

# Process drama as a tool for participation in explorations of 'wicked problems' in upper secondary chemistry education

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This study targets a special form of educational drama called *process drama*, as a potential means for enabling student engagement with wicked problems. The overarching aim is to explore how process drama may afford student agency in dealing with wicked problems in upper secondary chemistry education. It is a design-based study with two cycles of intervention in two schools. A process drama plan was designed to focus on the wicked problem of plastic pollution. The interventions were video- and audiotaped and thereafter transcribed. The data were analysed using a combination of qualitative content analysis and a sociocultural framework of the two dialectics *agency/structure* and *margin/centre*. The analysis resulted in three themes regarding how plastic pollution and plastic use was explored in the process drama. The students participated in a constant flow between margin and centre where different spaces for students' agency was afforded. In brief, our main finding is that process drama enables students and teachers to participate in a variety of ways in the exploration of wicked problems, and talk about plastic pollution and plastic use, while drawing on knowledge and perspectives of science as well as values and societal and social science perspectives and knowledge.

Keywords: process drama, wicked problems, agency, upper secondary chemistry education

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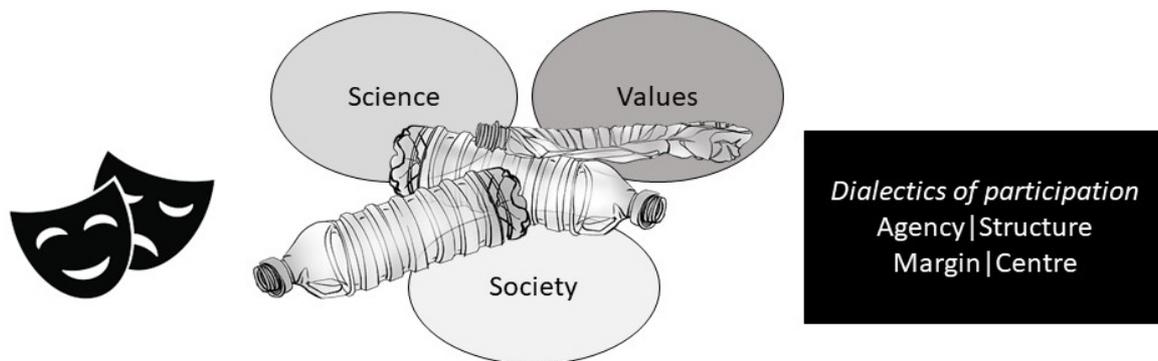
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## Wicked Problem: Plastic Pollution



- Fiction-reality interactions are important.
- A challenge to strengthen student agency in using disciplinary chemistry resources as part of process drama.
- Balance between creative freedom and productive constraint.



## 1 Introduction

Commonly adopted approaches for teaching chemistry in many countries tend to portray chemistry as a discipline of isolated topics disconnected from other areas of life (Freire, Talanquer & Amaral, 2019). Notably, Orgill, York & MacKellar, (2019) contend that there is a lack of teaching traditions that address global sustainability issues and the current planetary emergency, advocating systems thinking in chemistry education “to integrate knowledge about the molecular world with the sustainability of Earth and societal systems” (Mahaffy, Matlin, Holme & McKellar, 2019, p.362). This study seeks, through the use of drama, to contribute to disrupting conventional chemistry teaching practices to enable student engagement in explorations of how chemistry knowledge may come to matter when dealing with complex sustainability issues. More specifically, the study explores ways to promote a holistic understanding of Chemistry, where chemical processes are not seen as isolated but as part of larger systems, such as the environment, industrial processes and biological systems. The goal to promote a holistic understanding is very much in line with the European sustainability competence framework, GreenComp (European Commission, 2022).

Complex sustainability issues deal with complexity, uncertain facts, disputed values, high stakes and the need for urgent decisions and are of such a nature that they require both knowledge of science and careful considerations and actions based on values (cf. Bazzul, 2015). The issues can be understood as *wicked problems* (Rittel & Webber, 1973) that are “characterized by incomplete, uncertain or contested expert knowledge, conflicting values and objectives, a lack of unambiguous problem formulations and the impossibility to find uncontested definitive solutions (Block, Van Poeck & Östman 2019). The concept of “wicked” should not be understood as malicious, but rather in the sense of multifaceted or elusive. Tackling wicked problems require changes in people’s lives, which makes them highly political (Block et al., 2019).

Integrating wicked problems into chemistry teaching can be challenging (Bursjö, 2014; Burmeister, Schmidt-Jacob & Eilks, 2013), in that it challenges ‘the accumulation of isolated facts without relevance and proposes a holistic approach to chemistry education embedded in, for instance, sustainability awareness, integrative worldview perspectives, and pluralism’ (Herranen, Yavuzkaya & Sjöström, 2021, p. 11). The teaching must simultaneously deal with the chemical content as well as complex sustainability issues, including emotions and ethical and moral values (Block et al., 2019) – aspects that are often missing in traditional chemistry teaching (Vilches & Gil-Pérez,

2013; Zuin, Eilks, Elschami & Kümmerer, 2021). The teaching must not only impart subject knowledge but be organised in ways that provide students with opportunities to participate in conversations about the social implications of chemistry (cf. Lundegård & Caiman, 2019). Hence, there is a need to develop teaching methods that integrate these issues into chemistry education. This study focuses on chemistry teaching in relation to wicked problems and how drama may be used as a means to support student participation in conversations about such problems.

### 1.1 Process drama in chemistry education as a means for tackling wicked problems

Although several studies have acknowledged the value of using educational drama in teaching about sustainability (McLaughlan 2006; McNaughton, 2008; Österlind, 2018, Lehtonen, Virret & Österlind, 2020; Lundegård & Caiman, 2019; Ødegaard, 2023), few have examined its potential in chemistry education at upper secondary level.

In this study, the focus is on how a particular form of drama called *process drama* may provide students with affordances for making chemistry knowledge relevant in relation to wicked problems. It is a form of educational whole-group drama where students and teachers participate as both observers/audience and actors, and take different roles during the drama (Warner & Anderson, 2004; Bowell & Heap, 2013). The term process refers to the fact that the drama activity prioritises learning through engagement in the process rather than through a performative result (Clark-Fookes & Henderson, 2021). Process drama is commonly used to support students' understanding of a topic and making connections between different areas of knowledge as well as between ethics and emotions.

What distinguishes process drama from other forms of drama and role-play is that the teachers participate and take roles in a narrative created with the students on site (Hallgren & Österlind, 2019). This enables the teacher in role, (teacher-in-role [TiR]) to act flexibly – to shift ways of positioning authority and control of the process depending on how the drama unfolds (Heggstad, 2014).

The teacher uses a plan for where to start the drama, called pre-text, based on a predetermined theme, and sets of drama pedagogy conventions (Hallgren, 2018). Examples of drama conventions are improvisations, still images, writing-in-role, and reflection out of role which enable different ways of exploring and deepening the understanding of the process drama's content. The students are enabled to participate in

conversations which include several actors by assuming roles such as, for example, researcher, politician, activist, where conflicting issues can be explored without having to expose personal opinions or stances. In line with Warner and Andersen (2004), the role does not require that the student adopt a deep portrayal of the role character; rather, the role offers an opportunity to experience the problem from a different perspective.

