Insights into Sustainable Development: Secondary School Students' Conversations about Product Life Cycles

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Abstract

In this study, we provide insights about secondary school students' conversation about products' life cycles in relation to three dimensions of sustainable development: economic, social, and ecological sustainable development but also what traces of view that appear in these conversations. Production and consumption are part of complex technological systems that affect nature and life on earth, and knowledge about these systems are required to achieve sustainable development. In technology education, students can have the opportunity to talk about products and their life cycles. Hence, this study aims to explore what emerges in students' conversations about products' life cycles in relation to sustainable development. Data collection was conducted in Sweden through seven semi-structured interviews, with in total 21 students participating in groups. All student responses have been analysed using thematic analysis to explore dimensions and views of sustainability. Results show that the students discuss with regard to all three dimensions of sustainable development. However, the phases of a product's life cycle occur to varying extent within the different sustainability dimensions. Additionally, the students also connect dimensions with both harmonious and contrasting perspectives but also talk about the dimensions isolated. When participating students discuss, traces of mainly anthropocentric and technocentric view emerge. This has implications for technology education, where for example deliberative conversations can be used for engaging students in sustainable development.

Keywords

Technology education, Sustainable development, Product life cycle, Student Conversations, Views on Sustainability

Introduction

Today's society is characterized by rapid consumption and increased production (Stables and Keirl, 2015), making the concept of the product life cycle in relation to sustainable development a centre of a gradually urgent discussion. These production and consumption patterns form complex technological systems that significantly impact the environment and overall planetary well-being. Growing awareness has highlighted that traditional consumption and production are not a reasonable path forward (United Nations, 2015). Furthermore, to achieve Global Goal 12 of the Sustainable Development Goals, it is essential for people to have relevant information

and awareness to ensure sustainable consumption and production (Global Goal 12.8 in United nations, 2015).

In this context, education plays a critical role as a catalyst for change by building understanding and developing the skills needed to address these complex issues (UNESCO, 2005). Within this, technology education plays a crucial role. Traditionally, technology subjects rests on a foundation of design and manufacture (McGarr and Lynch, 2021), where problem solving through product design is a reigning paradigm (Stables and Keirl, 2015). However, evaluating technology and assessing its impact are also integral to curricula for technology education in for example Irland, New Zeeland, and Sweden (McGarr and Lynch, 2021; Ministry of Education, 2018; Skolverket, 2022). Within this content, understanding of and knowledge about product life cycles is essential in conscious designing and evaluation of technology for sustainable development.

Additionally, students should also develop skills and attitudes to foster sustainability awareness (Bianchi et al., 2022). In today's society, we face a range of challenges related to sustainability, including climate change, resource reduction, and social inequality. Meeting these challenges requires an in-depth understanding of how various factors interact. For these reasons, insights into students' perspectives on sustainable development and product life cycles are crucial for developing technology education for sustainable development.

In this study, we contribute to these insights by analysing students' conversations about product life cycle in relation to sustainable development. Building on a preliminary study (Sundler & Hultmark, 2023) presented at the PATT40 conference, this study expands the research to include seven student groups (21 lower secondary students) from different schools in Sweden. The analysis has been deepened, and a new research question has been added to explore students' views on sustainability.

Background

Over the years, various reports and studies have outlined different sustainability competences. Recently, Scalabrino (2022) reviewed 36 studies on Education for Sustainability, forming the basis for the European Unions (EU's) sustainability competences GreenComp (Bianchi et al., 2022). GreenComp aims to shift values towards protecting our planet and emphasises integrating sustainability into education and training systems to benefit both planetary and public health. It includes knowledge, skills, and attitudes under 12 competences.

According to Bianchi et al. (2022) valuing sustainability involves reflecting on personal values and recognising diverse approaches to sustainability. These moral and philosophical approaches shape various assumptions and arguments, highlighting the necessity to identify multiple values and explain how they differ among individuals but also over time. It is also essential to gain knowledge to critically examine the extent to which these values are consistent with sustainable development. Exploring the inherent tensions and complexities of sustainability issues is crucial to promote successful learning about sustainable development. This means that teaching cannot only address the individual dimensions of sustainability - social, ecological, and economic - but also needs to show how the dimensions interact and influence each other within a technological system. Systems thinking, included in the GreenComp-competences, involves viewing sustainability problems from multiple dimensions and understanding how the

different parts of the system interact (Bianchi et al., 2022). By examining these interactions, a deeper insight can be developed into the challenges and opportunities for achieving sustainable development (Herremans & Reid, 2003; Sterneäng & Lundholm, 2012). Teaching for sustainable development advocates for a holistic perspective with a pluralistic approach, emphasising the interconnectedness of economic, ecological, and social dimensions (Berglund & Gericke, 2016). Within this lays contradicting and harmonious perspectives that can be hard to balance.

