

Increasing Students' Quality of Argumentation by Using Drama in Lower Phase Secondary  
Education

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### Abstract

In this study it is explored how drama can be used as a teaching tool to foster the quality of students' argumentation about socio-scientific issues in the lower phase of secondary education (ages 12 to 15). Four biology classes of a high school in The Netherlands took part in this study, containing a total of 117 students. Two of these classes formed a control group attending regular lessons, the other two classes attended an intervention in which drama was used as a teaching tool. Both the intervention- and control lessons consisted of the same topics. The following six topics were used: Bee mortality, Bird mortality, Exotic species, Pollution due to medicine, Pollution due to microplastics, and Sustainable holidays. At the start of the lesson series all of the students took a pre-test, and at the end of the lessons all of the students took a post-test, both measuring their quality of argumentation. During the lessons field notes were taken by the researchers, and the final performances of the intervention groups were videotaped and transcribed. The transcriptions from the final performances were scored to measure the quality of argumentation they contained. Qualitative descriptions of the intervention lessons are given, and the data from the pre- and post-surveys is analysed. The results from the pre- and post-tests show an increase in the quality of argumentation for the intervention group. In the post-test the students created more extensive arguments containing more rebuttals than they did in the pre-test. No significant difference in the quality of argumentation for the control group was found. This suggests that drama is a valid teaching tool to help foster the quality of argumentation in the lower phase of secondary education. The qualitative analysis suggests that for students in this age group a strong focus on acquiring information is needed, the students that spend more time researching their topics created plays containing higher quality argumentation, and ended up improving their argumentation the most.

## INTRODUCTION

Today's society is confronted with numeral controversial socio-scientific issues regarding health and environment, in which citizens play an active role, for example in the products they choose, whether they get vaccinated or not, or which political parties they vote for (Kolstø, 2006). Because of this there is an increasing interest to improve scientific literacy in citizens, including a stronger focus on analysing and evaluating information and making informed decisions (Kolstø, 2006; Zeidler, Sadler, Simmons, & Howes, 2004). To facilitate the development of citizens who are more scientifically literate, and who are capable to take part in discussions and develop their opinions and morals, there has been an increase in demand for citizenship education in schools. The Dutch education council has published a report stating the importance of citizenship education, and summarises this as “learning to function in a democratic society” (Onderwijsraad, 2012). Oulton, Day, Dillon and Grace (2004) state that in order to be fully scientifically literate, young people need to be aware of the nature of controversy and be able to see how arguments are constructed to sway opinions.

A teaching tool that allows education to contribute to creating a higher scientific literacy, and get students more involved, is the use of socio-scientific issues (SSI's) as contexts in the classroom (Zeidler, Sadler, Simmons, & Howes, 2004). SSI based instructions not only involve the way decisions are made in the scientific and social world, but they also involve the moral principles that are involved in the students' own lives (Sadler & Zeidler, 2009). Including students' own moral principles in education is a crucial part to improve moral development in students', which plays an important role in citizenship education (Althof & Berkowitz, 2006). An increasing focus on citizenship education in science classes is important, because science and scientific knowledge are often involved in decision making in social issues. Science and society are interconnected, so to empower students as citizens there is a need to put more emphasis on science and scientific knowledge (Kolstø, 2001). The importance of citizenship education and its link to scientific literacy become more apparent when exploring the two following issues.

Currently there are numerous relevant socio-scientific issues that involve the role humans have in the environment, a prominent example of a heavily debated issue like this, is the role humans play in climate change. The scientific community has a firm consensus regarding this issue: climate change is happening, and is largely caused by human actions. Besides this the public opinion is also growing in support of human caused climate change, Eurobarometer published a survey in 2017 that shows that 92% of European citizens see climate change as a serious problem (Special Eurobarometer 459). However, there are still public and political figures who deny the existence of climate change, or the effect human actions have on the climate, these discussions are especially prominent online (Harvey et al., 2017). Two factors that explain this are: the complexity of climate change as an issue, and the numerous stakeholders benefiting from uninformed citizens (companies invested in fossil fuels for example). Online sources in support of climate change denial are often linked to companies financially benefiting from climate change denial, and the arguments used purposefully lack any context, to make them easier to misinterpret and cause confusion about the causes of climate change (Harvey et al., 2017). So focusing purely on scientific argumentation is not enough to convince everyone. Some people, for example, have different worldviews and values and disagree with scientific findings on moral or emotional grounds. So besides a scientific discussion, moral and emotional perspectives also need to be taken into account.

Another recent example of a socio-scientific issue that shows the importance of scientific literacy and argumentation is vaccination. Over the last years there has been a decrease in the percentage of vaccinated children. A decrease in vaccination creates a higher risk of an outbreak of a disease, which would be prevented if the rate of vaccination is high enough. In their study, Milton and Mercier (2015) make an argument for the potential causes of this decrease in the rate of vaccination. Because the risks of contracting the diseases that vaccination help prevent is low, people are less likely to take actions to prevent it. And if this is combined with perceived risks that come with

vaccination, then people are more likely to weigh the risks of taking action higher than the risks of not taking actions. So in the absence of a salient threat, people are less likely to get vaccinated. The two main ways to overcome these hurdles, and prevent the vaccination rate from dropping further, are argumentation and trust, according to Milton and Mercier (2015).

A useful tool to bring socio-scientific issues into the classroom, and possibly increase the quality of argumentation among students, is the use of drama. Drama and role-playing have been shown to increase students' awareness of multiple viewpoints, and offer a good way for students to relate to socio-scientific issues and the stakeholders involved (Colucci-Gray, Camino, Barbiero & Gray, 2006). The advantage of drama over many other forms of teaching is that the students are not passive observers, but instead are actively involved in creating a script and enacting a play. This active involvement in drama creates a stronger feeling of being part of a community, and may also help to increase a feeling of empowerment within students (Bailey & Watson, 1998). Both being able to relate to multiple viewpoints, and an increase in feeling of empowerment are very useful developments in citizenship education.

But perhaps the most important addition that drama offers is the potential to increase students' argumentation. Multiple studies have shown that drama is a potentially very useful teaching method to help increase argumentation in students (Archila, 2017; Ødegaard, 2003; Verhoeff, 2017). By using drama students can explore socio-scientific issues through different role figures, which allows them to reason from the different perspectives of these stakeholders, creating a more complex understanding of the science concepts and argumentation. This has been shown in research done by Littledyke, Ross and Laking (2000) where students explored an issue where care for the environment competes with the need for employment. Tensions between different values can often lead to socio-scientific issues. Economical, medical and environmental benefits might be in conflict, and often personal beliefs and morals are also involved. These socio-scientific issues don't only revolve around knowledge, but the worldview and values of the people involved also play a large role. And this is what makes drama such a suited teaching tool, it offers a unique way to incorporate all of these tensions, values and worldviews into one teaching method. It allows for a larger part of the complexity of these issues to be experienced by the students taking part in it (Ødegaard, 2003). And Ødegaard and Kyle (2000) also mention, that if the best preparation for making the complex choices involved with these issues is experiencing them, then drama could provide the tool suited for that purpose.

