# Biology Students' Morality When Engaged With Moral Dilemmas in the Human-Nature Context

Tore van der Leij[1]*, Lucy Avraamidou[1], Arjen Wals[2] and Martin Goedhart[1]

[1]*Institute for Science Education and Communication, University of Groningen, Groningen, Netherlands, [2]Education and Learning Sciences, Wageningen University, Wageningen, Netherlands*

Framed within the Four Component Model (FCM) of morality, this case study investigates the nature of Dutch 15–16 years old biology students' morality in socioscientific issues in the human-nature context. In doing so, we discuss the morality of 12 students with data collected through individual semi-structured interviews following the implementation of a specially-designed curriculum. During the interviews the students discussed a moral dilemma related to the rehabilitation of seals. The findings indicate that students demonstrated aspects of all four FCM components. The students placed themselves in the perspectives of involved stakeholders, both affectively and cognitively. In addition, the students exhibited both rationality-based and emotion-based moral reasoning. A number of students experienced an "inner conflict" between cognitive and emotional reasoning, which affected their moral motivation and–as such–represented their moral reflection process. Students' moral emotions were often decisive in their moral decision-making. Among the different kinds of moral emotions (compassion, guilt, duty, respect), compassion appeared most. The findings are discussed alongside implications for future research with a focus on encouraging aspects of students' morality, which are an important part of citizenship skills.

Keywords: morality, socioscientific issues, biology education, four component model of morality, human-nature context

## INTRODUCTION

The grand challenges of our times, whether they are related to issues like climate change, loss of biodiversity, nano- and micro-plastics or responding to a pandemic, are not only highly complex but they also are characterized by a high level of ambiguity and uncertainty. Trying to resolve such challenges has proven to be difficult, as there is no universal agreement about the extent to which these issues are considered problematic, and about their underlying causes and their solutions. This cocktail of complexity, ambiguity, uncertainty and anxiety can easily become toxic when people are prone to simplification, polarization and manipulation, they lack the ability to distinguish between scientific evidence and ungrounded claims and fail to see how values and ethics play into the way these challenges are perceived.

Although these challenges are increasingly being addressed in contemporary education, little attention is paid to students' values, ethics and moral reasoning (e.g., Zeidler and Keefer, 2003; Zeidler et al., 2005; Jickling et al., 2006; Corrigan et al., 2007; Reiss, 2008; Fowler et al., 2009; Simonneaux, 2013). The study reported in this paper seeks to address this shortcoming by investigating the nature of secondary biology students' morality around the–often

painful–relationship between humans and nature. By obtaining more insight into the nature of students' morality, we intend to contribute to research and teaching aimed at developing students' morality in science education.

Discussions and decisions about some of the grand questions of our times, like, how to curb carbon emissions, how to feed the world, and how to make sure future generations can live well on the Earth, are all underpinned by values and ethics and involve engaging and reasoning in moral dilemmas. Whereas earlier approaches to science education, such as the Science-Technology-Society (STS) approach (e.g., Fensham, 1988) and the subsequent Science-Technology-Society-Environment (STSE)-approach (e.g., Pedretti, 2003; Pedretti, 2005), emphasized the impact of decisions in science and technology on society, they paid little attention to engaging students in how values, ethics and moral reasoning influence the STS(E)-interfaces.

This changed with the introduction of socioscientific issues (SSI) in science education, which highlight the "ethical dimensions of science, the moral reasoning of the child, and the emotional development of the student" (Zeidler et al., 2002; p.344). SSIs are typically value-laden as they possess conceptual ties to science content and to individuals' moral considerations, and they have implicit and/or explicit ethical components that require moral reasoning (e.g., Zeidler, 2015). Since the introduction of SSI in science education, several science education researchers have emphasized the importance of enabling students to reflect on their values, and to engage in moral dilemmas (e.g., Gough, 2002; Grace and Ratcliffe, 2002; Zeidler and Keefer, 2003; Oulton et al., 2004; Zeidler et al., 2005; Nielsen, 2012; Corrigan et al., 2020). Likewise, nowadays many national curricula and educational policies (e.g., NRC, 2012; ACARA, 2021) as well as international education guidelines (e.g., European Commission, 2015; P21, Partnership for 21st Century Learning, 2015; UNESCO, 2016) stress that education ought to enable students to engage with values and moral dilemmas.

Over the years, quite some empirical research has been conducted on guiding and encouraging students' morality in secondary science education (e.g., Kolstø, 2006; Grace, 2009; Bencze et al., 2012; Berne, 2014; Van der Leij et al., 2021). Despite the utility of these studies in providing insights into students' morality, one limitation that cuts across them is that they focused only on a single or a few aspects of morality (Van der Leij et al., 2021). In the research reported here, this limitation is addressed by examining all morality components and hence obtain a more comprehensive understanding of students' morality. In doing so, we aim to respond to the following research question: What is the nature of upper secondary biology students' morality when engaged with moral dilemmas in the human-nature context?

## Context: Citizenship, Morality and SSI in Netherlands

Developments in moral education during the last decade in Netherlands are part of developments in the Western world

and of worldwide globalization. Following a period of a relatively individualistic approach to citizenship, in Netherlands there is a renewed interest in the "moral task of education" (Tem Dam and Van der Rest, 2011; Veugelers, 2011). An individualistic approach to citizenship was partly due to the disappearance of institutions with a socializing function, such as the abolition of the compulsory military service, and the trend of secularization leading to the decrease of members of religious communities. At the same time, education is regarded as a "strong moral education institute" (Veugelers, 2011; cf. Tem Dam and Van der Rest, 2011, 2011).

Currently, in Netherlands schools are obliged to contribute to the development of students' citizenship (SLO, 2021), which emphasizes the importance of the moral task of education (Veugelers, 2011). The contribution of learning goals for upper secondary science education to students' morality is limited to the development of their "skill" of arriving at a (moral) judgment: "a (student) is able to express a reasoned judgment about a situation in nature or a technical application, at the same time being able to differentiate between scientific arguments, normative social considerations and personal views" (SLO, 2012).

This study is situated in Dutch upper secondary biology education. In Dutch biology education, SSI are predominantly used as contexts in which scientific concepts are learned, while moral argumentation and decision-making regarding these issues are often omitted (Van der Zande et al., 2009).

In general, within Dutch biology education, little empirical research has been conducted on students' morality, e.g., on students' moral argumentation and decision-making (e.g., Van der Zande et al., 2009), and on teaching SSI with a focus on encouraging students' morality (e.g., Van der Zande et al., 2012). In the few cases, empirical research into students' morality was conducted within a genomics context (e.g., Boerwinkel, Knippels and Waarlo, 2011).

## Conceptual Framework
### Moral Education and Morality

Early research into students' moral development has been done by Piaget (1932) and Kohlberg (1976), Kohlberg (1986). According to Kohlberg, moral development occurs in stages related to students' ages. These stages are categorized as pre-conventional, conventional, and postconventional. Moral education should be aimed at guiding students from one stage to another. In doing so, moral education can contribute to students' moral development by confronting them with aspects of the nearest moral development stage Kohlberg (1976), Kohlberg (1986).

However, Kohlberg's work has been criticized for not having a fully comprehensive conceptualization of morality. For instance, his view of morality emphasizes rational aspects of morality, neglecting emotional aspects. Likewise, his work focusses on only a few hypothetical dilemmas, thereby neglecting the context-dependency of morality (Rest et al., 2000; Zeidler et al., 2005). Building on Kohlberg's core assumptions, Rest et al. (2000) proposed a neo-Kohlbergian approach of morality, the Four Component Model of morality (FCM), which addresses these concerns and identifies four integrated abilities as necessary

conditions for effective moral functioning (cf. Narvaez and Rest, 1995). In SSI science education, guiding and encouraging students' morality generally takes place within this comprehensive conceptualization of morality (e.g., Zeidler et al., 2005). In the following section, we expand on the FCM, which we used as an analytical framework to investigate the nature of students' morality.

In primary and lower secondary education, moral education commonly focusses on cognitive, affective or volitional aspects of values transfer. In case of a cognitive focus, information processing with regard to the presented values is emphasized (e.g., by the teacher, or by school culture, or by society). If the focus is on the affective aspect of values transfer, the values and norms that have been put forward gain personal meaning for the students. If the volitional aspect predominates, the focus is on the students' willingness to put values and norms consistently into practice. From a developmental psychological point of view, values transfer predominates moral education in primary and lower secondary education (e.g., Van der Ven, 1985).

Secondary moral education (12–18 years old students) commonly focusses on values clarification, with a focus on stimulating students' awareness and development of their own values and norms (e.g., Van der Ven, 1985). This is about cognitive ("which values occur?"), and affective awareness of values ("which feelings are associated with these values?"). Through this clarification, the students gain more insight into their ethical preferences and, also perhaps, into possible inconsistencies in their appreciations (Hermans, 1986).