In a study by Öhman & Öhman (2012), students related the sustainability dimensions to each other but tended to describe the dimensions as harmonious, without contradictions or conflicts. Gustafsson & Warner (2008) suggests that engaging students in deliberative conversations, structured dialogues that encourage participants to explore different viewpoints and critically reflect on their one, can raise awareness of sustainability's complexity, promoting a deeper understanding and engagement for these issues. Additionally, such conversations promoting critical thinking and foster the development of skills needed to make informed and sustainable decisions. This greater self-involvement can ultimately lead to action competence in students.

Sustainable development is widely recognized as a crucial component of technology education (e.g., Elshof, 2009; Pavlova, 2013; Stables & Keirl, 2015). Elshof argues that technology education has a responsibility to create a new sustainable way forward by encouraging students to think and act differently about how they use, consume and design technology. Technology education should teach students to design products with social, economic, and ecological sustainability in mind where both human and non-human nature is valued (Pavlova, 2011). This emphasises that the views on sustainable development and what values are incorporated in these views holds significance, and students should be given the opportunity to develop these views within the frame of technology education.

Svensson and Von Otter (2018) showed that teachers' perceptions and teaching of technology and sustainability revolve around three themes: recycling thinking, consequential thinking, and systems thinking. The teachers felt it is important for students to gain an understanding of how a product is made, used and recycled. Additionally, they aimed to promote awareness of how technology impacts the environment, encouraging students to reflect on ethical dilemmas linked to technology consumption. Finally, systems thinking emerged as the third theme, encompassing three content categories when technology and sustainability were integrated: product life cycle analysis, material analysis and technological systems. Teachers and pre-service teachers also view sustainable development as interdisciplinary, covering topics like consumption, health, environment, justice, energy, resources, and economy (Bursjöö, 2014).

While there is research on teachers' views on sustainable development in relation to product life cycles, few studies focus on students' expression and views on these topics. For example, Juntunen and Aksela (2014) demonstrated improved argumentation skills among students through a life-cycle analysis project. However, more research is needed concerning sustainable development in relation to product life cycles from students' perspectives.

Aim and Research Questions

In technology education, students should be given the opportunity to learn about products' life cycles and relate them to sustainable development. Knowledge about how students talk about consumption and production linked to sustainable development is important for practitioners in technology education as well as for further research. However, there is limited research on this. Hence, the aim of this study is to explore students' conversations about sustainable development in relation to product life cycles with a focus on dimensions and views of sustainable development. This was done with guidance of the following research questions.

Research questions

1. What emerges from students' conversations about the life cycles of products in relation to dimensions of sustainable development?
2. How are the dimensions related to each other in the students' conversations?
3. What views on sustainability can be traced in students' conversations about the life cycle of products?

Theoretical framework

In this study, the concepts of sustainable development, product life cycle, and views on sustainability are of importance. To theoretically frame sustainable development, we used guidelines from the United Nations Commission for Sustainable Development (United Nation, 2001). This framework defines sustainable development through three main dimensions: *environmental*, *social*, and *economic*. Developed to form indicators for corporate social responsibility, it specifies factors for each dimension. The social dimension includes the factors equity, health, education, housing, and security. The environmental dimension covers atmosphere, land, oceans, seas and coasts, freshwater, and biodiversity. The economic dimension addresses consumption and production patterns and economic structure. These dimensions and their associated factors were employed in our study to sort students' conversations.

The product life cycle can consist of different phases. In this study, we view this life cycle as consisting of four phases: *Production*, *transportation*, *usage & retail*, and *disposal*. The production phase includes activities to prepare products for usage such as designing and manufacturing, while the transport phase includes all transports made from manufacturing to usage. The usage & retail phase includes retail, sales approaches and customer use. The last phase, disposal, includes any handling of products after the intended usage. This has been adapted from the phases used by Vaesen (2012) with modifications to be relevant in the context of technology education.