So when we realise the importance of argumentation and we see the positive effect drama can have on the quality of argumentation, how do we explain that drama is not a widespread and popular teaching tool? Besides advantages to learning outcomes drama also creates challenges for science teachers. Drama offers more freedom for the students to improvise, which might lead to a perceived loss of control by the teacher (Braund, 2015; Verhoeff, 2017). Because of this, using drama as a teaching tool requires more trust between the teacher and the students, which might turn science teachers away from using drama in their lessons (Dorion, 2009).

Besides these added challenges for science teachers, there is also a remaining uncertainty with the use of drama as a teaching tool for younger students. Many of the studies regarding drama as a teaching method have been done with university or pre-university students. For example Verhoeff (2017) has shown that drama can be used to increase the quality of argumentation for university students. But what has been relatively unexplored is how suitable this is with younger students, in the lower phase of secondary education. So in this study it will be explored in which way drama can be used to increase the quality of argumentation in students in the lower phase of secondary education. And especially regarding the currently prominent socio-scientific issues relating to the role humans play in the environment.

## **THEORETICAL FRAMEWORK**

Fostering scientific literacy has been the focus of a lot of different studies (Colucci-Gray, Camino, Barbiero & Gray, 2006; Gott & Duggan, 2007; Kolstø, 2001). But a clear definition of scientific literacy is not easily found, different studies interpret it in different ways, and look to foster different concepts in science that they deem important. DeBoer (2000) gives an overview of different historical views on scientific literacy and describes it as a general familiarity with science. In this study there is a focus on fostering argumentation, because in science argumentation plays an essential role, scientists need to be able to weigh evidence, consider alternative explanations, evaluate data and construct warrants in support of their hypotheses (Nussbaum, Sinatra & Poliquin, 2008). Besides argumentation within science, argumentation about science in a social setting also plays an important role, especially when we consider socio-scientific issues. This places science in a broader scope, where it's also influenced by social, political or economical perspectives. This is also described by Sadler and Zeidler (2009) as their "vision 2" on scientific literacy. So in order to foster scientific literacy, a familiarity with science; it is required to foster argumentation, an essential part of science (Duschl & Osborne, 2002), and an essential part of social discussions involving science.

## **SSIBL**

One approach to foster scientific literacy is Socio-Scientific Inquiry Based Learning, or SSIBL. The SSIBL framework is based on four pillars: Responsible research and innovation, citizenship education, socio-scientific issues, and inquiry based science education (Kyza & Levinson, 2014). SSIBL involves students in new developments in science using contexts from real life issues. The students tackle these issues in an inquiry based way, which means that they often have to come up with own ideas and hypotheses, and they have to find their own ways to test these. This actively involves students in the scientific process, which can help to show them the complex nature of socio-scientific issues (Kyza & Levinson, 2014).

When drama is used to foster argumentation in a scientific context, which is the case in this study and is also seen in Verhoeff (2017), it has a lot of concepts that overlap with SSIBL: It approaches socio-scientific issues that citizens face, and it does so in an open-ended way. Because of this drama faces a lot of the same challenges, for both teachers and students, that other SSIBL approaches face when it comes to classroom practices. Levinson and Amos (2018) describe various issues with implementing a SSIBL approach, some of these issues can also be encountered when using drama, namely: Authentic questions to start a SSIBL approach often do not come from students' own interests, integrating both descriptive and normative statements, and solutions to SSIBL are often complex and open ended. The lack of overlap between the students' interests and the teaching subject can make it challenging to get the students involved in an active assignment. And the combination of descriptive and normative statements, and the complexity of the issues make them more difficult to understand for students, and more difficult to explain for teachers. Next it will be discussed how these issues can pose challenges for teachers, and how these challenges can be approached in drama lessons.

## **Drama in science education**

Science lessons often focus on rational viewpoints, so it could be argued that normative statements don't fit very well in science education. Social issues however, combine both descriptive and normative statements. So if the goal is to fully experience the complexity of socio-scientific issues both types of statements must be included (Ødegaard, 2003). Role-playing drama provides a practical way of combining both types of statements into an argument. Not every stakeholder has to be a scientist who deals with just descriptive statements. The drama can also include lay people or activists who deal with how they feel things ought to be, not just how they currently are. In this way drama itself already provides a useful tool for combining statements that are both descriptive and

normative in nature.

Another challenge that implementing drama provides is the open-ended nature of the teaching method, which can make it more challenging to reach the desired outcome (Levinson & Amos, 2018). By using scripted drama, where the students first write a script before they perform, the open-ended nature of drama gets reduced (McSharry & Jones, 2000). In this study this approach is taken to make the practical aspect of drama lessons more manageable for the teachers. Verhoeff (2017) has used a similar approach. The students write a script, starting at an initial position, then an event is introduced which leads to consequences, and eventually builds up to a conclusion. A similar setup for the scripts is used in this study, except that instead of exploring the effects of neuroscience on society, in this study the effects of several environmental issues is explored. The students start their script at an initial position, then they introduce an environmental concern, the stakeholders involved have an argument, and eventually a conclusion (and possibly a solution) is reached. In previous studies another challenge with inquiry based learning is that it does not always lead to authentic action, and that questions and interests from students themselves rarely become the focal points for further inquiry (Alsop & Bencze, 2014; Levinson & Amos, 2008). In this study the students will be provided with several socio-scientific issues to choose from to write their scripts about. The issues have been chosen based on the constraints of the curriculum, the issues had to be about the role humans plays in the natural environment. And also to fit within the students' own life as much as possible, because being able to relate to the issues is an essential part of the effectiveness of the teaching method (Ødegaard, 2001).

### **Teaching drama in science classes**

Having relatable issues to work with is important, but there is still a crucial role for the teacher in guiding the drama, so that students are easier able to relate it both to their own life and to science (Ødegaard, 2001; Ødegaard & Kyle, 2000). Guiding the drama happens during the sessions in which the students are writing their scripts. During this phase they search for information, possible arguments about their issue, and potential stakeholders to include in their play. It is essential that the students are able to relate and empathise with the different stakeholders, and that they are able to form arguments from their viewpoints ( Ødegaard, 2003; Colucci-Gray, Camino, Barbiero & Gray, 2006). During this the teacher plays a facilitating role, the teacher helps the students choose proper stakeholders, and helps the students to empathise with them by showing the students possible arguments that the stakeholder might have. The role-play provides the tool for students to get insight and experience about the complex arguments involved in socio-scientific issues, and the teacher plays an important role in making sure that this tool is utilised properly.

### **Assessment of argumentation**

The students themselves are graded based on their efforts, and the contents of the scripts. From a research perspective the scripts are assessed based on the arguments they contain. The arguments in the scripts will be analysed and scored based on the framework provided by Erduran (2004), see table 1. This framework is based on the initial model for argumentation as described by Toulmin (1958). In his initial model Toulmin compares an argument to a court case, each side puts forward a claim and attempts to make a convincing case in support of their claim. This supporting case can be divided in three different types, according to Toulmin: data, warrants and backing. According to Toulmin data is defined as the initial facts to support the claim, warrants are what provides a link between the data and the claim, and the backing is explicit experience strengthening the warrants. And lastly arguments also contain rebuttals. These are statements to contradict or falsify a claim made by another party.