It has been suggested that process drama can be a powerful way to support students' active engagement in sustainability issues from a safe position. This is because students participating in role may be less vulnerable compared to when they are required to take a stand and/or argue for a position when participating as themselves (Hallgren & Österlind, 2019). Letting the students step into a role and experience complex environmental problems, entangled in values and attitudes, and explored from different perspectives, may, according to Berggraf Sæbø, (2011), contribute to new insights and transformed understandings.

To date, however, there has been no research on process drama in Chemistry education, which makes the implications of previous research on process drama uncertain. It is unclear whether wicked problems could be productively explored through process drama in chemistry teaching and to what extent process drama might contribute to challenging chemistry as a discipline of isolated topics disconnected from other areas of life. One might also question the value of process drama from a perspective of what disciplinary content students could be enabled to explore.

## 2 A sociocultural lens on agency and participation in process drama

This study draws on a sociocultural framework of agency and participation. In chemistry education practices, students and teachers participate in social knowledge building where structures and resources provide different conditions for student agency in learning.

According to Vygotsky (1934/1999), students learn when participating in activities through interaction with people and cultural resources. Learning is thus seen as an integral and inseparable aspect of participating in a social practice (Lave & Wenger, 1991). The notion of participation entails ways of being in and gaining access to communities of practice. In the course of growing engagement, ways of accessing and ways of being located in such communities expand (Wenger, 1998). Here, we focus on how

ways of participating in a community of chemistry education may be expanded through the incorporation of process drama.

Drawing from the notion of communities of practice (Wenger, 1998), Chemistry education ideally emerges as a joint enterprise of students and teachers engaged in forming collaborative relationships and, through interactions, coming to share more nuanced understandings of chemistry and chemical phenomena. By introducing process drama that deals with complex sustainability issues, into chemistry teaching, new resources are made available to the students and teachers which may then potentially be used to promote new ways of acting. Thus, expanding the repertoires of participation of both students and teachers for tackling wicked problems (Anker-Hansen & Andrée, 2015). Process drama provide resources for students and teachers to step into the fictional world, while being aware of the real world, which may foster deeper understanding of multiple perspectives in dealing with complex sustainability issues (White & Raphael, 2023). Moreover, previous research on the integration of science and drama has pointed to that drama has the potential to expand repertoires for participation in chemistry education by enabling students and teachers to express empathy, encourage dialogue and collaboration, and promote a more holistic approach to learning science (e.g., Clark-Fookes & Henderson, 2021; Varelas, Pappas, Tucker-Raymond, Kane, Hankes, Ortiz & Keblawe-Shamah, 2010).

As a framework for describing students' participation in chemistry education process drama we adopt the metaphor *margin|centre dialectic*<sup>1</sup>. The framework allows us to see learning as participation as a fluid process and to make sense of how transformation, development and learning unfold within the classroom at individual and collective levels (Roth, Goulart, & Plakitsi, 2013). Drawing on Goulart and Roth (2006), the margin|centre dialectic implies that each moment of participation constitutes both marginal and central participation, creating a flow of participation that is constantly changing in the classroom. In line with this view, changes and movements in activity cannot take place without an agent achieving some form of agency.

Furthermore, through a dialectical sociocultural lens, agency is understood in the two dialectical relations, agency|structure and agency|passivity (Goulart & Roth, 2010; King, 2012). Agents and structures are theorised as a dialectical relationship where structures in themselves include social arrangements, relationships and

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<sup>1</sup>We use the “Sheffer stroke “|” to combine two mutually excluding yet mutually presupposing manifestations of an overarching unit” (Roth, Goulart, & Plakitsi, 2013, p. 10).

practices that can exercise power and limit people's lives (Osterkamp, 1999). In process drama the agency emerges with the material (e.g., artefacts used in the drama activity) and social structures; providing opportunity and space for student learning (Andrée, 2020).

## 2.1 Aim and research questions

The aim is to explore how process drama in upper secondary chemistry education may afford students agency when dealing with wicked problems where chemical knowledge may be important. The study is designed as a process drama intervention focussing on plastic pollution and plastic use. Today, plastics are found everywhere on the planet, from oceans to human blood. While there are numerous initiatives to address this problem, consensus on how to deal with it is lacking and the solutions being proposed raise considerations about values related to, for example, the environment and social and economic justice.

The research questions are:

- What dimensions of plastic pollution and plastic use do students explore when participating in a chemistry education process drama?
- How is student agency achieved in a process drama on plastic pollution and plastic use?

## 3 Method

The study was conducted as a design-based study where a process drama focussing on plastic pollution and plastic use was designed, implemented, analysed and re-designed in two cycles in upper secondary chemistry education in two schools (A and B) in Sweden.

### 3.1 Designing an intervention

A process drama plan was designed to confront the local and global challenges of plastic use and waste, and what stakeholders could do to tackle the problem from a sustainability perspective. The process drama plan included travels back and forth in time to explore the motives and needs, as well as the current and future consequences of plastic pollution. The process drama included time travel to a future dystopian

plastic society and was therefore initially entitled ‘The Journey to Dystoplastica’. An aim of the research lessons was to create opportunities for students to participate in conversations about the social implications of chemistry. Our idea was to enable the students to participate in conversations about the plastic problem that included several actors with different interests, where chemistry knowledge is required and where they could confront societal problems and questions regarding plastic waste.

In the design of the process drama, we included authentic data from an interview with a researcher in environmental chemistry conducting research on the threat of plastic pollution and a recent publication from his research (MacLeod, Arp, Tekman, & Jahnke, 2021). A reason for this was to connect the practice of school chemistry to authentic practices of research in chemistry (Anker-Hansen & Andrée, 2019). The process drama was constructed with student roles as chemists, researchers, politicians and journalists. In doing so, we intended to give the students roles that served the context from different perspectives (Bowell & Heap, 2013). In school A the students were provided with short role descriptions written by the first author. In school B a part of the students were provided more elaborate and detailed role descriptions written by authentic stakeholders. The students were grouped in ‘cross-professional’ teams so that the different roles would meet in a joint venture to tackle the plastic problem. Another decision guiding the design of the process drama plan was that the teacher in role, TiR would take different status positions (low, middle or high-status positioning), in order to be able to influence the course of the drama from the inside (Heggstad, 2014). At School A, the drama was set at the Public Health Authority (PHA), at School B, it was the Swedish Environmental Protection Agency (SEPA). After having implemented the process drama in School A, we revised the process drama plan to give the students more time for reflection – both in role and out of role – to make connections between what they had experienced in the drama and their personal life (Hallgren, 2018). Thus, we intended to create spaces for interaction between fiction and reality. According to Bolton (1984) the interaction between fiction and reality through reflection in and out of roles can be seen as the main pedagogical potential of drama (Bolton, 1984).

An overview of the episodes (1–13) and drama conventions included in the process drama plan is provided in [Table 1](#).