There are different moral and philosophical views on sustainability. In this study we use *anthropocentrism*, *technocentrism*, and *ecocentrism* as theoretical frame. Anthropocentrism places humans at the center, viewing natural resources primarily as means for human use and benefit. In contrast, ecocentrism prioritises nature considering humans as part of the natural ecosystem and emphasising the well-being and balance of nature (Dobson, 1996). Technocentrism focuses on technology as the key to solving environmental and societal problems (Bianchi et al., 2022). Pavlova (2011) suggests weak anthropocentrism as a more balanced approach in technology education, which seeks to harmonise human needs with respect for nature´s rights and well-being. This view encourage a holistic approach to

sustainability, integrating ethical and moral values which can underpin design projects in technology education.

Method

Data collection

To obtain a rich dataset (Robson & McCartan, 2016), data were collected through seven semi-structured interviews, where 21 ninth-grade students (15-16 years old) participated in groups. These students were from seven different schools across Sweden. The participant selection was subjective (Denscombe, 2018) to obtain a geographically and socio-culturally diversity among the schools. Additionally, one school was included because it was sustainability certified by the Swedish National Agency for Education, highlighting its commitment to address sustainable development (Swedish National Agency for Education, n.d).

Group interviews were conducted to stage a possible classroom situation where students discuss product life cycles based on given questions. In group discussions, students' conversation can be enhanced when they are stimulated by each other's thoughts and comments (Robson & McCartan, 2016). Open questions related to the product life cycle were asked, with follow-up questions from the interviewer or another student. For example, the question used to prompt conversation about production was: "What do you know about the production of things like clothes and footballs, or mobile phones?" The approximately 50 minutes long interviews were audio recorded and subsequently transcribed manually.

Analysis

The data was analysed through thematic analysis, as described by Braun and Clarke (2006). During the analysis process, the authors adopted an interpretive approach regarding what the students were expressing. From the theoretical framework, a code-scheme was established (Table 1). The transcripts were read and reread, and an initial coding of the data was performed separately by two authors using the code-scheme. The coding was then discussed, and any uncertainties in the coding were resolved.

Table 1. The code scheme used in the thematic analysis.

Sustainable development	Product life cycle	View
Social dimension Ecological dimension Economical dimension	Production Transportation Usage & Retail Disposal	Technocentric Ecocentric Anthropocentric

Afterward, sections that were deemed relevant to the research questions were selected and a repeated deductive coding of the relevant sections were conducted jointly by two authors, combined with inductive coding for context. The students' statements were then sorted based on dimension of sustainable development and phase of the product life cycle and from this sorting deductive themes were constructed to answer research question (i). In a subsequent stage, themes were constructed from the deductive codes to answer research questions (ii) and (iii). The construction of themes was made from similar patterns of meaning across the dataset, paying close attention to the research questions and the theoretical framework. The themes

were evaluated, and through discussion among the authors, the themes were refined to have clearer distinctions from each other.

Ethical considerations

The research adhered to ethical principles to protect students´ privacy. The Swedish Ethical Review Authority reviewed the study's approach and data management plan and gave its approval for the implementation. Following the Swedish Research Council´s ethical guidelines (2017), the school principal and teachers were informed about the study´s purpose, voluntary participation, result usage, and contact details. Students received a separate letter with this information, emphasizing voluntary participation and anonymity. All participating students were over 15 years old and were therefore considered capable of giving informed consent. Those who chose to participate provided written consent, and their legal guardians were informed beforehand. Additionally, all names used in the article are fictitious to further ensure confidentiality.

Results

The thematic analysis revealed that students encompassed all three dimensions of sustainable development: social, ecological, and economic. However, their consideration of the phases of products' life cycle varies in emphasis across these dimensions, and certain phases are more prominent related to specific dimensions. Furthermore, the students interconnect these dimensions, sometimes harmoniously, illustrating their ability to complement each other. At other times, they contrasted the dimensions and highlighted conflicts or trade-offs. There are also cases where students discuss each dimension in isolation, without connecting them to the others. The views that can be traced from the students' conversations predominantly reflect anthropocentrism and technocentrism. Meaning that the students often focused on human-centred considerations and technological solutions when contemplating sustainable development. Here follows a deeper description of the results.

What emerges in students' conversations about the life cycles of products in relation to sustainable development?

In the analysis, when students talked about the social dimension of sustainable development it was mainly in terms of the production of goods. When addressing the economic dimension, they primarily talked in connection to usage and retail as well as transportation. In contrast, when the conversation turned to the ecological dimension, students covered all stages of the product life cycle.