Erduran has build upon Toulmins model to use it to analyse discussions in a classroom setting. Erdurans version of this model uses rebuttals as the core component to analyse arguments. Using rebuttals as the core to analyse arguments results in a more practical methodology. This was needed

because in discussions between students Erduran encountered difficulties in clarifying what counts as a claim, warrant, data or backing in an argument. Statements in arguments could often be classified as both a claim or a warrant, for example. This highly depended on the context in which they were viewed. So in order to make the discussions between students clearer to analyse, Toulmins framework has been adapted by Erduran into the framework shown in table 1.

*Table 1: Framework for assessing argumentation (Erduran 2004), including a slightly adapted example from one of the scripts in this research.*

<b>Analytical Framework Used for Assessing the Quality of Argumentation</b>		
<b>Level</b>	<b>Description</b>	<b>Example</b>
1	A claim versus a counter-claim, or a claim versus a claim.	“I use pesticides in my garden.” “You shouldn't use those.”
2	A claim versus a claim with either data, warrants, or backings but do not contain any rebuttals.	“I use pesticides in my garden.” “You shouldn't use those. I'm an animal lover, and the pesticides also kill my birds when they eat the caterpillars.”
3	Arguments with a series of claims or counter-claims with either data, warrants, or backings with the occasional weak rebuttal.	“I use pesticides in my garden.” “You shouldn't use those. I'm an animal lover, and the pesticides also kill my birds when they eat the caterpillars.” “If you're an animal lover, you should protect your own birds.”
4	Arguments with a claim with a clearly identifiable rebuttal. Such an argument may have several claims and counter-claims.	“I use pesticides in my garden.” “You shouldn't use those. I'm an animal lover, and the pesticides also kill my birds when they eat the caterpillars.” “If you're an animal lover you shouldn't let your birds come into contact with pesticides, and take better care of them”
5	An extended argument with more than one rebuttal.	“I use pesticides in my garden.” “You shouldn't use those. I'm an animal lover, and the pesticides also kill my birds when they eat the caterpillars.” “If you're an animal lover you shouldn't let your birds come into contact with pesticides and take better care of them” “It's not possible to prevent my birds getting into contact with pesticides, they feed on insects in my garden, which always come into contact with pesticides from your garden.”

The learning goal for the students during this intervention is to increase the quality of their argumentation, by learning to empathise with different stakeholders and approaching socio-scientific issues from different perspectives. The goal of this study is to show in which ways drama can best aid this process for students in the lower phase of secondary education, and to provide

insight into the difficulties teachers might face when using drama with students in this age group. The main question for this study is: How can the use of drama to address socio-scientific issues increase the quality of argumentation of students in lower secondary education?



## METHODS

To answer the research question the following setup has been used. Four biology classes in lower secondary education took part in this research, two of which as a control group receiving normal lessons and two receiving the intervention based on drama. All classes had the same amount of lessons, and the students in all classes worked on a socio-scientific issue relating to the role humans play in the natural environment. The main differences were the teaching methods and final assignments. The control classes followed the textbook and for their assignment they presented their issue in a presentation, possibly with the use of a slide show. The intervention classes created a script containing different stakeholders relating to their issue, and presented this in the form of a play. To show whether the intervention had an effect on the quality of argumentation or not, data was collected in the form of a pre-test at the start of the lesson series, and a post-test at the end of the lesson series. During the lessons observations were made by the researchers to give insight in the lesson process, and the possible effects this had on the results regarding quality of argumentation.

### The school

The research was conducted at a high school (secondary education) in The Netherlands. The school is located in an urban area: a small town very close to the city of Utrecht. The school provides Montessori education. Here the students are responsible for scheduling their own tests and assignments, and they have more freedom compared to traditional education. The school also works closely with teacher training programs from Utrecht University, so the school is used to provide room for educational research. The students attending the school are also used to taking part in research. The school is attended by mostly Dutch native students with relatively wealthy socio-economic backgrounds. The school is attended by both girls and boys, roughly equally divided. Lesson duration is 65 minutes, and class sizes are around 30 students.

### The student assignments

The students in the control group were divided in six groups, each consisting of four, five or six students, and each group worked on one of the six available topics (see table 2) using the textbook. As a closing assignment each group gave an oral presentation for the rest of the class supported by a slide show.

The students in the intervention group were also divided in six groups, each consisting of four, five or six students. Each of these groups worked on one of the six topics, and wrote a script about their topic. The requirements for their scripts were the following: it had to be about an argument on their issue, and their scripts had to contain at least one scientific stakeholder and one lay person. A few stakeholders were provided by the teacher to help the students get started, but the majority had to be chosen by the students themselves. Examples of scientific characters could be biologists or doctors, and examples of laymen involved could be concerned citizens or talk show hosts. The closing assignment for the students was to perform their script in front of the class in the form of a play.

*Table 2: The socio-scientific issues the students could choose from, and the teacher provided stakeholders (students were also able to provide their own stakeholders).*

Socio-scientific issue	Teacher provided stakeholders
Developing a sustainable holiday	Someone going on holiday, environmental scientist
Water pollution due to medicine	Doctor, patient
The increase of bee mortality	Farmer, environmental scientist
The introduction of exotic species in ecosystems	Biologist, the affected species

Microplastics	A company using plastics, environmental scientist
Bird mortality due to pesticide usage	Biologist, pesticide user

### The intervention

During the intervention the learning goal for the students was to become more familiar with the complex nature of SSI's, and to improve the quality of their argumentation regarding SSI's. The lesson setup for the intervention consisted of three parts. A first part to introduce the topics, the assignment, and some potential stakeholders regarding the environmental issues the groups can choose from. During this lesson the students just needed to listen, and make sure that at the end they had created their groups and chosen a topic. During the second part of the intervention the students worked on writing their scripts or presentations with possible aid from the teacher. Their assignment during these lessons was to finish their script or presentation by the end of the third lesson, so that they would be able to present or perform during the last lessons. And during the third part of the intervention they presented their presentations, or their scripts in a drama performance, to the rest of the class. These three parts were spread out over a total of five lessons spanning four to five weeks. The lessons took place during the last semester of the school year.