Upper secondary moral education (15–18 years old students) is preferably aimed at values communication, which focusses on the values and norms present in society. "The self-evident nature" of these values and norms and their legitimacy is discussed in argumentative dialogue. Moral education following this approach contributes to learning to participate in argumentative communication about the ethical quality of the values and norms of the culture (Van der Ven, 1985; cf. Habermas, 1983; Habermas, 1990). Given the age of the participants in this study (15–16 years old), our intervention aimed at both values clarification and values communication.

## The Four Component Model of Morality

In implementing our teaching material we aimed at guiding and stimulating students' morality process. The morality process can be characterized by various components, which are described by the "Four-Component Model" of morality (Narvaez and Rest, 1995; Rest et al., 1999). In this model, four psychological processes ("components") contribute to specific moral behavior: moral sensitivity, moral reasoning and judgment, moral motivation, and moral character.

### Moral Sensitivity

(Rest et al., 1999; Bebeau, 2002), also referred to as "ethical sensitivity", is used to describe that a student senses that the SSI at stake is a moral issue. This includes the ability to imagine cause-effect chains of events, and interpret and anticipate the reactions and feelings of the different interest groups, which is often referred to as "taking perspective".

### Moral Reasoning and Judgment

Refers to proposed actions that are justifiable in a moral sense (Rest, 1984). Reiss (2008) discussed a number of ethical frameworks to decide whether a specific action is right or wrong, taking the framework's moral principles as a starting point. The ethical frameworks central to the implemented course and interviews were either based on teleological reasoning (i.e., moral reasoning based on its consequences), or on deontological reasoning (i.e., moral reasoning based on moral principles) (Mephan, 2018). These kinds of moral reasoning are mainly rational in nature. In addition, students' moral reasoning is often based on care-based considerations, or on intuitions, which we interpret as emotive-based and intuitive-based moral reasoning, respectively (cf. Sadler and Zeidler, 2005).

### Moral Motivation

Moral motivation is used to refer to the degree of commitment to taking action, valuing moral values above other values [e.g., cultural values, personal interests, (group) solidarity], and taking personal responsibility for moral outcomes (Rest et al., 1999). Moral motivation acknowledges that one may have legitimate concerns that are not compatible with the moral choice (Bebeau, 2002). Due to ambiguities and contradictions between culture and context these concerns can even lead to emotional and cognitive conflicts (Zeidler and Keefer, 2003).

### Moral Character

Moral character implies that the acting person has sufficient motivation, self-respect and self-confidence to attune her/his behavior to the chosen standard. This is influenced by "ego-control": the feeling that one could successfully intervene (according to the chosen norm) in social reality (Rest, 1984).

As we mentioned in the introduction, over the years a number of researchers have–more or less implicitly–drawn upon this framework to examine students' morality. For instance, Grace (2009) demonstrated that peer group discussions and students following a decision-making framework contributed to students' awareness of the values at stake, and therefore to their ability of taking perspective, an ability which is central to the first component of the FCM of morality (Narvaez and Rest, 1995; Rest et al., 1999). Studies by Berne (2014) and Juntunen and Aksela (2014) also provided evidence about the importance of group work. Furthermore, these studies showed that the quality of the peer group discussions was decisive for students' progression of ethical reasoning, which is central to the second morality component of the FCM.

Another set of studies showcased the importance of reflecting on personal values (Kolstø, 2006; Jones et al., 2012; Rundgren et al., 2016; Walsh and Tsurusaki, 2018) contributing to positive cognition about which values were most important to the students, which, in turn, led to a positive cognition about the knowledge to come to a decision. This awareness of personal values is central to the third morality component of the FCM.

Studies by Bencze et al. (2012) as well as by Tal and Abramovitch (2013) examined students' moral behavior. It appeared that in a pedagogical framework aimed at

student-led activism, the participating students were able to develop and implement research-informed socio-political actions (Bencze et al., 2012). Likewise, Tal and Abramovitch (2013) demonstrated that education that is "student-oriented", "constructionist", and focused on "taking a stand" contributed to students' skills to take action.

In this study we do not focus on a single or a few aspects of morality, but we attempt to examine students' morality as a whole. In the implemented course and during the interviews afterwards, students were encouraged to engage with (different) moral dilemmas in the human-nature context. We used the FCM as an analytical framework to describe the different manifestations of students' morality. In doing so, we aimed at responding to following research question: What is the nature of upper secondary biology students' morality when engaged with moral dilemmas in the human-nature context?

## METHODS

### Research Approach

This study is situated within a constructivist paradigm as it aims to understand and interpret students' morality in SSIs, seeking to inform science educators in teaching morality (Lincoln et al., 2011). We adopted a qualitative case study methodology to gain an in-depth understanding of students' morality by looking at individual students (cf. Creswell, 2014). In a specially-designed course, students were engaged in different topical SSI in the human-nature context, aimed at encouraging their morality. The data collected during this intervention were introductory essays, worksheets (with individual and group assignments), and audio recordings of group dialogues. After the intervention, semi-structured, audio-recorded interviews were conducted. Given that the data collected during the interviews were the most "rich" in terms of the different morality aspects exhibited by the students, we decided to use the interview data as a basis to investigate the nature of students' morality. In doing so, we first described the individual students' morality, after which different themes and (sub) categories emerged. Subsequently, we compared the individual students' morality, which contributed to a more comprehensive understanding of the nature of the students' morality.

### Context

For the purpose of the study a special course was designed given that lessons on morality are practically absent in the Dutch national science curriculum. The course engaged students in discussing moral dilemmas in the human-nature context by explicitly addressing all morality components.

In the preliminary phase of the intervention design, we conducted semi-structured interviews with six biology teachers, three teacher educators (biology, social studies, philosophy), two (environmental) philosophers, and an expert in green pedagogy. The purpose of the interviews was to gain insight into the needs and context with regard to guiding and stimulating morality in science education. The analysis of the interviews generated a number of design principles, which were used for the development of a prototype for teaching morality within upper secondary biology education.

Additionally, the FCM of morality informed the intervention design, aimed at encouraging the various morality aspects. Likewise, the pedagogical approach of our intervention was informed by the SSI framework (Zeidler et al., 2005), which emphasizes four areas of pedagogical importance, namely: 1) nature of science issues (e.g., students investigate the types of arguments that are used regarding the dilemmas), 2) classroom discourse issues, 3) cultural issues, and 4) case-based issues. Particularly, the latter two areas refer to aspects of morality. More specifically, in case-based issues the emphasis is on the moral aspect of SSI, which contribute to students' awareness of the moral nature of the dilemma, stimulating their moral reasoning. Central to cultural issues is the importance of mutual respect during discussions. The students become aware of their normative values which influence their moral decision-making (Zeidler et al., 2005). All four areas of pedagogical importance were taken into consideration in the design of the intervention.

The prototype was tested with a group of twelve preservice biology teachers and in a professional learning community of five experienced biology teachers. During these meetings audio recordings were made of the feedback sessions, which were transcribed and analyzed for further developing the intervention. The outcomes of the development phase of the intervention were discussed in the research team, after which implementation of a revised version of the prototype took place over a 3-month period. The intervention was carried out in three biology classes (15–16 years old students) at two schools with in total 60 students in the classes of two experienced biology teachers (both have more than 20 years of teaching experience), one of them is the first author of this paper. At the time of the intervention they were quite comfortable with organizing group activities (e.g., working together on group assignments). However, both teachers felt a strong need for the further development of stimulating and guiding students' morality in their daily biology education practice. **Table 1** presents an overview of the implemented course.

The introductory lesson focused on the role of ethics in addressing biology-related moral dilemmas, i.e., SSI within the human-nature context. In doing so, various ethical approaches were presented and how each approach could contribute to moral decision-making. The students were also introduced to the ethical matrix (cf. Mephan, 2018), a heuristic that they would use in the subsequent lessons to investigate and discuss different dilemmas with each other. In the following weeks, during one class-hour each week, the students discussed different topical moral dilemmas (see **Table 1**).

For each dilemma an ethical matrix had been developed, which included perspectives from different interest groups with their arguments and moral values. An example of an ethical matrix (excerpt) that the students used while discussing the dilemma "Should we stop eating meat, why?" is presented in **Figure 1**.

The lessons consisted of both individual and group assignments, which alternated between analytical assignments

TABLE 1 | Overview of the implemented course: Introductory lesson and the addressed moral dilemmas.

| Week | 1 | 2 | 3 | 4 | 5* | 6 |
|---|---|---|---|---|---|---|
| Topic | Introduction (ethics) | Feeding large herbivores | Return of the wolf | Meat consumption | Genetic testing | Use of neonics |

*Not in the human-nature context.