The Social Dimension

The students' conversation was primarily centred around the production of goods when they talked about the social dimension. In the group interviews, the focus predominantly centred on working conditions and resource use in production, particularly within the cotton industry for cloth production. Here, students frequently highlighted that cotton is a water-intensive crop and its impact on water resources. They discussed how water is essential for basic needs, such as drinking and hygiene and that water consumption affects people's living conditions. They highlighted that cotton is cultivated in countries that already have water shortages, which worsens the situation. They cited the severe degradation of the Aral Sea´s water level due to cotton production, which affects people's living conditions.

The students also identified production locations, including China, India, Bangladesh, and the USA, noting that some of these countries lack democratic governance. They emphasized the prevalence of child labour and poor working conditions commonly found in the production industry. For example, in Excerpt A, students were talking about working conditions and child labour. Alice said that workers struggle financially on their salaries and have long working days and experience significant exhaustion. This not only impacts their health but also affects their life expectancy and overall lifetime earnings. Alex continues and claims that dangerous substances in the work environment cause poor health and premature death. Jane highlights that these countries have a low Human Development Index (HDI), but that this would increase if children were educated rather than being forces to work.

Excerpt A

Alice	But it's not just child labour, it's working conditions in general with long hours and low pay. They wear themselves out until ... so they don't live very long, so they don't have the energy left to work when they get older, which means that they can't earn as much money and they can't live on what they earn because the salary is far too low.
Alex	In many cases it is also ... it can be really dangerous environments they work in. Poisons and so on are very often used, and it is allowed in many countries to use life-threatening pesticides and so on, where many people die or are seriously injured.
Jane	But in the cotton industry, this happens every year and many people are poisoned. Another problem with child labour is that it is negative for the country in the end because they are not educated, so they can't help move society forward, that's what I was going to say. So what is it called? Their D..i..
Nina	HDI
Jane	Yes, their HDI is low, and it could be increase if the focus was on educating children for just one more year.

When the student groups talked about the social dimension, they did not address transportation or usage and retail. Disposal was only referred to briefly when they said that unused food can be prepared and given to people in need.

The Ecological Dimension

When the conversation revolved around the ecological dimension of sustainable development, students talked about all aspects of the product life cycle. In relation to usage and retail, the students reflected on their own consumer behaviors and thought processes when purchasing goods. They emphasized the impact of consumption on the environment, and many expressed that they try to reduce their consumption by minimizing clothing purchases and maximizing the lifespan of clothes to reduce new purchases. Additionally, several students mentioned that they buy second-hand clothes because it is better for the environment. They discussed the impacts of online shopping versus purchasing directly in stores, acknowledging that both affect the environment and result in emissions. In the conversations, they stated that instore shopping allows the opportunity to try on items directly to ensure proper fit, while online shopping often results in unnecessary transportation when returning unwanted goods. According to their statements, returns can involve shipping items to other countries for inspection and repackaging, thereby increasing the environmental impact. An example of this can be seen in

Excerpt B, where the student stated that it is environmental better to buy items in stores than online.

Excerpt B

Liam	Buying in a store is better than buying online, that is, if you think environmentally, because if you buy in a store then you just take it and go home, but if you buy from a website, it may be long shipping.
Olivia	Yes, because if you buy on a website, it's just your package that will be shipped to you if we say that you buy in-store, it's like a large amount. And then when you order online, it may not fit, but if you instead buy in-store, you can try it on and then you don't have to order maybe three sizes because it's free return and then it's sent back. It was on the news that it is sent to Poland to be repackaged and refolded and it is as if it is first sent from a warehouse to your home, you try on your clothes and one size fits, you send back the rest that ends up in Poland and then back to Sweden. It's like a whole transport extra than if you actually went to the store and actually just tried it on and just bought a garment.
Ava	Yes, exactly, because in the store you can return the goods directly there in the store if something does not fit. So it is more sustainable to buy in the store, then it is not sustainable to buy new clothes all the time because it emits so much.

In connection to disposal, several students stated that it is more beneficial for the environment if products and resources are reused. Students highlighted the importance of recycling, noting that raw materials can be repurposed into new products. They also pointed out that donating clothes and other items to second-hand stores is considered both climate- and environmentally friendly.