Table 3: Overview of the lessons part of the intervention

Lesson	Lesson content	Lesson goal students	Activities during the lesson
1	Introduction to the different topics, creating groups, choosing a topic	Understanding the assignment, and having a general understanding regarding their SSI	<b>Teacher:</b> Introducing the topics, explaining the assignment <b>Students:</b> Listening, forming groups, choosing topics, generating first script ideas
2	Script writing, creating stakeholder characters, finding information	Creating a basic setup for their script with one stakeholder to be played by each group member	<b>Teacher:</b> Guiding groups in script writing and researching, managing the atmosphere in the classroom <b>Students:</b> Script writing, researching, asking questions, discussing within their groups
3	Finishing the script, practising the play	Complete writing the script, and practising it if they have the time for it	<b>Teacher:</b> Guiding groups in script writing and researching, answering questions, managing the atmosphere in the classroom <b>Students:</b> Script writing, researching, asking questions, discussing within their groups
4 & 5	Three groups perform their play, and are assessed by the members of the other groups	Performing their own play. Reviewing the plays of other groups, and having a basic understanding of the other SSI's presented	<b>Teacher:</b> Managing the performances <b>Students:</b> Performing their own script, reviewing performances by other groups

Table 4: Overview of the lessons part of the control group

Lesson	Lesson content	Lesson goal students	Activities during the lesson
1	Introduction to the different topics, creating groups, choosing a topic	Understanding the assignment, and having a general understanding regarding their SSI	<b>Teacher:</b> Introducing the topics, explaining the assignment <b>Students:</b> Listening, forming groups, choosing topics,
2 & 3	Researching the topics, creating presentations	Understanding their SSI and creating a complete presentation to present in the final lessons	<b>Teacher:</b> Guiding groups in researching their topics and creating presentations, answering questions, managing the atmosphere in the classroom <b>Students:</b> Researching their topic, creating a presentation, asking question, discussing with their group
4 & 5	Three groups present, and are assessed by the members of the other groups	Presenting their SSI. Reviewing the other presentations, and having a basic understanding of all the other SSI's presented	<b>Teacher:</b> Managing the presentations <b>Students:</b> Presenting, reviewing other presentations

### Group setup

Four different second grade biology classes took part in this research. All four classes were of the havo/vwo combination level, this is the Dutch pre-higher professional educational level (havo) combined with the pre-university level (vwo). The students still have to decide which level they will continue to attend in their third year. These classes consisted of students ranging from age 12 to 15. Two of these classes functioned as a control group, receiving the traditional form of education following the textbook. The other two classes received a specially designed intervention based on the use of drama. Two of the classes consisted of more girls than boys, classes C2 and P2. Class C2 consisted of 17 girls out of a total of 30 students, and class P2 consisted of 17 girls out of a total of 29 students. The other two classes consisted of a roughly equal amount of girls and boys, classes C1 and P1. Class C1 consisted of 15 girls out of a total of 29 students, and class P1 consisted of 14 girls out of a total of 29 students. Class C1 was randomly paired with either class C2 or P2, and subsequently the pairing was randomly assigned either the intervention or the traditional form of education. Class C1 and C2 became the control group, and class P1 and P2 became the intervention group.

Table 5: Class information

Class	Amount of students	Amount of girls	Amount of boys	Average age (years)	Intervention- or control group
C1 (control 1)	29	15	14	13,6	Control
C2 (control 2)	30	17	13	13,7	Control

P1 (play 1)	29	14	15	13,9	Intervention
P2 (play 2)	29	17	12	13,6	Intervention

### Data collection

Data was collected through the use of surveys, audio- and video recordings, interviews, and written field notes by the researchers.

Both the control group and the group receiving the intervention filled in two surveys, a pre- and post-test regarding the quality of their argumentation based on previous research done by Lin and Mintzes (2010). For the full survey in Dutch see appendix A. The pre-test was taken at the start of the first lesson, and the post-test was taken at the end of the last lesson. These pre- and post-test were used to determine whether there has been an improvement in the quality of argumentation as a result of the intervention. In the surveys the students were asked to complete an assignment regarding a current SSI in The Netherlands, the discussion surrounding the nature reserve 'De Oostvaardersplassen'. Both the pre- and post-test were on the same topic, similar as done in the research by Lin and Mintzes. Due to the use of control groups the influence of the pre-test on the learning outcome can be taken into account. The assignment the students had to make is the following:

1. Do you agree with the given statement, yes or no? And why do you agree or disagree?
2. Imagine someone else does not agree with your opinion, what possible arguments might they have to disagree?
3. When someone doesn't agree, like the person from question 2, which arguments can you use to persuade them?
4. When you would be asked to support your arguments (at question 1 and 3) with evidence, which evidence would you provide?

Besides this, the students were also asked to fill in some personal details, including their gender and age. This data was collected to potentially relate their personal details with their learning outcomes. The survey also included a way to track each student individually, to later be able to relate learning outcomes to possible behaviour during the lessons. The post-test also included room for the students to give feedback on the lesson series.

Besides data collection through surveys in both the control group and the intervention group, the group receiving the intervention was monitored more closely. During the intervention lessons observations and field notes were made of the group discussions, and video recordings were made during the final performances of their scripts.

During the intervention field notes were made by the researchers. Because during the lessons certain behaviours from the students can be good indications that learning is going on. These notes include: students in a fierce debate, acting surprised, asking questions, looking confused, or having a passive or active attitude. These are all things to pay close attention to, both as a teacher and as a researcher, because they are indications about the learning that may or may not be going on.

Students in fierce debate are involved with their issue, but the quality of their debate may vary, so paying attention to what they are arguing about can give insight in their argumentation skills. And students being passive might be a sign that they are either stuck or unmotivated, and they might be in need of guidance or scaffolding from the teacher.

### Data analysis

The drama performances have been videotaped to be analysed in depth with regards to argumentation. The videos from the ending drama performances have been transcribed and scored based on the framework for assessing argumentation developed by Erduran (2004) (see table 1). And further analysis on the drama performances has been done into the amount of arguments used, and the different types of arguments that have been used. The presentations by the control groups

have not been videotaped, they are analysed through field notes taken by the researchers. The surveys have also been assessed and scored based on this framework.

This framework put forward by Erduran (2004) scores arguments based on the previous model of argumentation created by Toulmin in 1958, but with more focus on the rebuttals. The main parts of Toulmin's model for argumentation that are used here, are: claims, backings and rebuttals. A claim is an assertion put forward for general acceptance, something that ought to be done. This is the start of an argument. This initial claim can either be supported or rejected. Backings are reasons or experiences to support an initial claim. And rebuttals are arguments or reasons that contradict or falsify an earlier claim.

The following argument taken from one of the scripts is used to give an example of the analysis of the quality of the argumentation.

(...)

**Activist (to doctor):** *“Stop using these antibiotics! It's polluting the drinking water!”*

**Doctor:** *“Why?”*

**Activist:** *“Antibiotics remain present in excrement. And in the sewers only 7% is removed by filtering, the rest ends up in our drinking water.”*

**Doctor:** *“But what else do you want? To risk babies, adults and animals dying? The use of antibiotics has good reasons.”*

(...)

**Scientist:** *“Yes indeed. But we also have to consider the effects on the environment. So is it possible to figure out a solution for this?”*

(...)

In this example the activist starts out with a claim: “stop using antibiotics”. And as backing to this claim the activist says that the antibiotics are polluting the drinking water. In response to the activist, the doctor uses the increased risk of death in babies, adults and animals as a rebuttal to the initial claim. The doctor does not agree to stop using antibiotics because they provide health benefits.

And in response to the doctor, the scientist introduces a counter-claim: “we also have to consider the effects on the environment”. This is a counter-claim, and not a rebuttal, because it introduces a new reason to stop using antibiotics, but it does not rebut the argument made by the doctor.