<table>
<tr><td colspan="5" align="center">"Should we stop eating meat? Why?"</td></tr>
</table>

| | Arguments from recent media publications (appreciative a/o factual?) | moral values | | |
|---|---|---|---|---|
| | | well-being (health/ welfare) | autonomy (freedom/ choice) | justice (fairness) |
| Animals | 50 percent of the pigs suffer from pneumonia; more than 70% of the fattening pigs have a growth disorder. More than 70% of the sows have a stomach condition, such as a stomach ulcer. 10% of the sows have a bladder infection. Animals are deprived of freedom. They have no possibility of performing their natural behaviour. | Animal welfare | Freedom (of natural behaviour) | Intrinsic value |
| The living environment | The meat you want to eat is at the expense of a whole bunch of other animal species. 35 percent of the biomass of mammals is taken by humans and 61 percent by livestock consumed by humans. Only 4 percent is still wild. This percentage of wild animals is further decreasing: it is estimated that around 2100 there will only be 2% wild animals left, …. One cow annually delivers just as many greenhouse gases as driving 70,000 kilometres by car, and the production of 1 kilo of beef requires a total of 15,000 litres of water. | Nature conservation | Biodiversity (self regulating) | Sustainability |

FIGURE 1 | Example of ethical matrix (excerpt) that the students used while discussing "Should we stop eating meat? Why?"

(e.g., what type of argument is central within this perspective?) and reflective assignments (e.g., which moral value is most important to you, why?). During the assignments the students could use supplementary material in which the different ethical approaches and types of arguments were explained. Likewise, they could also appeal to the teacher who had a non-central, supportive role.

## Role of the Researcher

The first author served as a teacher-researcher. As such, he had an insider's position in the study. At the time of the intervention, he had established a trustful relationship with the students, which made it possible for him to notice any sensitivities during the intervention. This enabled him to make small adjustments to the intervention, based on the feedback from both the students and from his colleague teacher. For example, during the first lessons it appeared that the analysis of the arguments took a relatively long time, which led us to reducing the number of arguments for the next lessons.

## Data Collection

After the intervention semi-structured interviews were conducted with 12 students, all majoring in science. During the interviews students were invited to reflect on a topical SSI within the human-nature context. Biological knowledge and multiple perspectives, each with certain arguments and moral values, were part of the moral dilemma. Before the interviews were carried out, their design (structure, content) was discussed in the research team.

The selection of the students was purposeful, aimed at establishing a diversity in terms of student characteristics: gender, school and group during the intervention, their average score in biology, and the talkativeness and task orientation they had shown during the group discussions.

During the interviews the students were introduced to a moral dilemma that they had not encountered in the classroom before: "Should we stop rehabilitating seals in Netherlands? Why or why not?" At the time of the interviews, there was controversy in Netherlands about the continued need of taking care of needy seals, since the seal population had increased considerably in recent years. From an ecological perspective, the seal population could be considered "healthy". On the other hand, for people considering animal wellbeing more important, taking care of abandoned or sick seals remains strictly necessary. During 2017–2018, the students were taught about genetic variation of populations, and about vulnerable and changing ecosystems. Therefore, their conceptual understanding at the time of the interview was sufficient to understand the biological background of the dilemma.

Students were asked to give their main argument and their main moral values, and which arguments were most decisive in their opinion (emotions, arguments, moral values). Furthermore, the students were asked to indicate the different stakeholders and to reflect on both an argument and a moral value, presented by the interviewer. The interviews served as the data source for the purpose of this study and they were audio recorded and transcribed verbatim.

**TABLE 2 |** Characteristics of participants (names are pseudonyms).

| Student | Age | School[a] (group[b]) | Score biology[c] | Characteristics (exhibited during group activities) |
|---|---|---|---|---|
| Bruce | 16,5 | 1 (3) | 8,8 | talkative, task-oriented, involves other group members, takes charge; likes "to win" the discussions |
| Christopher | 16,2 | 2 (2) | 7,8 | quite talkative, variable task-oriented, involves other group members, at times annoyed by behaviour of other group member |
| Demi | 15,5 | 2 (1) | 6,6 | quite talkative, task-oriented, involves other group, at times annoyed by behaviour of other group member |
| Ilysa | 16,6 | 2 (1) | 7,4 | quite talkative, task-oriented, involves other group members, at times annoyed by behaviour of other group member |
| Jason | 15,7 | 2 (1) | 7,6 | quite talkative, task-oriented, involves other group members, at times annoyed by behaviour of other group member |
| John | 16,0 | 2 (2) | 6,8 | not very talkative, variable task-oriented, at times annoyed by the "group atmosphere", involves other group members |
| Liam | 15,9 | 2 (2) | 7,4 | very talkative, variable task-oriented (often distracted), reacts a lot to the others, at times involves the other group members, at times negative about the assignment |
| Madelyn | 15,8 | 1 (1) | 6,1 | task-oriented; in general: relatively little discussion and "quick agreement" with other group members |
| Sophie | 15,7 | 1 (1) | 8,5 | alternately motivated (more at a later stage); task-oriented; in general: relatively little discussion and "quick agreement" with other group members |
| Sarah | 16,3 | 1 (2) | 6,7 | increasingly communicative in the course of the intervention; task-oriented; involves other group members |
| Vaughan | 15,4 | 1 (3) | 6,3 | quite talkative; at times deviates from the assignments; likes "to win" the discussions; varying task orientation |
| Vernon | 16,3 | 1 (2) | 6,9 | quite talkative; alternately motivated (more at a later stage); varying task orientation (more at a later stage); involves other group members; self-critical |

[a]School: school 1 = school where teacher-researcher is employed; school 2 = school located in other town, where the participating teacher is employed.
[b]The group composition remained unchanged throughout the intervention. At school one there were three audio recorders (hence three groups); at school two there were two audio recorders (hence two groups).
[c]Scale 1–10; end of academic year (Summer 2018).

**TABLE 3 |** Example of coded statements belonging to "ethical sensitivity".

| Theme | Sub category | Sample of codes | Sample of data/quotes |
|---|---|---|---|
| Ethical Sensitivity | Taking Perspective | Affective perspective taking (PA) | I think you should take care of them, (…) if they are impaired (…), because that's a sign that they are not doing well. In that case the mother could have left it behind, (…) I don't think you should really leave them behind, which is also pathetic (…) every now and then you should go there and have a look if it is still there, as with that 24 h rule. But if it is still there, then I would take care of him. (Sarah*) |
| | | Cognitive perspective taking (PC) | One (person), of course, thinks that "one should take care of it", while the other thinks "You better just let them go their own way, and if they die ... well, that's just ... a natural law". (Vaughan) |
| | | Ecological perspective taking (PEc) | If the population, or many of those animals die, and I think seals are quite important in the marine ecosystem, in that case, I would say, "take care of five of them, so the population can grow a little." (Bruce) |

*Pseudonyms are used throughout the paper.

The interviews were conducted in a quiet part of the school building and lasted approximately 30 min. The interviews were conducted by the first author. During the intervention, he was the teacher of the students of school 1 (cf. **Table 2**), which might have been an advantage, given the existing relationship between him and the students, instead of having an outsider doing the interviews. On the other hand, during the interviews it was not noticeable that the students of school 2 (cf. **Table 2**) felt inhibited in their talkativeness.

## Data Analysis

Data analysis was conducted by adopting an inductive, *in vivo* coding strategy. In doing so, we first selected fragments that were related to specific morality components. Subsequently, we narrowed them down to four themes (Creswell, 2014), congruent with the four components of the FCM of morality. Each theme comprised a number of subcategories, and each subcategory comprised a number of codes. For reliability purposes, 20% of the interview data was analyzed and coded by another researcher from our research team. The interrater agreement was over 90%. Different interpretations were discussed and verified until consensus was reached. The interpretation of the findings was checked with co-authors to reach inter-subjectivity (Lincoln et al., 2011).

**Table 3** shows an example of the coding of students' statements, in this case statements belonging to the theme "ethical sensitivity". Codes were created for all components of the FCM.

Codes regarding FCM-1 (ethical sensitivity) and FCM-2 (moral reasoning and judgment) could be deduced directly from the interview statements. However, with regard to FCM-3 (moral motivation) and FCM-4 (moral character), we performed additional analyses, which are described hereafter.

Examining students' moral motivation (FCM-3), we selected students' statements reflecting their personal relation to the dilemma. Our analysis led to an understanding of the students' personal values that were important to them. This

TABLE 4 | Exemplary comparison of three students' "teleological moral reasoning".

| Theme | Sub category | Sample of codes | Sample of data/quotes |
|---|---|---|---|
| Moral reasoning and judgement | Moral reasoning | Teleological moral reasoning | The opponents say the population is weakened if you do that, which I think it is. So, I wouldn't take care of as many seals as possible. (Christopher) |
| | | | I think it's not fair for those seals. Taking care of them might help at first, but in the end, it might have more consequences than perhaps intended. (Jason) |
| | | | If you let such a weaker (individual) go back into the sea, then its offspring could also be . . . so it might counteract the seal's evolution, which on the long term might be bad for the entire species. (Vaughan) |

morality component recognizes that students have concerns that do not match with their choice of particular moral values, which may lead to an "emotional or cognitive conflict". We have interpreted statements as "cognitive conflicts" if students demonstrate uncertainty about which (deontological or teleological) values weigh the most. Statements were interpreted as "emotional conflicts" if students demonstrate uncertainty in balancing emotions and (deontological or teleological) values or rational arguments.