**Table 1.** An overview of the process drama plan.

Episode	Description	Drama convention(s)	Aim
1.a	<i>Cycle 1-Picture gallery</i> Looking at depicted animals affected by plastic pollution. After looking at the pictures, each student has to continue the sentence saying: I see...or I hear...	I see... or I hear...exercise.	Create entry into the drama and common focus on plastics.  Raise ethical thoughts.
1.b	<i>Cycle 2-Warm-up exercise</i> Students were encouraged to choose an object from a bag that contained plastic artefacts and molecular models of organic compounds related to plastics. They were encouraged to reflect on what it had to do with the drama, and then tell the whole class what they thought.		Create entry into the drama and common focus on plastics.  Connect previous chemistry knowledge to the process drama.
2.	<i>Listen to the plastic problem on the radio.</i> The students sit or lay on the floor encouraged to close their eyes, and imagine driving their car. The teacher as a radio newscaster tells a story about polluted seas in the neighborhood. The students are called to an important meeting with the Public Health Authority/Swedish Environmental Protection Agency	Narrative by TiR.  Visualize the plastic problem.	Create context about the plastic problem.
3.	<i>Role taking and information at the Public Health Authority/Swedish Environmental Protection Agency.</i> Students assume roles by sitting on chairs (with role descriptions on the seats) placed in teams, as chemists, researchers, politicians and journalists. The teacher as Public Health Authority representative provide information about plastic pollution, and the background to why the teams had been called to the meeting.	TiR as Public Health Authority representative (middle-state position).  Improvisation students and TiR.	Information about the plastic problem.  Get role improvisation going and create tension between the participants
4.	<i>Task to write reflection in the form of SMS.</i> The students write a text message to a friend in which they express in one sentence something they have experienced during the meeting. They then get to read the message aloud.	Writing in-role, visualize and sharing thoughts	Reflection on what one has experienced
5.	<i>Students and teachers out of role</i> discuss what they have experienced in the drama.	Whole-class reflection out-of-role.	Allowing students to ask questions and share their thoughts  Highlight issues from different perspectives
6.	<i>Information from the Space Agency chief about the assignment.</i> TiR as Space Agency Chief informs the teams about the time machine, and the mission to travel in time.	TiR as Space Agency chief (high-state position).  Improvisation students and TiR.	Establish context  Raise the tension and clarify the dilemma

7.	<i>Time travel back in time and meeting with the chemist Hermann Staudinger.</i> The teams travel back to the 1920s where they are met by a chemist who talks about the first plastic materials and how they were made.	Visualize ritual of time travel  TiR as the Chemist Hermann Staudinger  Improvisation students and TiR.	Clarify movement in time  Information about and creating an understanding of the history of plastics.
8.	<i>Task to make an advertising jingle.</i> The students are invited to help the chemist Hermann to make an advertising jingle, where the teams are assigned the task of showing with their bodies and verbally why plastic is good.	Tableau  Small-group teamwork and performance in whole-class.	How plastic was seen "back then" as a fantastic material for the future.
9.	<i>Students and teachers out of role</i> discuss what they have experienced in the drama.	Whole-class reflection out-of-role.	Allowing students to ask questions and share their thoughts.  Highlight issues from different perspectives.
10.	<i>Time travel to Dystoplastica and meeting with villager.</i> The teams travel 100 years forward in time, to the future Dystoplastica. They create a collective statue of things they see in the polluted environment, and meet a villager.	Visualize ritual of time travel.  TiR as a villager (low- or middle-state position).  Improvisations students and TiR.  Creation of collective statue.	Clarify movement in time  Reflections on the consequences of plastic use
11.	<i>Task to write reflections in the form of diary.</i> Back in the time machine, each team member reflects on their time travel experiences thus far, by writing in their diary. They are asked to underline the most important sentence which the teacher then reads aloud.	Writing in-role.	Reflections on what one has experienced
12.	<i>Time travel back home and task to work with the assignment.</i> The teams travel back to the Public Health Authority/Swedish Environmental Protection Agency. The teams are tasked to present three important proposals to reduce the negative impact of plastic on the environment. They must also state which plastic materials we should develop and which plastics we should avoid.	Visualize ritual of time travel  Small-group teamwork in- role with reporting in whole-class.	Clarify movement in time  The students work collectively to come up with proposals for tackling the plastic problem.
13.	<i>Students and teachers out of role</i> discuss what they have experienced in the drama. Finally, students' reflections on how it felt to do the process drama and development of the process drama are discussed.	Whole-class reflection out-of-role.	Allowing students to ask questions and share their thoughts about their experiences in the process drama.

### 3.2 The setting

The process drama plan was implemented in the form of two pro-longed lessons (two and three hours respectively) in two municipal upper secondary schools. The lessons were planned and conducted in collaboration with three teachers and were enacted in the respective schools' drama/music rooms. The students had no previous experience of working with process drama in upper secondary school.

In School A, 14 students (aged 17–18), in their final year of upper-secondary school, participated. The process drama was conducted during a thematic week on human rights, where one day was devoted to natural science. The students had completed all the chemistry courses when the process drama was conducted. The first author, who had previously taught chemistry to the students in their first upper secondary year, participated as a teacher and a TiR. Their class mentor and Swedish (mother-tongue) teacher also participated as a TiR.

In School B, 17 students (aged 16–17), in their second year of upper-secondary school, participated in the process drama. It was conducted as part of the ongoing teaching of organic chemistry in the second year of the students' science education. The first author participated as a teacher together with the students' teachers in Chemistry and Biology, acting TiR.

We have conducted the research in accordance with the ethical regulations and guidelines provided by the Swedish Research Council (2017). The students and teachers were informed orally and in writing about the research, and all participating teachers and students gave formal written consent to collect their personal data for research purposes through audio- and videorecording. The collected data do not entail sensitive personal data (GDPR EU 2016/679).

### 3.3 Data collection and analysis

The collected data included video- and audio recordings of the research lessons (Table 1) and were transcribed verbatim.

To investigate what dimensions of plastic pollution and plastic use the students explored when participating in a chemistry education process drama, we used *qualitative content analysis* (Graneheim & Lundman, 2004; Erlingsson & Brysiewicz, 2017). First, we discerned *meaning units* (1) – words, sentences or paragraphs containing aspects related to each other through their content or context. In the next step, these meaning units were condensed into *codes* (2) – terms that most exactly

described a particular meaning unit. Then we grouped those codes that related to each other through their content or context into *categories* (3). The analytical process is illustrated in [Table 2](#).

Each category functioned as an umbrella for various content regarding how plastic pollution and plastic use was explored in the process drama. For example, the meaning units sorted under the code's *organic chemistry concepts* and *different types of plastics* were associated with the category *using resources of chemistry*. Together with other categories (*framing the plastic issue as a scientific problem* and *scientific-oriented solutions to problems of plastic*) a theme was formed which we labelled *exploring the plastic problem from a scientific perspective* (see [Table 2](#)).

**Table 2.** Examples of how the qualitative thematic content analysis were applied in the study.

Meaning unit	Code	Category	Theme
<i>Student: I have two hydrocarbons - ethylene and propene [two molecular models]... but they are hydrocarbons and they build long chains and they are not directly water soluble...</i>	Organic chemistry concepts	<b>Using resources of chemistry</b>	<b>Exploring the plastic problem from a scientific perspective</b>
<i>Student 1: Yes, and then what do we want to focus on, bioplastics?</i> <i>Student 2: yes, bioplastics</i> <i>Student 3: plastics from nature</i> <i>Student 2: e.g., sugarcane</i>	Different types of plastics		

To analyse student agency, we searched for instances in the transcriptions that displayed how student agency was achieved. We used the constructs of margin|centre and agency|structure to analyse and describe how the students were enabled to participate in the process drama. For example, when the students participated in an improvisation in the future *Dystoplastica*, they meet TiR as a villager, who talked about plastic from a scientific perspective. At the start the villager took on a role resembling a teacher-in-disguise (Berggraf Sæbø, 2009). However, all of the sudden one student stepped into a role of visiting the future and asked the villager ‘How do you experience this, this situation?’. With this utterance, the student introduced a value perspective and changed the structure of the drama. Drawing on the notion of margin|centre, our analysis revealed that in the beginning TiR was positioned at the centre and the students at margin with the dialogue controlled by the TiR, but when the student stepped into role, the student disrupted the social structure and moved to the centre of the drama activity.