This is an example of a level 4 argument “an argument with a claim with a clearly identifiable rebuttal. Such an argument may have several claims and counter-claims.”

## RESULTS

During the intervention the students worked at writing a script which would be performed in the final lessons. First we will look at the activities of the students during the script writing sessions, and what possible effects these activities can have on the learning outcomes of the students. Then the final scripts will be described, with regard to the quality of the argumentation that is present in them, the type of stakeholders that were present, and the nature of the arguments that were used. To support the analysis quotes from the scripts are used. All scripts have been written and performed in Dutch and are added in appendix A, the quotes used have been translated to English. These results will then be compared to the final presentations of the control group, to give insight into the difference regarding argumentation in both assignments. And lastly we will look at the results from the surveys to see whether the students increased the quality of their argumentation as a result of either of the lesson series.

### Script writing sessions

The script writing lessons started with a short introduction by the teacher, instructing all the students to start working on their scripts, find stakeholders to play, and eventually write out their final script for their play, and to ask any questions if they have them. During the script writing sessions the students were working in their own groups, trying to think of an argument they could use relating to their topic, and thinking of different stakeholders that could be involved (both laymen and scientific characters). So during these lessons the classrooms were filled with six different groups of students, each discussing their own socio-scientific issue within their group. Between all the groups there were two main approaches that stood out, some groups focused on finding information about their issue, and other groups focused on discussing the format of their script and the different stakeholders that could play a part in it. Out of the total of twelve groups the majority, eight out of twelve groups, took the information focused approach. The other four groups started out with a focus on the drama aspect of the assignment. Both approaches will be discussed below, alongside some examples.

A good example of a group that focused on researching their topic, is the group about bird mortality in class P1. This group quickly found a few sources describing how pesticide usage can lead to an increased mortality in bird populations. They mostly had content specific questions. For example already in the first lesson they were wondering if there was actual data available to show that bird populations were affected in recent years. And with the aid of the teacher they found bird counts done by a Dutch bird protection organisation, which show a decline in the count of tomtits. So far, taking this approach is quite similar to creating a traditional presentation, which the students are familiar with. So as long as they are just researching their topic, nothing new is demanded from them. This makes it look like they are doing well and are making progress, but eventually they also need to think of a format and stakeholders for their script. Creating a script was something new for them, so for some of the groups this was a moment where they got stuck, and a few of the groups would raise their hand to ask for help at this point. But with two of the groups the teacher would only find out they were having trouble getting started with the script after coming over and asking them how they were doing. The groups that got stuck here had a lot of information, but didn't know how to get started with a script. So at this point guidance from the teacher is important to get them started again. A successful way to guide students in getting started with their script was to break down the assignment for them. This was done by asking them questions to guide them towards stakeholders. For example when the students had data showing that birds are dying because of pesticides, they were asked who they thought cared about this. They answered: "someone who loves birds." So now they had their first stakeholder: someone who loves birds. As a follow up question they were asked what this stakeholder would want. And according to the information that they found about pesticide usage, they reasoned that someone who loves birds would want no pesticides to be used. And lastly as a follow up question to this, they were asked who would disagree with this

view. They said someone who uses pesticides, of course. And now they had their first two stakeholders, and the core of their argument. After this the group continued on their own, and they were able to create the rest of their script. A basic way to get groups started on their scripts can be boiled down to three questions: Who cares about this, what do they want, and who would disagree. If they are able to answer these questions, they should have a good core to build the rest of their script around.

One of the groups that started by brainstorming about the format for their script, is the group about bee mortality in class P2. They started out by discussing the stakeholders that could be involved in their issue. This started out with the idea that someone would have to play a bee, because that was the main stakeholder in their topic of course. They were immediately excited about who would have to play a bee, and started a contest to see who was the best bee impersonator. Impersonating bees does not seem like the most valuable way to spend their time. But being able to relate to a stakeholder is an important part of drama. So for the teacher it's important to realise when a group gets carried away with impersonating a stakeholder, and when it's still useful. It's useful when a group is impersonating a relevant stakeholder that plays a part in their socio-scientific issue, for example a scientist. Being able to better relate to a scientist, having a better understanding of what they think and why they think so will help the students to better understand the issue and the scientists' involvement in it. On the other hand the same can not be said for a bee, although impersonating a bee might be entertaining for the students, it's not very useful. The usefulness comes from the relevance the stakeholders play in society, and the added understanding students get from impersonating them. For example, this group did not only impersonate bees, they also considered playing a farmer, scientist or beekeeper, and also impersonated those stakeholders. The farmer and beekeeper both had to speak in a rural dialect, while the scientist had to sound fancy and official, according to the group. Discussing and impersonating stakeholders like this was common amongst the groups taking the more drama oriented approach, and it shows that the students already have an idea of how different stakeholders behave, and that they have different backgrounds. And besides this, relating to stakeholders in this way also helps to make the drama more closely resemble real world scenarios. This helps both the actors and the audience to better relate their topic to real life socio-scientific issues.

Eventually both approaches needed to result in a complete script, with enough information to create an argument and also relatable stakeholders for the students to play. So both approaches need at least some guidance in both script writing and researching their topic. However the amount of guidance needed varies between the groups. The research focused groups often found a lot of information but then got stuck when they had to start writing a script, and the drama focused groups often had a lot of exciting ideas for stakeholders and situation, but had more trouble creating a content rich argument.

### **Overview of the final scripts**

A total of twelve scripts were written, on six different topics. Each of the topics was covered by two groups, one from each of the classes. For an overview of all of the script and their storylines, stakeholders and other characters, see table 6 below. For the full scripts in English or Dutch see Appendix B or C, respectively.

Table 6: Overview of all the final scripts and the characters they contain.