Similarly, in order to examine students' moral character (FCM-4), we investigated statements that were "indicative" for students' moral behavior. In doing so, we first investigated students' statements demonstrating their moral sentiments towards (some of) the interest groups affected by the dilemma (cf. Noddings, 2002). According to Noddings (2002), knowledge of moral principles needs to be complemented by a moral sentiment in order to strengthen someone's moral motivation, moral behavior, or moral character. Bearing this in mind, we considered insight into students' moral sentiments as an indication of their moral character, here with regard to the rehabilitation of seals. Therefore, we investigated the relationship between students' moral sentiments and their decision-making. Likewise, we also investigated the relationship between students' arguments, which can be interpreted as more rational, and their decision-making. Finally, we examined which of these factors, either their moral sentiments or arguments, were decisive for their moral decision-making. In fact, the students did not really "make a decision", rather they assumed a certain moral position. Bearing this in mind, we refer to this morality component as "moral decision-making". The table included in the appendix provides a complete overview of the codes we used.

In order to examine the nature of students' morality, we compared the morality components of different students. **Table 4** shows an example of a comparison of three students with regard to their "teleological moral reasoning", which is part of the theme "moral reasoning and judgment". Based on such comparisons, we were able to draw conclusions about this component of students' morality.

## Limitations
This study has some limitations that we wish to articulate. First, stimulating students' moral behavior remained underexposed. An important reason for this was the limited time available for the intervention: already during the preliminary phase of our study we were reminded that (science) teachers often experience an overload of the

curriculum, which forced us to design an teaching material which was relatively easy to implement and that would take little extra time. This limited the possibility of a more prolonged and in-depth engagement of the students with moral problems, but also to investigate the role of the teacher.

Second, we only used the data from the interviews, leaving out other data we collected, such as written essays, worksheets with individual and group assignments and audio recordings of group dialogues. The reason for this was that the interview data showed the morality components most prominently. The intervention, which preceded the interviews, served as a context from which the nature of students' morality was investigated. As such, we could have used the classroom data for triangulation purposes. It is likely that during the group discussions, with the accompanying distractions, students' morality would have emerged differently, or to a lesser extent.

## FINDINGS

The findings of the study are presented using the Four Component Model of Morality (FCM) as a structure to showcase how and to what extent the students demonstrated each of the four morality components. In the introduction of the FCM components we already identified the abilities associated with each component. The quotes below, which are used to illustrate our findings, are derived from the individual interviews with the twelve students, when they discussed the case of the seals.

### Ethical Sensitivity
**Table 5** provides an overview of students' morality regarding their ethical sensitivity, and the number of times that aspects of this component were shown by the students during the interviews. Furthermore, we added the number of students who demonstrated the specific aspect.

With regard to ethical sensitivity, we found that students exhibited the ability to take perspective and that they were aware of the topic's human-nature relationship. In terms of taking perspective, the students adopted affective, cognitive, and environmental perspectives. Affective perspective-taking includes placing oneself in the feelings of the other (human or animal). The quote in **Table 5** (PA, Sarah) is illustrative for a student placing herself in the seal pup's feelings. Other statements showed that students placed themselves in the feelings of the mother seal and the accidental (human) passer-by encountering a seal pup.

Cognitive perspective taking includes placing oneself in the other person's thoughts or reasoning. The quote in **Table 5** (PC,

**TABLE 5 |** Students' morality regarding their ethical sensitivity (*n* = 12).

| Code | Illustrative quote | Total |
|---|---|---|
| Affective perspective (PA) | I don't think you should really leave the pups behind, it's pitiful . . . Yes, every now and then you should check if it's still there, like with that 24 h rule. And if it is still there I would take care of it. (Sarah) | 56 (11) |
| Cognitive perspective (PC) | I think the people who take care of them also want the best for the animal, so they should not always be removed from their natural habitat. (Madelyn) | 23 (12) |
| Ecological perspective (PEc) | We should stop rehabilitating, because otherwise . . . the population will also become weaker. (Liam) | 28 (8) |
| Human-nature relationship (HN) | A choice that might be most important for humans . . . , for their conscience as well . . . And, of course, they maybe just think it's really cool to see such a seal grow. And if they release it again, they think, "thanks to me it can swim again, thanks to me it hasn't been caught by some beast or something". (Vaughan) | 19 (12) |

*Numbers in cells refer to the number of quotes illustrating the specific code and (in parentheses) the number of students who demonstrated the specific aspect.*

**TABLE 6 |** Students' morality regarding their moral reasoning and judgment (*n* = 12).

| Code | Illustrative quote | Total |
|---|---|---|
| Emotive-based moral reasoning (EMR) | I don't think you should really leave (the pups) behind, it's pitiful . . . Yes, every now and then you should check if it's still there, like with that 24 h rule. And if it is still there I would take care of it. (Sarah) | 30 (11) |
| Deontological moral reasoning (DMR) | Of course, it is true that we have affected their habitat, so if, for example, they were injured by something we caused, or if they were simply injured, we should help them. (Madelyn) | 44 (12) |
| Teleological moral reasoning (TMR) | Normally these (weak) pups would die . . . According to opponents it weakens the population, which I think it does. So . . . I wouldn't try to take care of as many seals as possible. (Christopher) | 26 (11) |
| Using biological concepts (BC) | If many animals in the population die because of diseases . . . , and I think seals seem pretty important in the marine ecosystem to me . . . So, I'd say, rehabilitate five of them and let them grow up, causing the population to grow a little . . . (Bruce) | 36 (8) |

*Numbers in cells refer to the number of quotes illustrating the specific code and (in parentheses) the number of students who demonstrated the specific aspect.*

Madelyn) is illustrative for a student placing herself in the line of reasoning of the people who take care of the seals. With regard to this kind of taking perspective, students placed themselves in both the proponents and the opponents of rehabilitating seals.

Taking an ecological perspective means that the students approached the dilemma from the perspective of the seal population or the ecosystem. **Table 5** (PEc, Liam) shows an illustrative quote of this kind of taking perspective.

Since the dilemma was situated in the context of the human-nature relationship (HN), we also examined students' views on this relationship. We presume these views influence their ethical sensitivity regarding this issue. We interpreted students' views on this relationship as predominantly deontological or teleological. Students' deontological views emphasized human's obligation to take care of the seals, assuming that humans are guilty of the poor condition of the seal, and therefore responsible for helping them. Students' deontological views also emphasized their concern for autonomy of the seals. The quote below illustrates both aspects.

I think that if we're to blame, we should settle it. But if we're not guilty of those crying pups on the beach . . . well, then it's how it is supposed to be. So, it simply is the balance the seals have built up with nature, ... I mean, you can't prevent all seals from dying (Bruce).

Central to students' teleological views were cost-benefit analyses about consequences of rehabilitating seals for the population and/or the ecosystem. An illustrative excerpt is the following:

Normally these (weak) pups would die . . . According to opponents (of rehabilitating seals) it weakens the population, which I think it does. So . . . I wouldn't try to take care of as many seals as possible. (Christopher)

Summing up, the data showed that students exhibited different kinds of perspective taking. In presenting the findings we distinguish between taking affective, cognitive, and ecological perspectives. Furthermore, the data provided insight into students' views on the human-nature relationship, which were predominantly deontological or teleological. We found that the majority of the students exhibited these aspects of ethical sensitivity ranging from eight to twelve students (see **Table 5**).

## Moral Reasoning and Judgment

**Table 6** presents an overview of students' morality regarding their moral reasoning and judgment, and the number of times that aspects of this component were shown by the students during the interviews.