The students discussed various modes of transportation and they considered environmentally friendly methods for transporting goods. They stated that transportation affects the environment due to high emissions, with airplanes and trucks generating particularly high levels of carbon dioxide emissions. Therefore, these were deemed bad for the environment, while the use of ships was seen as a better alternative. The students also proposed additional solutions, such as producing goods closer to consumers to reduce emissions and using trains or other electric vehicles for transportation to minimise environmental impact.

When discussing production, the students said that it contributes to climate change and that products manufactured in Sweden are more environmentally friendly. They also highlighted concerns regarding the use of raw materials, with one student pointing out that we use resources and raw material that we do not have. Which reflects the concern that we are consuming raw materials at a rate that exceeds what is sustainable and available.

The Economic Dimension
When students talked about the economic dimension, they focused on transportation and usage & retail. They noted that buying frenzies, driven by frequent sales like Black Friday, Singles' Day, and Cyber Monday, lead us to purchase more than we need. They also noted that constant new trends and extensive marketing, especially on social media, unconsciously influences us to buy more. In comparing online shopping to in-stores shopping, they mentioned

that while online shopping is often cheaper, it may also come with potential quality issues. Shopping from Swedish websites was viewed as a preferable option.

Regarding transportation, the students stated that boats and airplanes are the two most common modes of transport. They noted that while both are efficient, they have distinct advantages and disadvantages. Flights were considered fast but expensive, while boats are time-consuming and fuel-intensive, yet capable of transporting large quantities of goods. One student suggested improving the efficiency of cotton transport by processing cotton on the farms themselves and have facility and warehouses in each country. She explained that this would reduce transport distances with lower costs and emissions, but also save time.

Regarding production, the students talked about how companies profit by exploiting cheap labour to minimize production costs and then selling products at higher prices abroad. One student suggested reinvesting profits to increase farm productivity and efficiency, which would increase earnings for the country and ultimately improve workers' wages and conditions.

When students talked about disposal, the conversation focused on the resale of goods. The students stated that surplus food and second-hand items can be sold at lower prices. Thus, they considered second-hand items more affordable.

How are these dimensions connected in the students' conversations?
The results show that when the students talk about the product life cycle, they express connections to each dimension of sustainable development. However, they also establish connections between the dimensions, and through the analysis three themes were constructed: The Dimensions are Isolated, The Dimensions Harmonise, and The Dimensions are Contrasted.

The Dimensions are Isolated
In the students' conversations, the dimensions sometimes appear isolated from each other, meaning that the students talk only from one perspective of sustainable development. This is particularly prominent when they talk about the social dimension in relation to production. In Excerpt C, the students Nina and Alex can be seen speaking about poison and working conditions.

Excerpt C

Nina	There are also a number of toxins in the production process. and the workers get sick from it and don't get the best care, so it's kind of horrible.
	…
Alex	In many cases it is also ... it can be really dangerous environments they work in. Poisons and so on are very often used, and it is allowed in many countries to use life-threatening pesticides and so on, where many people die or are seriously injured.

They emphasise that issues related to workers' health arise when companies use poison in their production, which relates to the social dimension of sustainable development. However, they do not establish connections to, for example, the ecological dimension and how the same toxic chemical affects ecosystems and non-human species.

The Dimensions Harmonise

The students express that the economic and ecological dimensions harmonise when they talk about transportation and disposal. In the example below, Jane states that reducing transportation distances could simultaneously decrease emissions and lower fuel costs (see Excerpt D).

Excerpt D

Jane	These are a lot of unnecessary transport distances, and it would be possible to eliminate many thousands of kilometres and thus reduce emissions, simply by reorganising a little, and everyone would benefit in the long run because there would be lower fuel costs.

Furthermore, when they talked about disposal, they also consider both the economic and ecological dimensions. They express that reusing resources, such as second-hand is both cost-effective and climate friendly.

In one group, students discussed the use of pesticides in production from both the ecological and social dimension. They stated that pesticide spraying affects biodiversity and causes animals and plants to die. They further pointed out that the chemicals eventually end up in lakes, streams, and groundwater, highlighting that spraying crops impacts humans as well, who then drink the contaminated water and eat the sprayed food.

The Dimensions are Contrasted

The dimensions are primarily contrasted when the students talked about production and usage & retail. The economic and social dimensions are contrasted when discussion production and companies' economic growth. The students stated that companies use cheap labour, often in poor working conditions and child labour, to maximise their profits.