## 4 Results

The results are presented in two parts: (I) Explorations of plastic pollution and plastic use, and (II) Student agency when dealing with complex sustainability issues in the process drama.

### 4.1 Part I: Explorations of plastic pollution and plastic use

We discerned three themes related to exploring the plastic problem. Each theme is illustrated with an overview of the theme in the form of a content map with categories, codes and examples of meaning units (See Figure 1, 3 and 4), followed by a presentation with descriptions and empirical examples from the qualitative content analysis regarding how the different categories were expressed in the process drama.

#### 4.1.1 Theme 1: Exploring the plastic problem from a scientific perspective

The first theme describes how the students explored the plastic issue as a scientific problem with scientifically framed solutions to problems of plastic pollution (Figure 1). The students used resources of chemistry, physical as well as imaginary, including knowledge of applications, properties, and different types of plastics, as well as organic chemistry concepts related to plastics.



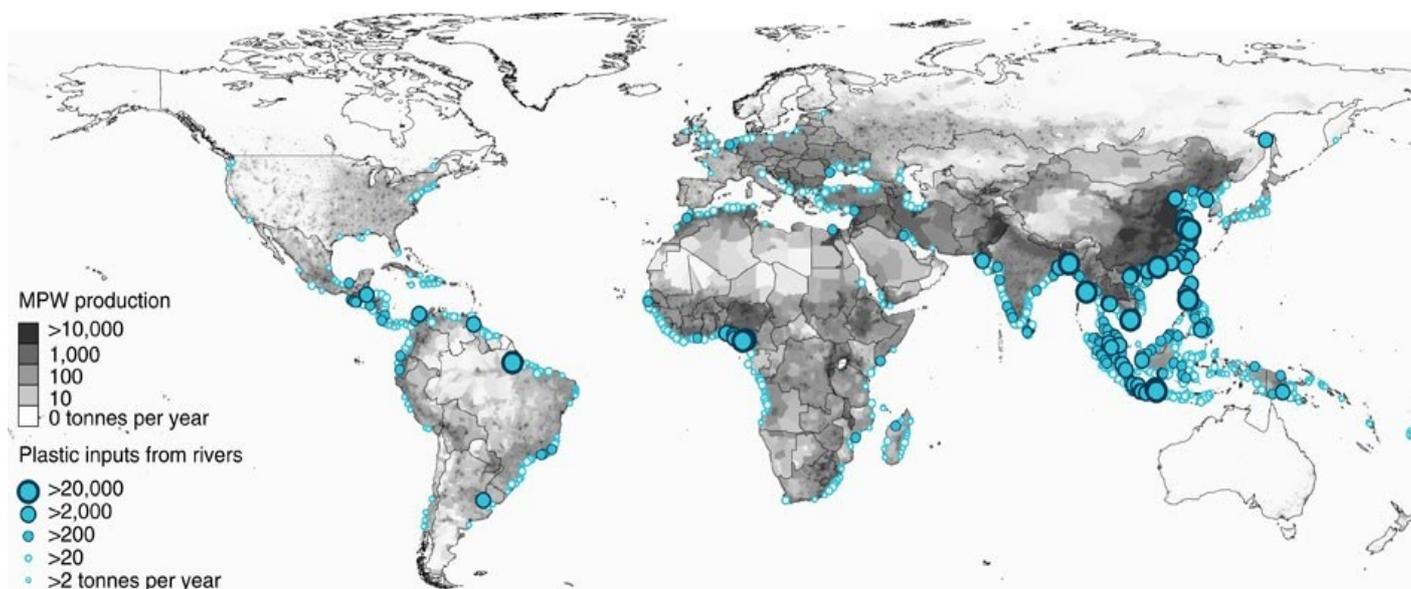


Figure 2. Mass of river plastic flowing into oceans in tonnes per year, reprint from Lebreton et al. (2017).

*Using resources of chemistry.* During the process drama, the students were provided with plastic artefacts and molecular models of organic compounds related to plastics. In Episode 1b, students were encouraged to choose an object from a bag, reflect on what it had to do with the drama, and then tell the whole class what they thought. One student said:

I have two hydrocarbons ... both ethylene and propene [two molecular models] ... but they are just hydrocarbons. And they build long chains, and they are not directly water soluble, so they can be stored in fatty tissue, and if they end up in nature it is not so good for organisms. Yes, maybe connected to environmental toxins.

Here, the process drama drew the students' attention to the disciplinary resources of organic chemistry. Another example that encouraged the students in School A to use resources of chemistry is illustrated below when the students met the TiR acting as the German chemist Hermann Staudinger from the past. The excerpt begins when the teams have just landed with their time machines in the 1920s (Episode 7, Table 1). There they are met by Staudinger who asks questions about the material in students' clothes and shoes. Staudinger talks about the first plastic materials and how they were made, such as parkesin, celluloid and bakelite, while throwing celluloid balls to the team members. Suddenly he snatches a plastic bag from a student's pocket:

1. TiR (Hermann): But this [the plastic bag in his hand] is fantastic! How, how do you make these?
2. Fares: Fossil fuels.
3. Omar: Oil, perhaps...
4. TiR (Hermann): But oil, yes, you know I've started experimenting with it. What kind of molecules do you use?
5. Mira: Organic, I mean carbon and all.
6. TiR (Hermann): Coal and organic...but this particular mouldable mass I have produced, it is very plastic (pulling his hands back and forth) and what did you say you called it?
7. Dora: Plastic.
8. TiR (Hermann): *Aaaaaaaa!* (loud roar) That's why you call it plastic. *It's plastic!!!*
9. Acke: Yes!  
[...]
10. TiR (Hermann): Huh, what do you call those that have two carbons? Those that have two carbons with double bonds in between? What are they called then?
11. Kelly: (whispering to her team members) Ethene?
12. Omar: Mono...
13. TiR (Hermann): What did you say?
14. Kelly: Ethene.
15. TiR (Hermann): Well, that's exactly the one I've been using! Do you think that is what you are using now in the future? You who come from the future!
16. Kelly: Yes...

Hermann continues by asking what molecules were formed when he heated the substance, to which Gosia replies, 'Poly, polysaccharides'. Mira continues:

17. Mira: No, what are they called?
18. TiR (Hermann): Poly...ethylene?
19. Mira and Gosia: Polyethylene, yes!!!
20. Gosia: It's not sugar!

The episode ends with Hermann asking the teams for help to make an advertising jingle, where the teams show why plastic is fantastic. In the process drama, the TiR directs the activity but positions the students as knowledgeable about materials of today. When the TiR (line 10) asks what the molecules with two carbons that have two double bonds between are called and Kelly in line 11 answers 'ethylene', they jointly actualise chemistry knowledge. Gosia also actualises chemistry knowledge when she exclaims, 'it's not sugar' (line 20), which refers to the polysaccharides mentioned earlier (lines 18–19). The teacher asks for genuine information that is important to Hermann and the students respond by activating disciplinary knowledge.