The students showed different kinds of moral reasoning and judgment, interpreted as either rational (i.e., teleological and deontological moral reasoning and judgment), or as predominantly based on emotions (i.e., emotive moral reasoning and judgment). Teleological moral reasoning and judgment implies that in their reasoning the students emphasized the consequences of rehabilitating seals. The quote in **Table 6** (TMR, Christopher) is illustrative for how a student thinks about the consequences of rehabilitating seals for the population or the ecosystem. Deontological moral reasoning and judgment means that students' reasoning was based on

**TABLE 7** | Students' morality regarding their moral motivation (n = 12).

| Code | Illustrative quote | Total |
|---|---|---|
| Deontological values (DV) | But if it is indeed our fault, and that we pollute the sea ourselves, that is why the animals are worse off. In that case I think we should do something about it. (Liam) | 37 (11) |
| Teleological values (TV) | Normally these (weak) pups would die … According to opponents it weakens the population, which I think it does. So … I wouldn't try to take care of as many seals as possible. (Christopher) | 46 (12) |
| Emotions (EM) | I don't think you should really leave the pups behind, it's pitiful as well. (Sarah) | 14 (8) |
| Emotional conflicts (ECon) | If it's really hurt, then you want to take it with you and take care of it. (…) On the other hand, these animals should be given the freedom to (…) return to the sea themselves. (Sophie) | 2 (2) |
| Cognitive conflicts (CCon) | When the population is in danger, due to us, we must do something about it. If it goes well, we should not interfere. So, I don't really have a feeling about it … On the other hand, if it is our fault, it is right that we do something about it. (Bruce) | 8 (6) |

*Numbers in cells refer to the number of quotes illustrating the specific code and (in parentheses) the number of students who demonstrated the specific aspect.*

moral principles, like justice or autonomy. The quote in **Table 6** (DMR, Madelyn) demonstrates a student's awareness of the righteousness of helping seals. Furthermore, students demonstrated that they considered autonomy an important moral principle to come to a moral judgment, for example:

If they can save themselves, and they are doing much better now (…), then I don't see why you should take care of them. (Demi)

This quote demonstrates that this student found the seals' self-reliance important. According to her, people should not interfere because "they are doing much better now". Besides these predominantly rational arguments, students showed emotive moral reasoning and judgment, based on emotions or moral sentiments, like compassion, guilt and sympathy. The quote in **Table 6** (EMR, Sarah) demonstrates a student's compassion towards the seal pup ("it's pitiful"), which leads her to favor rehabilitating them. In addition to compassion, "guilt" also occurred as an underlying emotion is students' moral reasoning and judgment, out of which the following statement is exemplary:

If we are indeed guilty, and (if) we pollute the sea ourselves, (and) that's why the animals are worse off, I think we should do something about it (Liam).

This example also shows that making a conceptual distinction between emotional and deontological moral reasoning and judgment is difficult, since emotions underlie deontological values. In this example, "guilt" (an emotion, or moral sentiment) leads to a sense of "duty" to rehabilitate the seals if they are needy, which is a deontological value.

Finally, we looked at the use of biology concepts, like population and evolution, in students' moral reasoning and judgment. Although such concepts appeared in 36 statements, only eight of the 12 students used these in their moral reasoning and judgment. "Population" was used most often, which is illustrated by the quote in **Table 6** (BC, Bruce). When using "population" to substantiate their argument, the students argued that taking care of the seals ("cause") could have both positive and negative consequences for the seal population ("effect"). Therefore, we interpreted this kind of reasoning as teleological moral reasoning and judgment.

Likewise, biological concepts were central in some students' deontological moral reasoning and judgment as well to emphasize the "intrinsic value" of the (sea) ecosystem or the seal species.

Biological concepts used in this context were "evolution", "natural balance", "(endangered) species", and "survival of the fittest". As a student stated: "the (natural) balance should not be affected".

Summing up, 11 out of 12 students showed deontological, teleological and emotive-based moral reasoning and judgment. The findings also demonstrated that making a conceptual distinction between emotive-based and deontological moral reasoning and judgment was often difficult and that most of the students used biological knowledge in their moral reasoning (8 out of 12 students). As evidenced in the findings, biological concepts were part of both teleological and deontological kinds of reasoning.

## Moral Motivation

**Table 7** presents an overview of students' moral motivation, and the number of times that aspects of this component were shown by the students during the interviews.

Personal values play a key role in students' moral motivation, which we refined into deontological, teleological, and emotional personal values. If there was a relationship between students' personal values and deontological values, we interpreted this as "deontological values" (DV). The quote in **Table 7** (DV, Liam) illustrates that this student emphasized human's responsibility: if we are responsible (for the seals' poor situation), we have an obligation (deontological value) to do something about it. We interpreted this statement as a personal value as well, since it shows that the student personally considered justice as an important value: if we (humans) are guilty (of the seals' poor situation), then we should do something about it.

If there was a relationship between students' personal values with teleological values, we interpreted this as "teleological values" (TV). The quote in **Table 7** (TV, Christopher) illustrates that this student takes a perspective assuming that taking care of (weak) individuals has negative consequences for the population (on the long term). We also found statements demonstrating that students felt "emotionally related" to the dilemma, which we interpreted as a kind of personal value as well. The illustrative quote in **Table 7** (EM, Sarah) shows that this student took the perspective of "the other", in this case the seal pup, demonstrating "compassion" for the pup.

In a number of cases it appeared that there was a "conflict" in the process of students' moral reasoning, either a cognitive

**TABLE 8 |** Students' morality regarding their moral character (*n* = 12).

| Code | Illustrative quote | Total |
|---|---|---|
| Compassion (COM) | If they really need that help to regain their strength, (. . .), then I am in favour of rehabilitating them. (Demi) | 9 (9) |
| Guilt (GLT) | If they have been hurt by something we have done, or if they have simply been injured, we should help them. (Madelyn) | 6 (6) |
| Duty (DTY) | If we are indeed guilty, and (if) we pollute the sea ourselves, (and) that's why the animals are worse off, I think we should do something about it. (Liam) | 5 (5) |
| Respect (RES) | Simply put, they are living creatures of course, and I actually think that if you have the chance to save them, then it is actually a bit sick not to do it. (Vaughan) | 1 (1) |
| Rational arguments (RAT) | I think that (. . .) the population might be weakened by saving that seal. (. . .) Of course, individual well-being is very important, but I think the well-being of an entire species, therefore more individuals, is more important. (Vaughan) | 6 (6) |
| Moral sentiments decisive (MSD) | I don't think you should really leave (the pups) behind, it's pitiful . . . Yes, every now and then you should check if it's still there, like with that 24 h rule. And if it is still there I would take care of it<br>It is not fair to abandon an animal, I think, because it doesn't save itself, so then it's not fair, we humans can help them. (Sarah) | 9 (9) |
| Rational arguments decisive (RATD) | I also wonder: what is causing these young pups on the beach? If people are the cause of it, then we disturb the balance. In that case it is appropriate to take care of them. But, on the other hand, if we have actually nothing to do with these seals swimming around fishing boats, in that case I would say, it might be pitiful, but you should leave them behind, because we have nothing to do with it. (Bruce) | 3 (3) |

*Numbers in cells refer to the number of quotes illustrating the specific code and (in parentheses) the number of students who demonstrated the specific aspect.*

conflict or an emotional conflict, which made it difficult to reach a moral decision. The occurrence of cognitive conflicts was evidenced by statements demonstrating uncertainty about which (deontological or teleological) values weighed the most. The quote in **Table 7** (CCon, Bruce) is an example, in which the student emphasized the duty to take care of seals (a deontological value) and the importance of the autonomy of the population (a deontological value).

Likewise, the occurrence of emotional conflicts was evidenced by statements demonstrating uncertainty in balancing between emotions, (deontological or teleological) values and rational arguments as illustrated by the quote in **Table 7** (ECon, Sophie). This student demonstrated compassion (a moral sentiment) towards the seal pup, while also emphasizing the importance of the seals' autonomy (a deontological value), namely their freedom to return to the sea themselves.

Concluding, students' personal values can be interpreted as predominantly deontological, teleological, or emotional. These values occurred among the majority of the students (ranging from eight to twelve students). Half of the students (6 of 12) demonstrated a cognitive conflict, and two students demonstrated an emotional conflict in their moral reasoning and decision-making.

## Moral Character

The design of the intervention was such that students did not have the time or the opportunity to actually engage in moral action. Therefore, we can only view students' moral decision-making as an "indication" for their moral character bearing in mind that "an indication for" and "actual display of" moral behavior (moral character) may not match in practice. **Table 8** provides an overview of students' morality regarding their moral character, and the number of times that aspects of this component were shown by the students during the interviews.

We found that different moral sentiments as well as rational arguments were taken into account in students' moral decision-making. Moral sentiments or rational arguments were decisive in

this process. We identified compassion, guilt, duty and respect as the most important moral sentiments.

Statements interpreted as "compassion" demonstrated a "strong feeling of sympathy for others (i.e., seals) who are suffering and a desire to help them" (Oxford Learner's Dictionaries, 2020), which is illustrated by the quote in **Table 8** (COM, Demi):

If they really need that help to regain their strength, (. . .), then I am in favor of rehabilitating them.

Statements interpreted as "guilt" demonstrated a "feeling of responsibility for doing something wrong, or for something bad that has happened" (Ibid.), which is illustrated by the quote in **Table 8** (GLT, Madelyn). To this student, it is important that if we are "guilty" of the seals' poor condition, we are obliged to rehabilitate them.

Statements interpreted as "duty" demonstrated that students felt they had to do something because it was their (moral) responsibility, which is illustrated by the quote in **Table 8** (DTY, Liam). The statement shows that "duty" is much related to "guilt": "If we are indeed guilty (of polluting the sea), (. . .) we must do ("duty") something about it".