Topic	Class P1	Class P2
Bee Mortality	Characters: Farmer, Bee, Activists	Characters: Civilian, Beekeeper, Bee Queen, Professor, Professors assistant
	Storyline: A farmer is spraying his crops, and as a result of this a bee dies. This causes a discussion between the farmer and two activists who happened to witness the bees death.	Storyline: A civilian meets a beekeeper in a supermarket and they talk about bees and the prices of fruit. Later the civilian visits the beekeeper and a professor to learn about bees and sustainability.
Bird Mortality	Characters: Presenter, Reporter, Neighbours, Biologist	Characters: Civilians, Store Clerk, Bird Lover, Professor, Activist
	Storyline: A television show about conflicts between neighbours is presented. In this episode one neighbour uses pesticides in her garden, and the other neighbour is angry about this because the pesticides are toxic for her birds. The issue is talked about, and a biologist comes on the show to offer her expertise on the subject as well.	Storyline: A civilian buys pesticides in a garden store. A discussion between her, an activist and a bird lover ensues. The next day they all attend a lecture on pesticides use by a professor.
Exotic Species	Characters: Civilians, Scientist, Squirrel	Characters: Narrator, American Lobster, European Lobster, Civilian, Chef, Professor
	Storyline: Two civilians meet with a scientist to ask about exotic species. With the help of a squirrel the scientists explains the issues that exotic species might cause.	Storyline: A fight between the two lobsters happens. This fight starts a discussion between the other characters about how to deal with these competing species. The issue is solved by catching the exotic lobster species and selling them in the chefs restaurant.
Medicine Pollution	Characters: News Presenter, Journalist, Civilian, Fisherman, Scientist, Activist	Characters: Parents, Doctor, Activist, Scientists
	Storyline: A news item is presented about medicine pollution. A journalist interviews several people involved, a civilian, scientist, activist and a fisherman.	Storyline: Two parents walk into a doctors office to get antibiotics for their child. An activist is also present and a discussion about medicine pollution, and the importance of medicine ensues. Two scientists show an experiment about filtering systems to collect medicine waste from water.
Microplastics	Characters: Quiz Presenter, Contestants	Characters: Talk show host, Professor, Activists, CEO of a plastics company
	Storyline: A television quiz about microplastics is hosted. The different contestant are asked questions about microplastics, and they try to best explain their thoughts on them.	Storyline: A biology talk show is hosted about microplastics and pollution. The uses of plastics, their economic value and their pollution is seawaters is discussed.
Sustainable Holiday	Characters: Civilian, Gas Station Clerk, Biologists	Characters: Narrator, Civilian, Farmer, Scientist
	Storyline: A man is going on a holiday with his family. While buying gas at a gas station he gets into a discussion about sustainability with the clerk and two biologists. He eventually decides to change his plans and go on a more sustainable holiday.	Storyline: A civilian is planning to go on a holiday in a sustainable way. He'll be staying at a farm and he will travel around by bike. The scientist explains how different aspects of the holiday contribute to its sustainability.



### Argumentation in the final scripts

Almost all of the scripts contained a few good arguments, with the highest level of argumentation reached being level 4, an argument with a clearly identifiable rebuttal. Unfortunately a few groups missed the argumentation part of the scripts, and ended up with scripts with no proper arguments in them. These were the groups that didn't have anything concrete written down at the end of the script writing sessions yet, even after the teacher had stimulated them to do so multiple times. They ended up finishing their scripts at home, but missed the argument because of this. But on the other hand a few groups also ended up with really good scripts, containing multiple types of arguments, and a high level of argumentation as well. For a complete overview see table 7 on the next page.

An example that shows the value drama has in creating high level argumentation, consisting of numerous claims and rebuttals, is from the performance about bird mortality due to pesticides. In this script a conflict between two neighbours is discussed in a reality television program. One of the neighbours uses pesticides to protect her hedge from caterpillars, and as a result of this the birds of her neighbour are dying. When asked about the issue by the reporter on the scene, the following argument arises:

*Aagje: "These caterpillars are destroying my entire hedge, that's why I use pesticides. But my neighbour does not agree."*

*Bertha: "I'm a huge animal lover, so I have a lot of birds nesting in my garden. And because my neighbour is using pesticides on these caterpillars my birds are exposed to these pesticides too. They ingest the pesticides when eating them. And now the birds in my garden are dying!"*

*Aagje: "These caterpillars just need to go! My entire hedge is being destroyed while I try so hard to maintain it! And if my neighbour is such an animal lover, why doesn't she get her birds food herself, instead of letting them eat the caterpillars!"*

The central issue is the use of pesticides, and both neighbours have conflicting opinions on this. Aagje is in favour of using pesticides and uses the destruction of her hedge as backing for her claim. Bertha on the other hand disagrees with the use of pesticides, and as a counter-claim she argues that they harm her birds. Aagje does not agree with this, and rebuts Bertha's argument by saying she could easily prevent harm to her birds by feeding them herself, instead of letting them eat caterpillars.

To attempt to resolve the argument a biologist is introduced. She says the following with regards to the use of pesticides and bird mortality:

*"Since 2017 bird mortality as a result of pesticides has been an issue. In 2015 we counted 11500 tomtits (a species of birds), in 2016 we counted 115000 tomtits, and in 2017 we only counted 79000 tomtits. So the amount of tomtits is decreasing, and a large cause for this is the use of pesticides to combat caterpillars, because birds are also exposed to this and die."*

The biologist supports the counter-claim to stop using pesticides. And provides an additional descriptive argument as backing to Bertha's initial counter-claim. This part of the script shows a level 4 argument: "an argument with a clearly identifiable rebuttal".

### Comparing the scripts between the different approaches

When comparing the argumentation from the four groups that took the more drama focused approach (Both bee mortality groups, P1 medicine pollution and P2 exotic species) to the groups that took the more researched focused approach a noticeable difference is seen. On average the drama focused groups have one argument in their script and their average highest level of argumentation is only 0,75. The groups that took the more research focused approach had an average of two arguments in their scripts, and reached an average highest level of argumentation of 2,625. So on average the research focused groups score higher on both the amount of arguments used and the highest level of argumentation reached. No noticeable difference in the nature of arguments used was seen.

Table 7: Overview of the level of argumentation in each script, the total amount of arguments, and the relevant stakeholders.

Script (research approach)	Highest Level of Argumentation	Total Arguments	Stakeholders and their views
P1 Bird Mortality	4	2 (lv 2,4)	Civilian 1: Protecting her garden using pesticides Civilian 2: Protecting her birds from the pesticides Biologist: Decreasing bird mortality
P2 Bird Mortality	2	2	Civilian: Protecting her garden with pesticides Activist: Reducing pesticide use, protecting the environment Bird lover: Saving birds Gardener: Selling garden plants
P1 Exotic Species	1	1	Scientist: Protecting the environment Squirrel: Living in a nice forest
P2 Medicine Pollution	4	3 (lv 1,2,4)	Parents: Want to use antibiotics Doctor: Uses antibiotics for treatment Activist: Opposes use of antibiotics
P1 Microplastics	4	4 (lv 2,2,4,4)	Participants in a quiz: Getting correct answers
P2 Microplastics	2	1	Activist: Decreasing plastic waste CEO: Making profits, regardless of the waste Volunteer: Decreasing plastic waste
P1 Sustainable Holiday	4	3 (lv 2,2,4)	Civilian: Going on an affordable and enjoyable holiday Biologists: Promoting sustainable holidays
P2 Sustainable Holiday	0	0	Civilian: Going on holiday Scientist: Promoting sustainable holidays
<b>Average:</b>	2,625	2	
Script (drama approach)	Highest Level of Argumentation	Total Arguments	Stakeholders and their views
P1 Bee Mortality	2	2 (lv 1,2)	Farmer: Protecting his crops Activists: Saving the bees
P2 Bee Mortality	0	0	Civilian: Affordable fruits Beekeeper: Saving his bees Professor: Decreasing bee mortality
P2 Exotic Species	0	0	European lobster: Staying alive American lobster: Staying alive Cook: Selling lobsters
P1 Medicine Pollution	1	2	Civilian: Using medication to prevent headaches Fisherman: Healthy fish to catch Scientist: Decreasing wasteful medicine consumption
<b>Average:</b>	0,75	1	

**The nature of arguments used**

The drama performances were varied in their arguments, using both descriptive (how it currently is) and normative (how it should be) claims. And often the scripts also had an emotional, moral or financial perspective on their issue. For example some stakeholders had certain emotional investments in parts of the issue, they cared about the environment or animal well-being, or they were scared about the risks that medicine or plastics brought with them. Other stakeholders had financial investments, they were the CEO of a company using a lot of plastics for example.