*Scientifically oriented solutions to problems of plastic.* In the process drama, the students explored solutions to problems of plastic pollution and emissions. For example, the students emphasised that education about plastic is pivotal because many

problems are about uncertainty and lack of knowledge. They also raised the importance of research and technology in solving the plastic problem.

The students discussed which plastics could be used and which should not. When one of the groups presented their proposals to the authorities, they emphasised that one should avoid ‘virgin plastic which is the brand-new plastic that comes from fossil fuels’. Instead, they claimed, one should invest in making bioplastics, for example, ‘polyethylene from sugar cane’, which would be ‘easy to grow’. Another group emphasised that one should avoid new plastics altogether – even bioplastics – because of the additives used. Instead, the group argued for the use of plastic ‘made of mainly recycled material and consisting of only one type of polymer’.

In school B, a need to know more about bioplastics arose when one of the students – Vilma who is acting as a journalist – poses a question about bioplastics to the team sitting in the audience: ‘I had a little question about the previous presentation about this bioplastics thing. I don’t know if I’ve heard wrong, but it’s still, you still make a plastic and it doesn’t have to, just because it’s bioplastic that comes from the environment, doesn’t necessarily mean that it can decompose in a good way...’

In response to the question raised, Astrid picks up her cell phone and looks at it during a moment of silence. She then replies ‘I’m not educated enough to answer that’. Here, a need to know more about bioplastics is established and even if the disciplinary chemistry knowledge is not shared/made public during the process drama, this knowledge becomes recognized as potentially important for taking a stance on the plastic problem.

In sum, through the process drama the students were provided the opportunity to explore different types of plastics and draw conclusions about which plastic might be the best solution from a scientific point of view. In the students’ reasoning, different perspectives on bioplastics emerged, displaying the complexity of the plastic issue. In the examples described above, the students used chemistry knowledge to reflect on solutions. And, while the students explored solutions, needs arouse among the students to learn more.

#### 4.1.2 Theme 2: Exploring the plastic problem from a societal perspective

The second theme (Figure 3) illustrates how the students explored the plastic issue from a societal perspective. In the process drama, the students became engaged in finding societal solutions to problems of plastic.

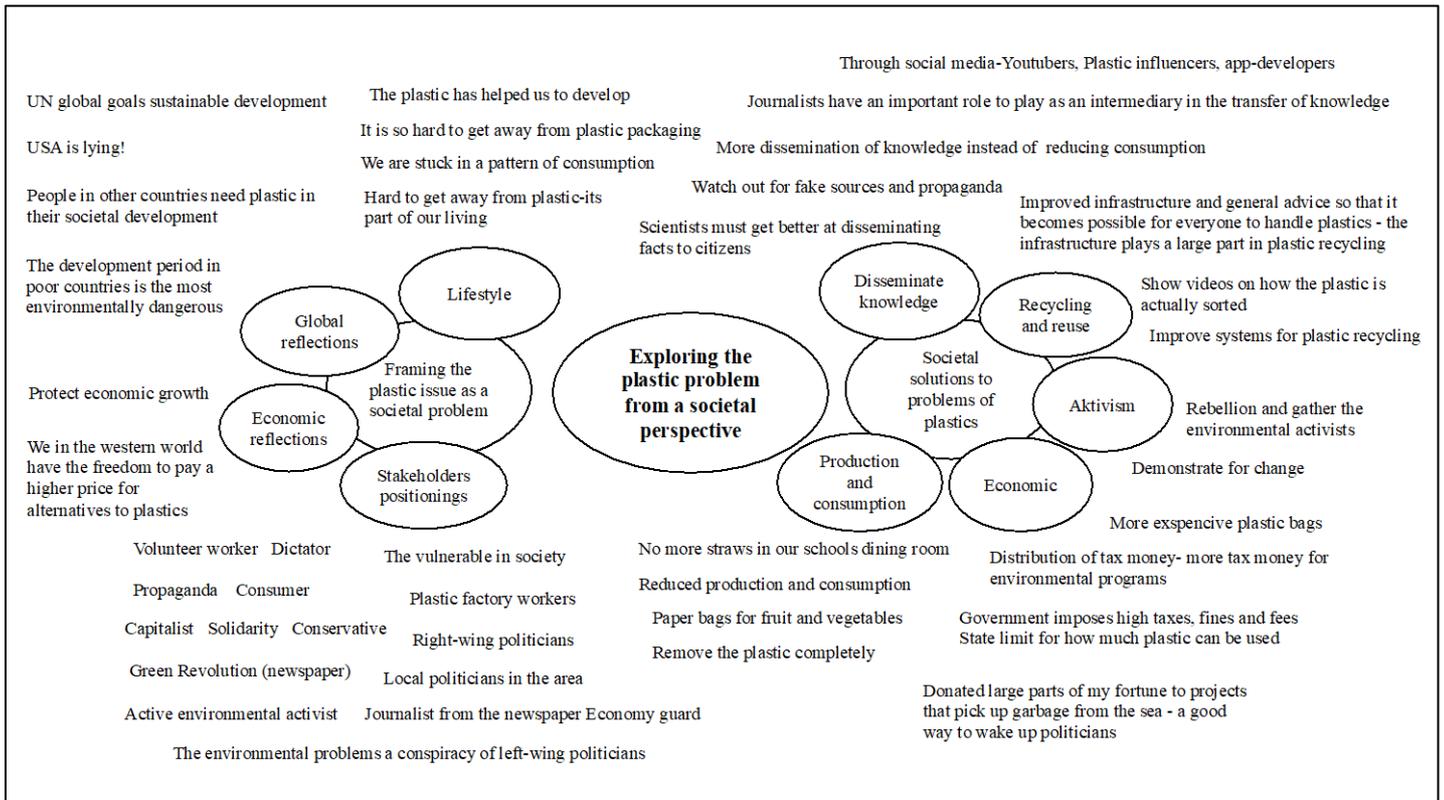


Figure 3. Content map of theme 2 (inner ellipse), displaying categories (middle ellipses), codes (outer ellipses) and examples of meaning units.

*Framing the plastic issue as a societal problem.* During the process drama, the students framed the plastic issue as a societal problem where different perspectives were highlighted. For example, when the students stepped out of role, some reflected on what the development of plastics has done to our societies and how it has affected our lifestyle. A student in school B said: 'in this modern society, we would not have been able to develop as fast without the help of plastics'.

The students also talked about the plastic issue from a global point of view. This is illustrated with an excerpt below from School A when the TiR 1, as a PHA representative, presenting the map over plastic pollution (Figure 2), is interrupted by one of the students:

1. TiR 1: Now we have come to the year 2029 and we have not yet reached these goals [the UN sustainable development goals on the slide] and it feels like we need to start thinking. And one thing (shows a slide with a map of river plastic, Figure 2) that we are so worried about now, that has been reported from all over the world, is how much plastic has accumulated on our coasts...
2. Sammy (journalist): *USA is lying!*

3. (silence)
4. Hakim (journalist): *Shut up!*
5. Dora (researcher): Hush!
6. TiR 1: What, what do you mean by the US is lying?
7. Sammy (journalist): There should be more there [on the map].
8. TiR 1: Yes, yes (looking and pointing at the map), you think there would be more plastic there?
9. Sammy (journalist): Yes.
10. TiR 1: Interesting, do you agree (looking at all the teams in the room)?
11. TiR 2 (left-wing politician): Yes, that's really the capitalists' stronghold! We can't trust anything from there. *Nooo...*

When TiR 1 presents the map on plastic distribution, there is an immediate reaction from Sammy who shouts 'USA is lying!' His reaction to the map can be interpreted as suspicion that there would be more plastic garbage along the US coast than the map shows. Sammy's reaction, however, creates uncertainty in the room – is he simply disturbing the teaching? Some students urge him to be quiet (lines 4 and 5). When TiR 1 asks what Sammy means she acknowledges his reaction and when TiR 2 (acting as a left-wing politician) says, 'we can't trust anything from there. *Nooo*' (line 11) she re-charges the imaginary narrative of the process drama. In retrospect, this interaction created space for framing plastic pollution as a societal and political global problem. The map functioned as a semiotic resource for recognizing the distribution of plastic pollution globally but also for critically questioning the map as a representation in the light of a global societal perspective.