Statements interpreted as "respect" demonstrated polite behavior towards or care for somebody/something that you think is important. The quote in **Table 8** (RES, Vaughan) illustrates that "respect" is a motive for supporting the rehabilitation of seals emphasizing student's respect for the intrinsic value of the individual seals.

Students' rational arguments were mostly related to the consequences for the seal population of rehabilitating them (population/ecosystem perspective), which is illustrated by the quote in **Table 8** (RAT, Vaughan). This student placed more value on the importance of the seal population (or on the entire species) than on the individual well-being of the seal.

Finally, we examined the decisive factors (either moral sentiments or rational arguments) in students' moral decision-making. Moral sentiments were decisive in the moral decision-making of nine of the students (cf. **Table 8**: MSD, Sarah).

"Compassion" was decisive when students expressed that the seals "really needed help". "Guilt" was decisive when the students emphasized that humans cause seals suffering, making them indebted to rehabilitate seals. "Respect" (for autonomy) was decisive, when students pointed at the importance of "nature taking its course". For three of the 12 students, rational arguments were decisive in their moral decision-making (cf. **Table 8**: RATD, Bruce). In their argument they emphasized the consequences of rehabilitating seals for the long-term health of the population. These findings provide evidence that "moral sentiments" weigh heavily in students' moral decision-making. This suggests the importance of facilitating students to reflect on moral sentiments that are important to them. In addition, the findings illustrate the importance of putting a "relational pedagogy" (e.g., Sadler, 2011) central to the context of moral education, as it creates the conditions enabling students to reflect on these sentiments.

Concluding, the findings showed that moral sentiments played a role in students' moral decision-making. We identified these sentiments as compassion, guilt, duty and respect. The sentiments appeared to be motives for advocating in favor of rehabilitating the seals. Furthermore, albeit to a lesser degree, rational arguments also weighed in students' moral decision-making, which led those students to decide that they were opposed to rehabilitating the seals, because of the negative long-term consequences for the seal population. These findings show that students' moral sentiments most often had a decisive influence on their moral decision-making, more so than their rational arguments.

## DISCUSSION

We used the Four Component Model (FCM) of morality (Narvaez and Rest, 1995; Rest et al., 1999) as an analytical framework to explore students' morality. The results show that not all manifestations of morality revealed themselves equally in every student. In **Tables 5–8** we presented how often the morality aspects surfaced, as well as the number of students who demonstrated specific aspects thereof.

In sum, the nature of the students' morality can be characterized as follows: within the given context (i.e., during the interviews following the intervention) the students showed different morality components. First of all, with regard to their ethical sensitivity, they demonstrated the ability to position themselves in the stakeholders' perspectives. In doing so, they explored the kinds of arguments and moral values used. The importance of this ability is also emphasized in current SSI literature (e.g., Zeidler et al., 2019), and it is congruent with other empirical SSI research in secondary science education (e.g., Grace, 2009).

Likewise, with regard to moral reasoning and judgment, the students demonstrated both rational-based and emotion-based moral reasoning, an outcome that was also found in other SSI research (e.g., Sadler and Zeidler, 2005). Furthermore, it appeared that not all students used

biological concepts in their moral reasoning. This result was somewhat expected, given that the context of the intervention and interviews was mainly aimed at stimulating the students' morality, and less (explicitly) on using biological concepts in their (moral) reasoning. The somewhat sparse use of conceptual knowledge in their moral reasoning is consistent with other research that showed that students rarely appeal solely to their scientific knowledge in their moral reasoning, and that their reasoning is often primarily based on values (e.g., Means and Voss, 1996; Bell and Lederman, 2003; Sadler and Zeidler, 2005; Kolstø, 2006; Nielsen, 2012).

With regard to the moral motivation component, it turned out that students' reflection on (personal) values was essential in their moral process to reach a (final) moral decision. The importance of this reflection is also emphasized in other SSI research (e.g., Kolstø, 2006; Jones et al., 2012; Rundgren et al., 2016), which demonstrated that when students were encouraged to reflect on their personal values. They developed a positive cognition of the values that were important to them, which helped them to come to a moral decision. In line with this, our findings revealed that students occasionally experienced an "inner conflict" (either cognitive or emotional), which served as evidence for the reflection process, which–likely–also helped them to come to a (final) moral decision.

Finally, we characterized students' final moral decision-making. It appeared that moral sentiments (emotions) were most often decisive in reaching a decision, which is also consistent with previous SSI research (e.g., Kolstø, 2006; Bencze et al., 2012; Juntunen and Aksela, 2014; Rundgren et al., 2016; Torkar, 2016). We interpreted this aspect as students' moral character, given the fact that–within this context–it was the outcome of their moral process. The importance of emotions in the moral process is also emphasized in the literature. For instance, Noddings (2002) emphasized the importance of encouraging students' awareness of their moral sentiments. She argued that knowledge of moral principles needs to be complemented by moral sentiments in order to strengthen someone's moral motivation, moral behavior, and moral character. In her vision of a pedagogy for moral education, she advocated nurturing conditions and relationships that invite a moral way of life.

The latter aspect, "invite a moral way of life", refers to the "moral behavior" component, which is often outside the direct influence of the moral education context (e.g., Van der Leij et al., 2021). This was also the case in this study: the teaching material was designed in such a way that implementing "moral behavior" was not facilitated, given the fact that there was no time for doing so. As a result, this component remained underexposed and conclusions regarding students' moral behavior cannot be drawn from this study. Examples of empirical studies from SSI literature, carried out in secondary science education, explicitly focus on stimulating students' moral behavior (e.g., Bencze et al., 2012; Tal and Abramovitch, 2013). These studies evidenced that a pedagogy focused on "student-led activism" contributed to stimulating

students' moral behavior. Possibly this aspect can be further investigated in future research within Dutch secondary science education.

## Recommendations for Future Research

Following from the results of this study, in this section we provide a number of recommendations regarding future research into guiding and encouraging students' morality within secondary science education.

First, given the influence emotions have on morality (cf. Zeidler et al., 2019), we recommend that researchers engage with research into SSI education with a special focus on nurturing the conditions and relationships that invite a moral way of life (cf. Noddings, 2002). Noddings (2002) made this recommendation from a (general) care perspective on moral education, which was not specifically aimed at SSI science education. However, also recent SSI literature emphasizes the importance of a relational pedagogy. For instance, place-based SSI science education aims to contribute to students' socio-cultural awareness and their moral sensitivity by teaching and learning morality within authentic contexts (e.g., Herman et al., 2020; Kim et al., 2020). Likewise, the SSI construct "socioscientific perspective taking" also pays attention to the moral context, in which the focus is on "how local people think, and how they categorize and perceive the world" (e.g., Kahn and Zeidler, 2019).

Second, since students' moral action-taking remained underexposed in our study, we recommend that further research be carried out on the interrelationships between moral character, action-taking and enacted moral reasoning. Research, also conducted in secondary science education (e.g., Sperling and Bencze, 2010; Bencze et al., 2012), showed that a student-led pedagogy, encouraging students' concerns, self-confidence and self-efficacy, was essential for successful "ethical implementation". Research focused on this morality component has also been carried out in science education in European countries. Embedded in a citizenship education context, the used pedagogical model ("socio-scientific inquiry-based learning") supports students in making decisions together, which they then can enact (e.g., Levinson, 2018). We consider it worthwhile further exploring the usability and efficacy of these pedagogies in different science education contexts.

Third, like any other study, this study was conducted within a specific socio-cultural context with a specific group of students, i.e., Dutch 15–16-year-old pre-university biology students. Zeidler et al. (2019) emphasize that SSI are always embedded in a specific sociocultural view of education (cf. Bencze et al., 2020), whereby the educational significance depends on the specific context relative to that SSI. From this point of view we consider it valuable to conduct further research in other socio-cultural contexts to examine the possible influence of such cultures on students' morality. Likewise, we recommend to investigate morality in other educational contexts (e.g., different educational levels: vocational and more academic) and among other age

groups, which likely enhances design and development of (local) SSI pedagogy.

Finally, this study examined the nature of students' morality. In it, the role of the teachers generally remained underexposed (e.g., Did they interfere in students' dialogue, or not? Were they explicit about their own opinion or not?). Needless to say, that the pedagogical climate in which moral education takes place is of great importance. Science education literature shows that science teachers often feel uncomfortable with the demands of SSI science education (e.g., Oulton et al., 2004; Bennett et al., 2010; Day and Bryce, 2011). Hence, more research into what skills they need, and how these skills can be developed, is of great importance. Such research can focus on the factors that contribute to a (science) classroom climate in which students feel safe enough to engage in joint reflections on their values, and how (science) teachers can guide and stimulate this process. This connects with the earlier mentioned concept of relational pedagogy: what kind of learning environment is conducive in inviting moral reasoning and engaging in values and ethics, and what is the role of a teacher in creating such an environment?