When conversing about usage & retail, the students contrasted the tension between economic and ecological dimensions, particular when purchasing cheaper products at the expense of environmental considerations. They also pointed out how companies use marketing strategies, such as claims of reduced environmental impact, in order to get people to buy more (see Excerpt E).

Excerpt E

Nina	Yes, but companies do carbon offset, but really it's like this: just because you grow a tree, you don't carbon offset.
Jane	No, it almost feels more like a sales trick that: we carbon offset because then consumers will feel: yes, but we can buy more, it's okay they have carbon offset because I bought their sweater.
Nina	Yes, and they say we are carbon offsetting, yes but we are planting some trees.
Jane	But how do you carbon offset? Are you going to go out and capture carbon dioxide with a net - that will be difficult? There will be a climate impact.
Nina	Yes and many people who carbon offset they might buy a big piece of land in Africa of all places and plant trees there.
Jane	Yes, and there is no certainty that they will do that either.

Alice	If they say that, they might do it but it could also mean that we are carbon offsetting and that means that they plant 10 trees in a year which is an extremely minimal carbon offset.
Alex	It doesn't say exactly what kind of trees they plant, not how many trees they plant or where they plant.
Nina	Yes, and then maybe they take land from people in other poor countries.
Jane	Yeah, they kind of buy it from the state and then that affects people who live there - so it's not necessarily positive.
Nina	Yes exactly

What views can be traced in students' conversations about the product life cycle?

From the thematic analysis, the students' views on sustainability were traced. From this, two themes were constructed.

Technology for sustainable development

The students generally exhibit a strong belief in the potential of technology to solve environmental problems, particularly evident when the students talked about transforming the transport system. They highlight electric cars, trucks, and trains as solutions to reduce or eliminate carbon dioxide emissions. In one conversation, the students discussed among themselves whether online or in-store purchases are better. They reached the conclusion that both have an impact on the environment and lead to emissions. However, the student James suggests that if transportation is electric, it does not affect the environment (see Excerpt F), and his statement remains unopposed.

Excerpt F

| James | It depends on what kind of transportation you use. If you travel by train or electric car, it does not affect the environment |

Sustainable development for humankind

Students related the product life cycle to environmental impacts with statements like "it destroys biodiversity", "it is bad for the environment", and "we should not waste Earth's resources". These statements are somewhat ambiguous in terms of their views. As their conversation continued, they sometimes explain why these environmental impacts are negative, often referencing how they ultimately affect humans. For example, they talked about pesticide spraying, water scarcity, and reduced biodiversity, noting how these issues would affect people's living conditions. One group talked about that spraying crop affects biodiversity (see Excerpt G). Student Liam states that biodiversity is important because it affects plants and animals. In the next statement, there are traces of an anthropocentric view as he states that ultimately humans will not be able to breathe. Olivia continues by pointing out that the spraying contaminates groundwater, which we drink, and emphasises caution, especially when spraying food that we will eat. In the conversations, the impact on humans is often the concluding point.

Excerpt G

| Liam | But organic stuff is good |
| Ava | Yes, it's better anyway |

Liam	But it's also more expensive. You also have to think that not everyone can pay for everything.
Ava	No, and then you have to make sure that the majority of all food production is organic, so maybe it will be a little cheaper. Or that the state goes in and subsidizes or something you have to do something anyway.
Olivia	Yes, to promote more climate-friendly. So if you constantly spray ... plants and crops and so on, then, then these chemicals will end up somewhere else eventually, for example in lakes or rivers or in the sea
Liam	Yes, but then this spraying also affects biodiversity, which is very important for the environment that biodiversity works because otherwise plants and animals would start to die out and eventually we will not be able to breathe as well.
Olivia	The spraying ends up in the groundwater and that groundwater... So we use that groundwater. We drink that groundwater. So spraying too much is not good. To a certain extent, it may be necessary in some situations, but you should probably be very careful about where and how you spray, especially food, which we also eat.

Water appears in further examples where an anthropocentric view can be traced. When students talked about how the cotton production leads to water shortages, they explain why this is bad based on the impact on people's living conditions. The impact of water shortage on other species is not mentioned in the students' statements. Thus, an anthropocentric view can be traced even in these conversations.

Discussion

In this study, we provide insights into secondary school students' conversations about product life cycles in relation to sustainable development. The findings show that the participating students talk about different parts of the product life cycle to varying degrees linked to the sustainability dimensions (research question (i)). When the students talked about the social dimension of sustainable development, they primarily considered the production of goods. While, when they talked about the economic dimension the students mainly talked in connection to usage and retail as well as transportation. However, when the conversation revolved around the ecological dimension, students talked in relation to all phases of products' life cycle.