*Societal solutions to problems of plastic.* The students explored solutions to the plastic problem, focusing on infrastructure that enabled recycling and reuse in our immediate surroundings, and reducing both production and consumption of plastic as a way forward. On several occasions during the process drama, they expressed concern about how to disseminate knowledge about the plastic issue to 'ordinary people' and reflected on how this could be resolved. They emphasised the role of journalists in acting as a bridge between politicians, scientists and citizens so that the plastic problem could be seen from different perspectives, and in counteracting the spread of false propaganda. To reach younger people in society, the students suggested to disseminate information through social media by way of 'plastics influencers' and YouTube videos. Also, students who had assumed roles as activists called for rebellion and demonstrations for change, while other students proposed economic solutions such as higher taxes, fees and fines to regulate plastic consumption.

In one group of students in School B (Episode 4, [Table 1](#)), two students (Eddie, acting as a left-wing politician and Maud as a journalist from the newspaper *Economy*

*Guard*) entered into a discussion about the distribution of tax money and where it should be taken from, and started to talk about solutions where they were combining fiction and reality.

1. Eddie: In many of the poor countries, they use plastic bottles to drink with and it could be good to try to provide them with tap water or more, like, sustainable solutions for the water.
2. Maud: Another solution is to build a large ring net [which collects the plastic in the oceans].
3. Eddie: It's kind of interesting because there's actually a project right now on the internet that some, yes, two big YouTubers, Mark Rober has joined together...
4. Maud: Yes, I have heard about that!
5. Eddie: I myself have donated a big part of my fortune to this project called TeamSeas...
6. Eddie: ... the goal is for them to clear 30,000, 30 million, what do you say, pounds of plastic from the ocean.
7. Maud: Yeah that, I like that!
8. Eddie: ... all the money then goes to these jobs, to people who pick up trash then and then they say that one, one dollar then is the same, as five pounds of plastic in the ocean.
9. Maud: That was a lot!
10. Eddie: Yes it's a lot, but it's not all and it definitely won't remove all the plastic in the oceans but it's a good start and it's a good way to wake up politicians.
11. Maud: Yes... I, I believe that small companies often find new markets for new technological developments. Yes, but to glow and grow I believe in that!  
[...]
12. Eddie: So, I'm kind of on your side... we need good engineers who can develop these new revolutionary ways of picking up trash from the sea. But until we get to a point where we have found a good solution or good new methods, then we need to have money so that we can hire people to pick up garbage from the sea and therefore we need tax money.
13. Maud: Ha, ha, ha...
14. Eddie: We need solidarity. We need volunteer workers who go out, go out on the beaches here and pick. It's, it's, it shows that we actually, we as humans can actually come together and solve these problems.

Maud and Eddie initially assume roles where they positioned themselves in opposition to each other regarding the distribution of tax money, but as the conversation progresses, they create and shared narrative where they raise and listen to each other's solutions based on their role positions (e.g., lines 3, 4, 11 and 12). In the narrative, they highlight the project TeamSeas (<https://teamseas.org>), a real-life fundraising campaign, initiated by Mark Rober and MrBeast, content creators on YouTube, to help bring attention to the problem of plastic pollution in our oceans. The excerpt illustrates how the process drama provides opportunities for the students to blend fiction and reality, creative imagination that takes shape in the present. Acting in role and connecting the TeamSeas project to actions taken in role, such as having donated

their fortune (line 5) affords the exploration of real-life as solutions to the plastic problem from a societal perspective. In addition, the students made visible that the plastic issue could be seen from several perspectives – the science perspective, by developing the technology to collect plastic from the oceans; but for it to work, societal solutions were required such as investing in small businesses and awakening politicians.

#### 4.1.3 Theme 3: Exploring the plastic problem from a values perspective

The third theme (Figure 4) illustrates how the students explored the plastic issue from a values perspective. In the process drama, they reflected on the division of plastic based on values –whether plastic was necessary or unnecessary, which made dilemmas visible to the students and enabled them to understand the plastic issue as a complex, value-laden problem. On several occasions during the process drama, the students directed improvisations towards value-based perspectives, even though the teacher had started from another perspective. A predominant code in this theme running through the categories was justice, in particular global justice.