## DATA AVAILABILITY STATEMENT

The raw data supporting the conclusion of this article will be made available by the authors, without undue reservation.

## ETHICS STATEMENT

Ethical review and approval was not required for the study on human participants in accordance with the local legislation and institutional requirements. Written informed consent was provided by the participants' legal guardian/next of kin for their participation in this study and the publication of any potentially identifiable images or data included in this article.

## AUTHOR CONTRIBUTIONS

All authors contributed to conception and design of the study. LA acted as a daily supervisor of TL, and helped him structuring the entire research process. TL is mainly responsible for the literature review, and for the interviews with teachers and experts during the preliminary phase. He also monitored the two pilot studies. Based on the outcomes of this preliminary phase TL developed the intervention which is central in this study, receiving feedback and suggestions for revisions from LA, AW, and MG. As a teacher-researcher, TL was one of the teachers during the implementation of the intervention, and he conducted the semi-structured interviews with the students. TL analyzed the data from the intervention, 20% of which was coded by LA as a second rater. Different interpretations of the data were discussed between LA and TL. TL wrote the first draft of the manuscript. LA, AW, and MG

wrote some sections of the manuscript, and acted–in their role as supervisors of TL, as critical readers. Their suggestions for revisions were processed by TL. In the end, all authors contributed to final manuscript revision, read, and approved the submitted version.

## FUNDING

## ACKNOWLEDGMENTS

## SUPPLEMENTARY MATERIAL

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/feduc.2021.729685/full#supplementary-material

## REFERENCES

ACARA (2021). Ethical Understanding Learning Continuum. Australian Curriculum, Assessment and Reporting Authority (ACARA). Available at: https://www.australiancurriculum.edu.au/media/1073/general-capabilities-ethical-understanding-learning-continuum.pdf (Accessed. January 21, 2021).

Bebeau, M. J. (2002). The Defining Issues Test and the Four Component Model: Contributions to Professional Education. *J. Moral Educ.* 31 (3), 271–295. doi:10.1080/0305724022000008115

Bell, R. L., and Lederman, N. G. (2003). Understandings of the nature of science and decision making on science and technology based issues. *Science Education* 87 (3), 352–377. doi:10.1002/sce.10063

Bencze, L., Sperling, E., and Carter, L. (2012). Students' Research-Informed Socio-Scientific Activism: Re/Visions for a Sustainable Future. *Res. Sci. Educ.* 42 (1), 129–148. doi:10.1007/s11165-011-9260-3

Bencze, L., Pouliot, C., Pedretti, E., Simonneaux, L., Simonneaux, J., and Zeidler, D. (2020). SAQ, SSI and STSE Education: Defending and Extending "Science-In-Context". *Cult. Stud. Sci. Educ.* 15 (3), 825–851. doi:10.1007/s11422-019-09962-7

Bennett, J., Hogarth, S., Lubben, F., Campbell, B., and Robinson, A. (2010). Talking Science: The Research Evidence on the Use of Small Group Discussions in Science Teaching. *Int. J. Sci. Educ.* 32 (1), 69–95. doi:10.1080/09500690802713507

Berne, B. (2014). Progression in Ethical Reasoning when Addressing Socio-Scientific Issues in Biotechnology. *Int. J. Sci. Educ.* 36 (17), 2958–2977. doi:10.1080/09500693.2014.941957

Boerwinkel, D. J., Knippels, M.-C., and Waarlo, A. J. (2011). Raising awareness of pre-symptomatic genetic testing. *Journal of Biological Education* 45 (4), 213–221. doi:10.1080/00219266.2011.572987

Corrigan, D. J., Dillon, J., and Gunstone, R. F. (2007). *The Re-emergence of Values in Science Education*. Rotterdam: Sense.

Corrigan, D., Buntting, C., Fitzgerald, A., and Jones, A. (2020). *Values in Science Education the Shifting Sands*. Switzerland: Springer International Publishing. doi:10.1007/978-3-030-42172-4

Creswell, J. W. (2014). *Educational Research: Planning, Conducting and Evaluating Quantitative and Qualitative Research*. 4th ed. Harlow: Pearson.

Day, S. P., and Bryce, T. G. K. (2011). Does the Discussion of Socio-Scientific Issues Require a Paradigm Shift in Science Teachers' Thinking? *Int. J. Sci. Educ.* 33 (12), 1675–1702. doi:10.1080/09500693.2010.519804

European Commission (2015). *Science Education for Responsible Citizenship*. Available at: http://ec.europa.eu/research/swafs/pdf/pub_science_education/KI-NA-26-893-EN-N.pdf (Accessed. February 13, 2017).

Fensham, P. J. (1988). Approaches to the Teaching of STS in Science Education. *Int. J. Sci. Educ.* 10 (4), 346–356. doi:10.1080/0950069880100402

Fowler, S. R., Zeidler, D. L., and Sadler, T. D. (2009). Moral Sensitivity in the Context of Socioscientific Issues in High School Science Students. *Int. J. Sci. Educ.* 31 (2), 279–296. doi:10.1080/09500690701787909

Gough, A. (2002). Mutualism: A Different Agenda for Environmental and Science Education. *Int. J. Sci. Educ.* 24 (11), 1201–1215. doi:10.1080/09500690210136611

Grace, M. M., and Ratcliffe, M. (2002). The Science and Values that Young People Draw upon to Make Decisions about Biological Conservation Issues. *Int. J. Sci. Educ.* 24 (11), 1157–1169. doi:10.1080/09500690210134848

Grace, M. (2009). Developing High Quality Decision-Making Discussions about Biological Conservation in a Normal Classroom Setting. *Int. J. Sci. Educ.* 31 (4), 551–570. doi:10.1080/09500690701744595

Habermas, J. (1983). *Moralbewusstsein und kommunikatives Handeln*. Frankfurt a.M.: Suhrkamp Verlag.

Habermas, J. (1990). *Moral Consiousness and Communicative Action*. Cambridge, MA: MIT Press.

Herman, B. C., Zeidler, D. L., and Newton, M. (2020). Students' Emotive Reasoning through Place-Based Environmental Socioscientific Issues. *Res. Sci. Educ.* 50 (5), 2081–2109. doi:10.1007/s11165-018-9764-1

Hermans, C. A. M. (1986). Morele Vorming—Empirisch-Theologisch Onderzoek Naar de Effecten van een Katechese-Curriculum in de Morele Vorming Omtrent de Milieucrisis. *Kampen: Kok*, 56–58.

Jickling, B., Lotz-Sisitka, H., O'Donoghue, A., and Ogbuigwe, A. (2006). *Environmental Education, Ethics, and Action: A Workbook to Get Started*. Nairobi: UNEP.

Jones, A., Buntting, C., Hipkins, R., McKim, A., Conner, L., and Saunders, K. (2012). Developing Students' Futures Thinking in Science Education. *Res. Sci. Educ.* 42 (4), 687–708. doi:10.1007/s11165-011-9214-9

Juntunen, M. K., and Aksela, M. K. (2014). Improving Students' Argumentation Skills through a Product Life-Cycle Analysis Project in Chemistry Education. *Chem. Educ. Res. Pract.* 15 (4), 639–649. doi:10.1039/C4RP00068D

Kahn, S., and Zeidler, D. L. (2019). A Conceptual Analysis of Perspective Taking in Support of Socioscientific Reasoning. *Sci. Educ.* 28 (6–7), 605–638. doi:10.1007/s11191-019-00044-2

Kim, G., Ko, Y., and Lee, H. (2020). The Effects of Community-Based Socioscientific Issues Program (SSI-COMM) on Promoting Students' Sense of Place and Character as Citizens. *Int. J. Sci. Math. Educ.* 18 (3), 399–418. doi:10.1007/s10763-019-09976-1

Kohlberg, L. (1976). "Moral Stages and Moralization: The Cognitive-Developmental Approach," in *Moral Development and Behavior: Theory, Research, and Social Issues*. Editor T. Lickona (New York, NY: Holt Rinehart & Winston), 31–53.

Kohlberg, L. (1986). "A Current Statement of Some Theoretical Issues," in *Lawrence Kohlberg: Consensus and Controversy*. Editors S. Modgil and C. Modgil (Philadelphia, PA: Falmer), 485–546.

Kolstø, S. D. (2006). Patterns in Students' Argumentation Confronted with a Risk-focused Socio-scientific Issue. *Int. J. Sci. Educ.* 28 (14), 1689–1716. doi:10.1080/09500690600560878

Levinson, R. (2018). Introducing Socio-Scientific Inquiry-Based Learning (SSIBL). *Sch. Sci. Rev.* 100 (317), 31–35.

Lincoln, Y. S., Lynham, S. A., and Guba, E. G. (2011). "Paradigmatic Controversies, Contradictions, and Emerging Confluences, Revisited," in *The Sage Handbook of Qualitative Research*. Editors N.K. Denzin and Y.S. Lincoln (Thousand Oaks, CA: Sage Publications), 97–128.