*Table 8: Overview of the amount of claims, backings and rebuttals used in the different scripts, categorised by their nature.*

<b>Script</b>	<b>Factual</b>	<b>Emotional</b>	<b>Moral</b>	<b>Financial</b>
P1 Bee Mortality	2	1		1
P2 Bee Mortality	3			1
P1 Bird Mortality	2	2		1
P2 Bird Mortality	1	1	1	2
P1 Exotic Species	2	1		
P2 Exotic Species	1			1
P1 Medicine Pollution	1	2	2	1
P2 Medicine Pollution	2	1	1	
P1 Microplastics	6			
P2 Microplastics	3		1	4
P1 Sustainable Holiday	2	3	2	1
P2 Sustainable Holiday	3			1

A good example to showcase the complexity of SSI's and the different arguments used, is the performance about pollution by medicine. This script follows a news item about medicine usage and the pollution as a result of this. A journalist interviews different stakeholders: a civilian, an environmental activist and a fisherman.

The civilian stakeholder is scared about the risks of getting sick, and says the following in response to being asked about his medicine usage:

*“Yes, I do take medicine. And I also take it preventively. I just really don't want to get a headache, because it prevents me from functioning properly.”*

The civilian in this case handles out of the fear of getting a headache. He has an emotional argument for his actions. Later in the script, when an environmental activist is asked what they think of taking medicine preventively, their response is:

*“...and especially taking medicine preventively, that just can't happen! You should only take medicine if you really need it. (...) I don't even take medicine for slight headaches, just because I care so much for the animals.”*

Here, the activist, being aware of the risks that pollution due to medicine creates, states that preventative medicine use should not happen. This is a normative argument. Then he follows it up by suggesting that if you really care about animals, you should try to reduce medicine usage. In this argument the activist believes the environmental risks outweigh the personal discomfort, while the civilian feels the opposite.

A descriptive argument is provided when the fisherman is interviewed, he is asked about the amount of fish he has caught lately:

*Fisherman: "Yes, that's quite bad. We used to be able to work one hour for a normal income, but right now that has already doubled."*

*Journalist: "Do you know what's causing this?"*

*Fisherman: "No, I don't know actually."*

*Journalist: "Well, this is a result of medicine use, mostly preventive use."*

In this script multiple perspectives on the issue are presented, and each stakeholder has their own argument as to why they contribute to the issue, or want to solve it. Both descriptive and normative arguments are used, and a possible cause for the issue is presented as well, which in this example stems from the emotional reasoning of the civilian.

Besides emotional investments shareholders also had financial investments in certain issues. For example, in the performance about bee mortality, a farmer who just finished spraying his crops with pesticides says the following in response to an activist blaming him for the death of a bee:

*"You don't have to get mad, they're only bees. And the pesticide will disappear on its own eventually, I think."*

The farmer does not think much of the death of a bee, and underestimates the damage done by the pesticides. He does not have any descriptive argumentation to support this, from his perspective bees are just not important and the pesticides are not an issue.

In response to the claim made by the farmer *"they're only bees"* an environmental activist replies with the following rebuttal:

*"Bees are actually very useful. They pollinate apple trees, for example, making it possible for us to eat apples."*

This is a descriptive argument to rebut the claim made by the farmer.

In the examples given above arguments of a different nature are shown. Discussions between different stakeholders can arise from emotional or financial reasons, and can be supported by descriptive arguments, normative arguments, or both.

### **A comparison between intervention and control group**

#### *Argumentation*

When the regular presentations of the control group are compared to the drama performances there is a noticeable difference seen in argumentation. In the regular presentations the socio-scientific issues were presented and their causes and effects were talked about. For example in one of the presentation about bee mortality it was told how pesticides contribute to an increasing bee mortality, and how as a result of bee mortality fruit and vegetable production suffers, and the prices of fruits and vegetables would increase. But all moral or emotional arguments were lacking. They discussed what was happening, but not what people thought or felt about it. At best you could conclude from the presentation that fruit and vegetables were getting more expensive, and that people wouldn't like that, but this was never explicitly stated. These presentations also didn't discuss why these issues arose in society in the first place. There were no normative phrases or arguments used, even though they made it obvious that there were issues right now. Why these issues started, and who might have benefited was not discussed. Often no solutions were presented either, and in the presentations where solutions to the problems were presented, it was superficial and not clear how these solutions would become reality. For example who would finance or execute these solutions, was not addressed at all. This made it seem like the issue had a clear cut solution, even though that wasn't the case in any of the topics. An illustrative example of this, is with the issue of microplastics. In the traditional presentation it was suggested to use less plastic, which would reduce the pollution. But it wasn't mentioned how this would happen, or what problems you might run into when trying to reduce the amount of plastic that is used.

The drama performances however, were centered around an argument. Because of this the performances included multiple perspectives on the issue. The different stakeholders in the drama performances discussed solutions to the problem, instead of just mentioning them. This creates a

more realistic view of how the issues remain present in society. Because ideal solutions for one stakeholder often have a negative impact for another stakeholder. As an example, the solution that was presented in the final presentations on microplastics, to reduce the use of plastics, was not explained in much detail. They said that plastics were often used as packaging material, but that much more sustainable alternatives were also usable, so we should just use those! But they didn't take into account that these alternatives have different properties, they might not be as durable or as cheap to mass produce. And even if an alternative would be perfectly suitable, the entire production process would still need to be changed to make its use possible. A lot of complications were left out of their solution, which made it seem easier and more feasible than it might be. The same issues with plastics were also discussed in one of the drama performances. However, in the drama performance it became clear that the solution to just use less plastics might not always be a realistic solution. This is illustrated in a quote from a CEO from the script from the microplastics group in class P2, in response to pollution due to plastics: *"I don't really have any issues with it. Plastics are much cheaper to work with than most other materials. Because of this I can produce my products for cheap."* This quote shows another perspective on the problem: plastics are widely used and the alternatives to using plastics are not suitable. So even though reducing the use of plastics is a solution, it's not a realistic one, it comes with financial issues for some of the stakeholders. Another example can be taken from the presentations about bird mortality. In the drama performance it is at some point suggested that the solution should be to stop using pesticides. However this quickly results in a heated argument about who is going to pay for this, and why it's even needed to stop using pesticides. When we compare this to the regular presentations this argument is not seen at all. The same solution is presented, to just stop using pesticides, but there is no rebuttal. This makes it seem like it's a good solution, even though in reality it might not be feasible at all.

When comparing the regular presentations and the drama performances, the drama performances offer more insight into the complexity of SSI's and explore the issues from different perspectives. This creates more opportunities for students to build arguments, and get a more realistic view of the issues that are present in society, and how difficult it can be to find solutions that work for everyone involved.

