concerns SSIBL-based LS-cycles aimed at fostering EC through science education. It goes beyond the scope of the study from Chapter 5 by its focus on student group discussion recordings as a primary data source, and by its extended period

of time spent in the classroom on fostering EC competences. EC competences such as opinion-forming, decision-making and action-taking regarding sustainability issues are the central research theme. The LS-team of four science teachers and three science education researchers collectively developed, tested, observed, redesigned, and reimplemented five lessons, based on SSIBL's phases of Ask, Find out, and Act. Data was collected from two classes of different schools, with sources including audio recordings of student group discussions, post-lesson interviews with students, and collected student booklets.

Data analysis shows that SSIBL was successful in fostering aspects of EC related to the key sustainability competences, such as systems thinking, strategic competence, and normative competences. Students posed a broad diversity of questions, for instance related to visions, causes, effects, systems thinking, and strategies. The data furthermore provide evidence that the lessons stimulated Socio-Scientific Reasoning aspects such as students appreciating the complexity of the issues and student perspective taking. Action competence components such as knowledge of action possibilities, problem knowledge, action skills, and criticism were also often observed.

Despite these successes, some challenges remain with fostering student action competence aspects such as positive outcome expectancy and willingness to act, although data sources show conflicting evidence on this regard. Whilst outcome expectancy and willingness were often negative during student interviews, one of the lessons does show positive aspects of these components of action competence.

Overall, this study confirms findings from Chapter 5, in solidifying SSIBL's suitability as an educational approach for implementing EC in science education at lower secondary level. Even though it is not successful in fostering all aspects of EC, it does promote a broad and diverse set of EC aspects that equip students with necessary competences for effective sustainability opinion-forming, decision-making, and action-taking.

Concluding remarks

This dissertation aimed to study EC and its inclusion in science education practice at lower secondary level. Through its five main studies, the views regarding EC from Dutch science teachers and lower secondary students were described, an assessment instrument for EC was developed, and SSIBL's potential to foster EC through science education was researched. Regarding these themes, several conclusions can be drawn.

First, regarding the teachers, we found that while most teachers think sustainability and citizenship are important, they experience a lack of support from the curriculum and feel less prepared regarding inclusion of normative aspects of EC in their teaching practice. Their students have a complex relationship with sustainability, on the one hand being worried and wanting to know what they can do to help, on the other hand feeling issues will only become

serious somewhere else or sometime in the future and being limited in their thinking to mainly individual and private sphere actions.

SSIBL's phases of Ask, Find out, and Act provide support for teachers when implementing EC in the classroom, and offer students the opportunity to develop important EC competences. Central to the SSIBL approach is implementation of dialogue as a teaching and learning activity. An open and inclusive dialogue enforces normative coverage of the topic, which is an essential aspect of effective SSIBL for EC. Whilst it can pose challenges for teachers, acknowledging emotions and other affective components regarding sustainability issues is important, for instance because of their role emotions in socio-scientific decision-making and to ensure pluralism in the classroom, making sure all voices are heard. It is crucial for fostering EC to provide a holistic perspective on the issue, making students consider different stakeholders, exploring their own point of view next to that of others, acknowledging different values and perspectives, and including different dimensions of the issue (e.g., time, place, ecology, society, economy). Furthermore, we suggest explicitly focussing on public sphere and collective actions to mitigate low levels of Outcome expectancy and Efficacy expectations students might have. Finally, it is important to ensure the goals of student actions are attainable. It is unlikely that students will solve climate change, yet they might be successful in replacing unsustainable school or community processes with more sustainable alternatives.

Several avenues for further research have opened up as a result of this dissertation. First, the transition from the Find out-phase into the Act-phase of SSIBL was difficult for students. Some of the depth and rigor of the systems students had made of the issue was lost when translating these into action strategies. It would be worthwhile to perform research in how to facilitate this action-taking process. Second, the relatively low levels of Willingness to take action and Outcome expectancy of the students should be researched. What causes these barriers to student Action competence? How could this situation be ameliorated or even prevented? Finally, it would improve our understanding of how to support science teachers in implementing SSIBL for EC if we investigated the teacher learning process during the LS-cycles.