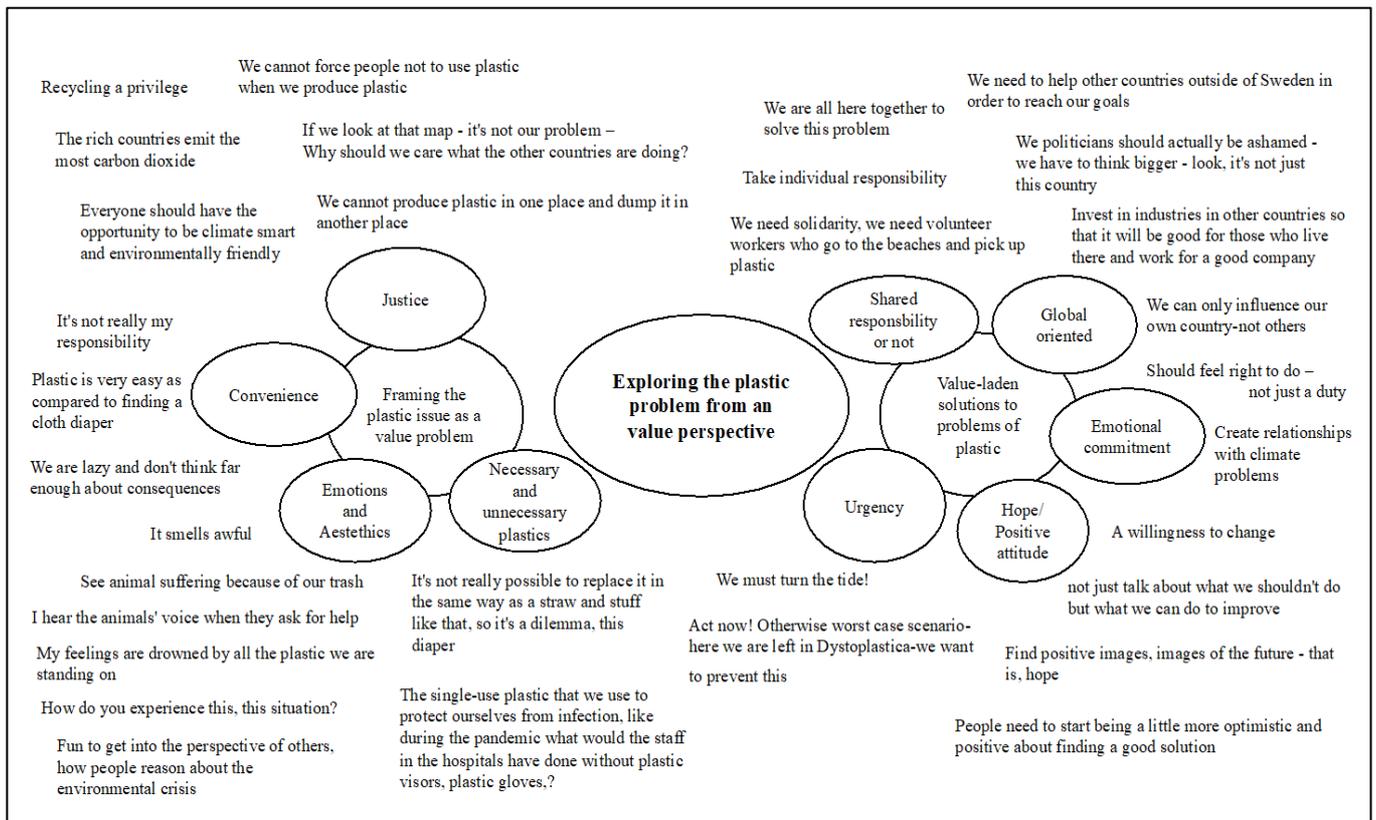


Figure 4. Content map of theme 3 (inner ellipse), displaying categories (middle ellipses), codes (outer ellipses) and examples of meaning units.

*Framing the plastic issue as a values problem.* In the process drama, the students reflected on what use of plastics could be considered important (e.g., plastic visors and other medical equipment), versus unimportant (e.g., disposable plastics such as straws). For example, when one of the students in Episode 1b chose a plastic diaper from the bag, she said: ‘...plastic is very easy compared to finding a cloth diaper’ and ‘it’s not really possible to replace it in the same way as a straw and stuff like that, so it’s a dilemma, this diaper’. Reflecting on the division of plastic according to its relative importance thus made the dilemmas visible to the students, which enabled them to understand the plastic issue as a complex problem.

On several occasions, the students actualised value perspectives and also forced the process drama narrative along a values perspective even though the teacher had begun with another perspective (e.g., scientific). One example of this is when the teams in School A had landed in Dystoplastica (100 years into the future). There they were met by a TiR acting as a villager draped in a torn blanket wearing both a gas mask and safety goggles. The teams walk around with the villager who informs them that they are walking on huge plastic graves and that the water has been poisoned:

1. TiR (villager): The microplastic has affected our water enormously, not only that we have all the plastic piles, but all the UV light has reacted with the plastics in them. I don’t know if you remember, have you, have you heard of these enormous, the plastic islands that exist?
2. Several students: Yes!
3. Sammy (journalist): Yes, we have heard about that in a report.
4. Mitch (politician): (steps forward towards the villager) How do you experience this, this situation?
5. TiR (villager): It, it, it’s barely possible to live here and what’s so terrible is that here we have all the plastic and if you look over there (points behind the students) at the barbed wire fence (all students turn in the direction) where we, where we are not allowed to go.

Here, the TiR introduces the scientific perspective by re-using the information about plastics given at the PHA in Episode 3 of the drama (line 1), but one of the students, Mitch, disrupts the teacher when he steps up to the villager and asks: ‘How do you experience this, this situation?’. He actualises an experiential aspect of living in the future. The teacher turns her gaze towards Mitch and answers in a sad tone (line 5), ‘it’s barely possible to live here’ and then continues by bringing in a justice perspective regarding why Polyplastica had the right to dump its plastic in Dystoplastica.

Value-laden problems were also explored when the students and teachers stepped out of role and discussed plastic pollution as a whole class. The students pointed to

the privileged conditions in the Western world regarding possibilities for recycling and sorting plastics, and compared this with the conditions of developing countries where infrastructure does not yet exist to the same extent. This triggered discussions about global injustices.

*Value-laden solutions to problems of plastic.* During the process drama, the students explored issues of global justice related to the management of plastics in developing countries. The students in School B talked about how Sweden should relate to other countries regarding plastic waste and some students said that ‘we have to think bigger and go outside Sweden’, while others expressed that Sweden should focus on its own plastic management.

When the students had a whole-class reflection out of role several noted that they had changed positions on the global justice dimensions of plastic pollution. In the teacher-led discussions, the students proposed solutions that focused on what Sweden and the Western world should do to aid poorer countries in developing their infrastructure for plastic waste management. When the School B teams presented their proposals to the SEPA, several value-related solutions to the plastic issue emerged and they emphasized the urgency to act and of sharing responsibility both locally and globally to tackle the plastic issue. In the quote below, a student emphasises emotional commitment as a prerequisite for people to change their minds and really do something about the plastic issue:

You also have to make sure to create an, an emotional connection in all this because it's quite difficult to feel it, like. You don't feel like this, *oh, now I threw away a straw*. It's not directly as you feel it, but then studying and learning and taking that responsibility makes you ... then maybe next time you feel like [...] it's wrong [...] because it will not last in the long run. Because it must also be important that you sense that it feels right to do it.

Here, the student emphasises the importance of knowledge: ‘to study and learn and take responsibility’ but also a moral dimension to feel what is ‘right to do’ as a prerequisite for to change the minds of people in order to really do something about the problem. This is an example of how the process drama enabled the students to conceive the plastic problem as a complex issue where scientific facts were important but not sufficient to tackle the problem of pollution.

## 4.2 Part II: Student agency when dealing with wicked problems in the process drama

In the process drama the students and teachers participated in a constant flow between margin and centre to explore the problem of plastic pollution. The participation can be characterized with varying degrees of autonomy from more to lesser structured forms of agency.

In the process drama, there were episodes that were more of an informational nature, such as when the teacher assumed an authoritarian role as the Swedish Space Agency's chief of staff. In these episodes, the students participated from positions at the margin and there was little space for them to enact agency. The TiR was at the centre, directing the drama activity to call students' attention to the topic of the drama plan and the students were positioned at the margin, directed to a collective centre, listening seemingly attentively with their gazes oriented towards the TiR. In some instances, the process drama was akin to traditional teacher-led teaching. For example, when the students in School A presented their proposals to the PHA, the teacher gave no indication of stepping into role, nor did she instruct students that they still were in the drama. For students and teacher alike, the presentation therefore came to resemble a traditional teaching format. In addition, the teacher often attempted to direct the students' participation in a way that favoured discussions which included chemical content. The teacher thus directed students in ways which restricted the students' agency.

When the class travelled back in time to meet Staudinger there was also limited space for student agency. Although the students were positioned as knowledgeable travellers from the future (e.g., when Staudinger asked them about the material on their clothes), the interaction resembled classic I-R-E (initiation-response-evaluation) interaction patterns, the type of teaching discourse where the teacher initiates a question which is followed by a response by a student, and then an evaluation by the teacher (cf. Lemke, 1990). In this episode, the TiR was positioning herself (in the role of Staudinger) at the centre of the activity, initiating and driving the conversation while the students responded. When the teacher asked for information that was important to Staudinger, the responses were confirmed as valid and/or further developed by the teacher – for example, when the teacher concluded: 'that's why you call it plastic. It's plastic!'. Thus, the teacher was at the centre and directed the activity according to the intended topic. In this episode, it was the teacher who directed the students to participate and when chemistry content was initiated, validated and further

developed by the TiR, space for student agency was simultaneously restricted. The social structure of interaction, thus, did not enable the students to initiate the questions.