Means, M. L., and Voss, J. F. (1996). Who reasons well? Two studies of informal reasoning among children of different grade, ability, and knowledge levels. *Cognition and Instruction* 14 (2), 138–178. doi:10.1207/s1532690xci1402_1

Mephan, T. B. (2018). *Ethical Matrix*. Food Ethics Council. Available at: https://www.foodethicscouncil.org/resources/ethicaltools/ethical-matrix.html (Accessed March 1, 2018).

Narvaez, D., and Rest, J. (1995). "The Four Components of Acting Morally," in *Moral Behavior and Moral Development: An Introduction*. Editors W. Kurtines and J. Gewirtz (New York: McGraw-Hill), 385–400.

Nielsen, J. A. (2012). Co-opting Science: A Preliminary Study of How Students Invoke Science in Value-Laden Discussions. *Int. J. Sci. Educ.* 34 (2), 275–299. doi:10.1080/09500693.2011.572305

Noddings, N. (2002). *Educating Moral People—A Caring Alternative to Character Education*. New York: Teachers College Press.

NRC (2012). *A Framework for K-12 Science Education*. Washington, DC: The National Academies Press.

Oulton, C., Day, V., Dillon *, J., and Grace, M. (2004). Controversial Issues - Teachers' Attitudes and Practices in the Context of Citizenship Education. *Oxford Rev. Educ.* 30 (4), 489–507. doi:10.1080/0305498042000303973

Oxford Learners Dictionaries (2020). *Retrieved from* https://www.oxfordlearnersdictionaries.com/.

P21, Partnership for 21st Century Learning (2015). P21 Framework Definitions 21st Century Skills. Available at: http://www.p21.org/storage/documents/docs/P21_Framework_Definitions_New_Logo_2015.pdf (Accessed. February 20, 2017).

Pedretti, E. (2003). "Teaching Science, Technology, Society and Environment (STSE) Education," in *The Role of Moral Reasoning on Socioscientific Issues and Discourse in Science Education*. Editor D. L. Zeidler (Dordrecht: Kluwer Academic Press), 219–239. doi:10.1007/1-4020-4996-x_12

Pedretti, E. (2005). "STSE Education: Principles and Practices," in *Analysing Exemplary Science Teaching: Theoretical Lenses and a Spectrum of Possibilities for Practice*. Editors A. Alsop, L. Bencze, and E. Pedretti (Maidenhead: Open University Press), 116–126.

Piaget, J. (1932). *The Moral Judgment of the Child*. Kegan Paul: Routledge.

Reiss, M. (2008). The Use of Ethical Frameworks by Students Following a New Science Course for 16-18 Year-Olds. *Sci. Educ.* 17 (8), 889–902. doi:10.1007/s11191-006-9070-6

Rest, J. R., Narvaez, D., Bebeau, M. J., and Thoma, S. J. (1999). *Postconventional Moral Thinking: A neoKohlbergian Approach*. Mahwah, NJ: Lawrence Erlbaum.

Rest, J. R., Narvaez, D., Thoma, S. J., and Bebeau, M. J. (2000). A Neo-Kohlbergian Approach to Morality Research. *J. Moral Educ.* 29 (4), 381–395. doi:10.1080/713679390

Rest, J. R. (1984). "The Major Components of Morality," in *Morality, Moral Behavior and Moral Development*. Editors W.H. Kurtines and J.L. Gewirtz (New York, NY: Wiley), 24–38.

Rundgren, C.-J., Eriksson, M., and Rundgren, S.-N. C. (2016). Investigating the Intertwinement of Knowledge, Value, and Experience of Upper Secondary Students' Argumentation Concerning Socioscientific Issues. *Sci. Educ.* 25 (9), 1049–1071. doi:10.1007/s11191-016-9859-x

Sadler, T. D., and Zeidler, D. L. (2005). Patterns of Informal Reasoning in the Context of Socioscientific Decision Making. *J. Res. Sci. Teach.* 42 (1), 112–138. doi:10.1002/tea.20042

Sadler, T. D. (2011). "Situating Socio-Scientific Issues in Classrooms as a Means of Achieving Goals of Science Education," in *Socio-scientific Issues in the Classroom—Teaching, Learning and Research*. Editor T. D. Sadler (Dordrecht: Springer), 1–9. doi:10.1007/978-94-007-1159-4_1

Simonneaux, L. (2013). "Questions Socialement Vives and Socio-Scientific Issues: New Trends of Research to Meet the Training Needs of Postmodern Societyfic Issues: New Trends of Research to Meet the Training Needs of post-modern Society," in *9th ESERA Conference Selected Contributions. Topics and Trends in Current Science Education*. Editors C. Bruguière, A. Tiberghien, and P. Clément (Dordrecht: Springer), 37–54. doi:10.1007/978-94-007-7281-6_3

SLO (2012). *Handreiking Schoolexamen Biologie Havo/VWO*. Enschede: SLO (Accessed June 11, 2021).

SLO (2021). Vakportaal Burgerschap. Available at: https://www.slo.nl/vakportalen/vakportaal-burgerschap/.

Solomon, J., and Aikenhead, G. (1994). *STS Education: International Perspectives on Reform*. New York: Ways of Knowing Science Series. Teachers College Press.

Sperling, E., and Bencze, J. L. (2010). "More Than Particle Theory": Citizenship through School Science. *Can. J. Sci. Math. Technol. Educ.* 10 (3), 255–266. doi:10.1080/14926156.2010.504487

Tal, T., and Abramovitch, A. (2013). Activity and Action: Bridging Environmental Sciences and Environmental Education. *Res. Sci. Educ.* 43 (4), 1665–1687. doi:10.1007/s11165-012-9327-9

Tem Dam, G., and Van der Rest, A. (2011). *Advies 'Onderwijs Vormt'. Den Haag: Onderwijsraad*. Den Haag: Onderwijsraad.

Torkar, G. (2016). Secondary School Students' Environmental Concerns and Attitudes toward Forest Ecosystem Services: Implications for Biodiversity Education. *Int. J. Environ. Sci. Educ.* 11 (18), 11019–11031.

UNESCO (2016). *Education for People and Planet—Creating Sustainable Futures for All*. Paris, France: UNESCO.

Van der Ven, J. A. (1985). *Vorming in waarden en normen*. Kampen: Kok Agora.

Van der Zande, P., Akkerman, S. F., Brekelmans, M., Waarlo, A. J., and Vermunt, J. D. (2012). Expertise for Teaching Biology Situated in the Context of Genetic Testing. *International Journal of Science Education* 34 (11), 1741–1767. doi:10.1080/09500693.2012.671557

Van der Zande, P., Brekelmans, M., Vermunt, J. D., and Waarlo, A. J. (2009). Moral reasoning in genetics education. *Journal of Biological Education* 44 (1), 31–36. doi:10.1080/00219266.2009.9656189

Van der Leij, T., Avraamidou, L., Wals, A., and Goedhart, M. (2021). Supporting Secondary Students Morality Development in Science Education. *Studies in Science Education*, 1–41. doi:10.1080/03057267.2021.1944716

Veugelers, W. (2011). "A Humanist Perspective on Moral Development and Citizenship Education," in *Education and Humanism—Linking Autonomy and Humanity* (Rotterdam, Boston, Taipei: SensePublishers), 9–34. doi:10.1007/978-94-6091-577-2_2

Walsh, E. M., and Tsurusaki, B. K. (2018). "Thank You for Being Republican": Negotiating Science and Political Identities in Climate Change Learning. *J. Learn. Sci.* 27 (1), 8–48. doi:10.1080/10508406.2017.1362563

Zeidler, D. L., and Keefer, M. (2003). *The Role of Moral Reasoning and Discourse on Socioscientific Issues in Science Education*. Dordrecht: Kluwer, 7–38. doi:10.1007/1-4020-4996-x_2

Zeidler, D. L., Walker, K. A., Ackett, W. A., and Simmons, M. L. (2002). Tangled up in Views: Beliefs in the Nature of Science and Responses to Socioscientific Dilemmas. *Sci. Ed.* 86 (3), 343–367. doi:10.1002/sce.10025

Zeidler, D. L., Sadler, T. D., Simmons, M. L., and Howes, E. V. (2005). Beyond STS: A Research-Based Framework for Socioscientific Issues Education. *Sci. Ed.* 89 (3), 357–377. doi:10.1002/sce.20048

Zeidler, D. L., Herman, B. C., and Sadler, T. D. (2019). New Directions in Socioscientific Issues Research. *Discip Interdscip Sci. Educ. Res.* 1 (1), 11. doi:10.1186/s43031-019-0008-7

Zeidler, D. (2015). "Socioscientific Issues," in *Encyclopedia of Science Education*. Editor R. Gunstone (Dordrecht: Springer), 998–1003. doi:10.1007/978-94-007-2150-0_314