This dissertation has identified SSIBL as a suitable educational approach for fostering EC through science education. We have hereby made a small but important step towards equipping students with the necessary competences to take action regarding sustainability issues. Ultimately, this is a prerequisite for the transition towards creating a more sustainable future for all.

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En de Z is van: Lieven – bij jou kan ik altijd.

Lieve allemaal: het is gezien, het is niet onopgemerkt gebleven.

Curriculum vitae

Michiel van Harskamp was born on 8 November, 1990, in Utrecht, the Netherlands. He completed his secondary education at the St. Bonifatiuscollege in Utrecht in 2009, after which he went to study Biology at Utrecht University. He also followed Art history courses during his Bachelor, and obtained his degree in 2013. He obtained his Master's degree in Science Education and Communication at Utrecht University's Freudenthal Institute in 2016.

After completing his Master, Michiel joined the SYNENERGENE and PARRISE EU projects, both of which concerned the societal impact of science and technology. For these projects, he collected data at schools, interviewed teachers, developed and applied questionnaires, developed lesson materials, performed lesson observations, gave workshops for teachers and educators, and organised conferences, among others. During the PARRISE project, the SSIBL approach (Socio-Scientific Inquiry-Based Learning) was developed. Upon termination of PARRISE in 2017, Michiel performed other research tasks at the Freudenthal Institute and helped organize the LERU Blended Conference of 2018.

After these projects, Michiel acquired NRO funding which enabled him to perform his PhD research at the Freudenthal Institute. His PhD research focussed on fostering Environmental Citizenship through science education at Lower Secondary level. To do so, the project used the educational approach developed in the PARRISE project, SSIBL. Together with a team of six chemistry and biology teachers, Michiel performed four main and multiple subsidiary cycles of Lesson Study. These involved working together with the teachers to design, implement, observe, and evaluate lessons and analyse the collected data in order to study student development of EC competences. Next to these LS cycles, he interviewed science teachers and students about their EC and designed an assessment tool for opinion-forming related to EC.

During his PhD, Michiel took part in the application process for two further EU proposals. One of these, the IMP>ACT project, was funded in 2023, and is scheduled to run from January 2024 till December 2027, during which Michiel will be employed as a postdoc researcher at the Freudenthal Institute. IMP>ACT will focus on impact assessment of Action Competence in sustainability in both formal and informal education throughout Europe. Currently, Michiel is employed at the University of Antwerp, at the Edubron research group, where his work is aimed at assessment of Action Competence in Sustainable Development in a Flemish context.

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Education for Environmental Citizenship (EC) aims to equip students with the competences for sustainable opinion-forming, decision-making, and action-taking. Yet because of the complexity of sustainability issues, it is challenging for science teachers to foster EC. This dissertation describes how Socio-Scientific Inquiry-Based Learning (SSIBL) was tested for its potential to foster EC through science education at lower secondary level.

Firstly, this dissertation describes current EC practice, and views and experiences of science teachers (Chapter 2) and lower secondary students (Chapter 3) regarding EC. The second aim is developing and validating an assessment instrument focussing on EC opinion-forming (Chapter 4). Finally, this dissertation explores the potential of SSIBL to foster EC through science education at lower secondary level, by means of several cycles of Lesson Study (Chapters 5 and 6).

This dissertation shows that SSIBL's phases of Ask, Find out, and Act enable students to practice EC competences in the context of science education. This is valuable to science teachers and teacher educators who wish to incorporate EC in their practice, and for researchers and policy makers with an interest in EC. Findings from this dissertation provide directions for how to foster Environmental Citizenship through science education at lower secondary level.

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