In the process drama, there were however several less structured instances where the students could enact agency. For example, when the students were invited to help the chemist Staudinger to make an advertising jingle, a less structured space for student agency emerged. The teams were assigned the task of showing with their bodies and verbally why plastic was good. Some students asked if they could make a jingle about the negative side of plastic, which the teacher responded was not the idea of the task. In this sense, the structure restricted student agency. However, as the students prepared, created and performed their advertising jingles, they all participated in the collective performance in the form of dance, song and rhyme. In these episodes there were many emotional expressions (e.g., laughter) and the students used various resources to participate in chemistry teaching. During this task more space for student agency emerged.

In the whole-class reflections (episodes 5, 9 and 13, [Table 1](#)) the teacher often directed the discussions by asking questions, thereby restricting the students' agency. However, the analysis also revealed that the TiR almost exclusively asked open questions so that spaces for students to choose to participate and discuss/reflect upon their experiences were created. In the whole-class reflections, the students and teachers raised thoughts and reflections about what they had previously experienced in the process drama, and in the subsequent whole-class discussions they often drew on the previous interactions in role. In this sense, the process drama gave the students 'stuff to talk about' regarding the plastic problem when participating out-of-role.

During the process drama, there were several instances where the students acted with greater autonomy and shifted the margin|centre of activity. Notably, the students became more actively involved in the improvisational parts. In improvisation episodes, in small groups, when the students were asked to interact with each other, such as at the PHA/SEPA offices, all groups observed in School B stepped into their roles and directed the narrative forward. In School B, the role cards for the researchers and the engineers had been developed with the help of authentic stakeholders to provide more elaborate role descriptions. The students who were appointed roles as scientists and engineers were thus provided more elaborate role cards than the others (e.g., journalists). However, all students were provided with role cards. They were also provided with blank name tags where they could decide their own names. The students

in School B were also given more time to improvise compared to students in School A. This enabled them to step into and more clearly experience different perspectives regarding the plastic issue. The drama thus enabled them to draw on personal funds of knowledge and intertwine these with fiction in a joint narrative (e.g., Maud and Eddie's conversation about the TeamSeas project).

In the process drama lessons there are also several instances where the TiR is positioned at the centre and the students at margin with the dialogue controlled by the TiR where a student suddenly disrupts the social structure and takes a position at the centre. This was the case when Sammy reacted to the map of plastic pollution presented by the TiR. When he shouted, 'USA is lying!' he shifted the centre of the classroom physically as well as discursively. Another example of disruption was when Mitch stepped into role during the visit to Dystoplastica and broke away from the teacher-led narrative by asking the villager how he *experienced* his situation, which actualised a values perspective. By stepping into the role, Mitch uses the structure provided by his role as a visitor to move to the centre and precipitate a change of perspective, mobilising the attention of the others to something different.

## 5 Discussion

The analysis showed that the process drama provided opportunity for the students to participate in explorations of the plastic issue that combined science with values- and societal perspectives and acknowledged the issue as a complex one involving eco-reflexive dimensions (Sjöström, Eilks & Zuin, 2016). This may have the potential to embrace system thinking in chemistry education (Mahaffy, Matlin, Holme & McKellar, 2019). Our results show that spaces were created for the students' agentic participation in an interplay between societal, values and scientific perspectives, both on a personal and social level. This involvement and focus on values and societal perspectives is not necessarily commonplace in upper secondary school chemistry teaching, where there is often a narrow focus on chemistry as a discipline (Vilches & Gil-Pérez, 2013; Freire, Talanquer & Amaral, 2019).

### 5.1 Spaces for participation

The students were afforded different spaces to act in role. In School A, the space was more restricted as they were given less time for improvisation and resources in the form of role descriptions than they received in School B, where the teacher clearly

showed how she was in role; this demonstration by the teacher created a resource which enabled the students to step into role themselves. Our results indicate how the role becomes a resource for both students and teachers to explore the plastic issue in chemistry teaching. Stepping out of the typical ‘teacher role’ (i.e., assuming a role that would not have been appropriate in a normal classroom situation) became a tool for the TiR to mediate and support the students’ agentic participation in exploring the plastic issue.

However, in line with previous research, we observed how the TiR in certain episodes restricted student autonomy (Braund, Ekron, & Moodley, 2013; Berggraf Sæbø, 2011). For example, when the students got to meet the TiR as the chemist Staudinger, the teacher directed the drama activity similar to a teacher-in-disguise (Berggraf Sæbø, 2009). The TiR has an important leadership role in influencing the students’ learning, but as in the case with Staudinger, there is a risk that the teacher turns the process drama into traditional teaching. When the TiR moved out of role, so did the students.

In their roles, while moving between fiction and real-life experiences, the students positioned themselves as stakeholders and discussed different societal solutions to address the plastic issue. Our findings point out how the students strove for authenticity and agentially reactivated real-life experiences, such as the TeamSeas project, into the narrative by drawing on personal funds of knowledge (cf. Andrée & Lager-Nyqvist, 2012). Thus, we conclude, in line with Ødegaard (2023), that process drama may enable students to bring the context of reality into chemistry teaching to tackle wicked problems.

On several occasions during the process drama, the students directed improvisations towards values perspectives, even though the teacher had started from a different perspective. Process drama thus enables going ‘outside the box’ in chemistry teaching – it provides room for exploration and learning at the margin of a teacher’s intention. Such margins can be transformed into new collective centres, as in the cases of the students who, by stepping agentially into role, moved the centres of activity and changed its structure. In this sense, process drama in chemistry education promotes pluralistic teaching practices where students, as envisioned by Öhman and Östman (2019), may gain opportunity to participate and critically assess several different ideas and ways of tackling wicked problems.

In the study, *all* students participating in the process drama moved across a trajectory of margin|centre. Participation was not static but, in line with Goulart and

Roth (2006), continuously changing. The students participated in the chemistry teaching in different ways by going in and out of role. When participants go into and out of role in process drama a phenomenon called *aesthetic doubling* (Østern & Heikinen, 2001) may be created. This refers to an oscillating process that, according to Österlind (2018), can create opportunities for reflection. In addition, the social structure of small-group constellation enabled students' movement towards centre, enabling them to actively participate in the whole-class activities (cf. Danckwardt-Lillieström, Andrée and Enghag, 2020). Hence, process drama in chemistry teaching enables a combination of close participation in the centre of the activity and distanced participation at the margins. The students were enabled to shift and position themselves between passive and active participation. From a dialectical perspective, in relation to margin|centre, our study points out that process drama in chemistry teaching enables students and teachers to participate in a variety of ways in the exploration of wicked problems.

## 6 Conclusions

Our study shows that process drama is a pedagogy that chemistry teachers can use to engage students in exploring how chemistry knowledge may come to matter in relation to wicked sustainability problems. However, although the students displayed agentic participation with a scientific perspective, it was often the teacher who introduced the chemical content. Thus, if we acknowledge that is not enough that the teacher uses certain chemical concepts, it remains a challenge to strengthen students' agency in using disciplinary chemistry resources as part of process drama. The results point to the various ways in which the teacher, may steer the students in a certain direction where different degrees of structuring of the students' agency become tangible. Hence, in line with previous research (Berggraf Sæbø, 2009; Ødegaard, 2023), our study shows that process drama in chemistry teaching requires a delicate balance between creative freedom and productive constraint.

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