But the dimensions of sustainability interact and influence each other within technological systems and exploring these inherent tensions and complexities should be a part of technology education in line for education for sustainable development. Emphasising a comprehensive and pluralistic approach and highlighting the interconnections between the dimensions is essential (Berglund and Gericke, 2016). We saw a need for a deeper exploration of how students´ combined or contradict the sustainability dimensions.

In Öhman & Öhman's (2012) study, students did not address conflicts of interest and tended to perceive the dimension as harmonising with each other. In contrast, the students in this study not only talked about how the dimensions interact harmoniously but also highlighted the conflicts of interest that can arise between them (research question (ii)). This mirrors the relationship between sustainable development and the product life cycle which is full of contradictory objectives. Examining these interactions provides a deeper understanding of both the challenges and opportunities involved in achieving sustainable development (Herremans &

Reid, 2003; Sterneäng & Lundholm, 2012). Viewing sustainability issues from multiple dimensions and understanding the interactions between and within systems is known as systems thinking, a key competence among the twelve preferred in GreenComp (Bianchi et al., 2022).

The GreenComp competences emphasise the importance of explaining and critically evaluating different views on sustainability. This involves reflecting on one's own view and being aware of various approaches to sustainability. These moral and philosophical views influence different assumptions and arguments presented (Bianchi et al., 2022). The results from research question (iii) show traces of viewpoints in these students´ conversations, the main findings were anthropocentric and technocentric. Although the ecological dimension was evident in their conversations about the entire product life cycle, indicating an awareness of the environmental impact from production and consumption, their viewpoints were anthropocentric and technocentric. Bianchi et al. (2022) emphasise that students should be encouraged to act responsibility and with care for our planet both now and in the future. The sustainability competences stress the importance of showing empathy toward all form of life. It is crucial to recognise that all living organisms and non-living elements are closely interconnected and interdependent, with humans being an integral part of nature rather than superior to it.

Limitations

In this study we wanted to provide insights into secondary school students conversation related to sustainable development. But in a study where students engage in group dialogue, it is difficult to get a comprehensive picture of students' thoughts and opinions. Some students may be more inclined to speak than others, which may lead to some voices dominating the discussion while others remain silent. This can affect the diversity of expressions that emerge from the dialogue. Additionally, the aim of this study is not generalisability, but rather to describe what emerges in the students' conversations. Both these matters have been considered in presentations of the findings. Furthermore, within the group interviews, students are assumed to be influenced by group dynamics or social norms. Therefore, what they express is not interpreted as perceptions of students but rather what they want to convey in this context. Nevertheless, such expressions and these group discussions provide valuable insights for technology education.

Implication for practice

These findings offer valuable implications for technology education, both in term of content and practice. Educators can leverage this understanding of how students discuss sustainable development and product life cycles to refine and enhance technology education curricula and teaching methods. Notably, the findings provide insights into specific dimensions of sustainability within the product life cycle that can be further emphasised in technology education. This to achieve a holistic perspective of sustainable development with a pluralistic approach that also highlights the interconnections between economic, ecological, and social dimensions (Berglund & Gericke, 2016).

In line with the pluralistic approach, it is crucial to understand diverse views on sustainable development, not to impose specific values on learners, but to illustrate that values are constructs and that we can choose which values we want to prioritize (Bianchi et al., 2022). The

method used in this study generated interesting discussions where perceptions, emotions, and values linked to sustainable development appeared. Similar classroom discussions as deliberative conversations can be part of technology education to initiate dialogues where students can learn from one another (Gustavsson and Warner, 2008). These conversations increase awareness of sustainability´s complexity, promote critical thinking, and help develop the skills necessary for making informed, sustainable decisions – ultimately leading to greater student action competence.

Technology education must equip students with the knowledge and skills needed to develop a responsibility toward both the current world and for the future. Integrating sustainability into the teaching of product life cycle creates a valuable opportunity to educate informed, conscious citizens who can drive positive change in technology development. As highlighted by Elshof (2009), Pavlova (2013), and Stables & Keirl (2015), technology education plays a crucial role in fostering a new perspective on how we use, consume and design technology with an emphasis on social, economic and ecological sustainability. Empowering students with a sense of responsibility will enable them to actively contribute to a more sustainable world.

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