### *The audience*

The drama performances were often much more captivating than the regular presentations. During the drama performances the audience paid more attention, the students were silent and almost all of them had their eyes directed towards the performance. While in the control group the audience paid noticeably less attention to the presentations. During the presentation it was noisy in the classroom at times, some students were looking at their phones or talking with their classmates, and not all students had their eyes towards the front of the classroom where the presentation was given.

There are a few main differences between the drama performances and the presentation that explain this difference. The first being the location in the classroom, the presentation were held in the front of the classroom next to a projector, with the audience sitting in rows facing the presenters. And with the drama was performed in the middle of the room with the audience shaped around it in a 'U' shape. Because of this difference all students in the audience for the drama performances were sitting in the front row, while for the regular presentations this was not a possibility. Students sitting in the back were more easily distracted, and had more trouble hearing the presenters.

A second advantage drama has is the interactive nature of the performance. The different actors in the play talk to each other, and depending on the nature of the conversation use a different style of voice, for example to act mad or surprised. The presentations don't have this, all the presenters talk in their regular voice, and there is no interaction between them.

The final difference is the use of props and the movement of the actors. During the drama performances the actors walked around different parts of the stage. And they used props, like a lab

coat or beakers, to perform parts of their play. This helps to make the performance more lively to watch compared to the regular presentation where the presenters stood still in front of the class, and no props were used.

All these factors combined help create a more engaging style of performing compared to regular presentations, resulting in a more involved attitude from the audience. Because of this drama does not only result in opportunities to improve the quality of argumentation for the actors, but it also offers more incentive for the audience to pay close attention. Unfortunately this didn't result in more questions and discussions after the performances, even though the teacher did stimulate the students to ask questions. A possible explanation might be the age and knowledge of the students, they were all still young, and besides their own topic they probably didn't have a lot of knowledge on these issues just yet. If this is the case it makes it more challenging to ask a question, and due to their age they might be a bit shy or insecure, and prefer to not ask anything as a result of that. So it's difficult to say whether or not the more involved attitude the students had during the performances also lead to an increased learning outcome related to argumentation.

### Survey Overview

The overview of the level of argumentation for each of the groups seen in table 9 shows an increase in the level of argumentation for most of the groups, especially in the classes that attended the intervention. Unfortunately the amount of valid responses in class C2 of the control group was much lower than expected, many of the students did not take the time to fill in the post-test seriously. The data for this group is limited as a result of this.

*Table 9: Overview of survey results, categorised by groups. The valid responses are the amount of students that took part in both the pre- and post-test, and gave serious answers in both.*

<b>Intervention / Control</b>	<b>Class</b>	<b>Group</b>	<b>Pre-test Average</b>	<b>Post-test Average</b>	<b>Valid Responses</b>
Intervention	P1	Bee Mortality	2	3	5/5
Intervention	P1	Bird Mortality	3	3,6	6/6
Intervention	P1	Exotic Species	2,5	3	4/5
Intervention	P1	Medicine Pollution	2,67	3	3/5
Intervention	P1	Microplastics	3	2,67	3/5
Intervention	P1	Sustainable Holiday	2,33	2,67	2/4
Intervention	P2	Bee Mortality	2	2,2	4/4
Intervention	P2	Bird Mortality	3	3,33	6/6
Intervention	P2	Exotic Species	2,2	3,4	4/5
Intervention	P2	Medicine Pollution	3,5	4	4/4
Intervention	P2	Microplastics	4,6	4,2	5/5
Intervention	P2	Sustainable Holiday	2,25	2,75	4/4
Control	C1	Bee Mortality	2,33	1,67	3/5
Control	C1	Exotic Species	2	2	2/5
Control	C1	Global Warming	2,2	-	0/5
Control	C1	Microplastics	1,67	1,67	3/5
Control	C1	Recycling	2,67	2,33	3/5

Control	C1	Sustainable Holiday	2,2	2,2	5/5
Control	C2	Bee Mortality	1,33	1,33	3/4
Control	C2	Bird Mortality	2	2	1/5
Control	C2	Sustainable Energy	4	3	1/2
Control	C2	Sustainable Holiday	3	3,33	2/5
Control	C2	Trump & The Environment	2	1	1/4

The main difference that was noticeable in the arguments the students constructed was that the students in the intervention classes used scientific research as backing to their claims more often in the post-test than they did in the pre-test. The last question of the survey asked the students what kind of evidence they might provide to back up their opinion. In the pre-test students often left this question unanswered or said that they wouldn't know what evidence to use. But in the post-test a lot of students suggested starting a research to look into animal mortality rates in the nature reserve, and that data from this research could be used to back up their opinion. A good example of one of the answers suggesting research is the following: *“I would start a research and look into the amount of animals, and compare that when they get food to when they don't get food”*. Besides the use of scientific research as backing there aren't any noticeable differences in the type of arguments that the students used in the pre- and post-tests. So, unexpectedly, no difference in the use of moral or normative arguments was seen.

**Survey Analysis**

After scoring the survey results using the framework given by Erduran (2004), this data was tested for normality using the Shapiro-Wilk test. This resulted in the following p-values: control group pre-test 0.000, control group post-test 0.002, intervention pre-test 0.000 and intervention post-test 0.000. So for all research groups the data is not normally distributed. The data was further analysed using a Kruskal Wallis test to determine whether there is a significant difference between the groups. The Kruskal Wallis test was done with four groups: the intervention group pre- and post-test and the control group pre- and post-test. This resulted in a p-value of 0,000 so there is a significant difference between at least two of the groups. Furthermore a post hoc analysis was done to determine which groups significantly differed from each other. This was done using a Bonferroni correction, the results are shown in table 10.

*Table 10: Results of a Kruskal Wallis post hoc test results using Bonferroni correction, comparing the level of argumentation in the pre- and post-tests for the control- and intervention groups.*

<b>Groups tested</b>	<b>P-value</b>
Control post-test – Control pre-test	0,636
Control post-test – Intervention pre-test	0,000
Control post-test – Intervention post-test	0,000
Control pre-test – Intervention pre-test	0,021
Control pre-test – Intervention post-test	0,000
Intervention pre-test – Intervention post-test	0,262

These results indicate that there is no significant difference between the control groups pre- and post-test, and between the intervention groups pre- and post-test. And that when comparing between

the control group and intervention group all the results do show a significant difference.

After the Kruskal Wallis test the control- and intervention groups were also tested separately using a Wilcoxon test, to check if there is a significant difference within these groups. And Cohen's d was calculated for the intervention group, since a significant difference was found. This resulted in the results seen in table 11.

*Table 11: Wilcoxon p-values when comparing the average level of argumentation in the pre- and post-test, for both the intervention and control groups. And cohen's d for the intervention group.*

<b>Group</b>	<b>P-value</b>	<b>Cohen's d</b>
Control pre-test - post-test	0.825	-
Intervention pre-test - post-test	0.005	0.43

The intervention group had a significant difference between the pre- and post-test with a p-value of 0.005. Cohen's d for the intervention group is 0.43, showing an increase in argumentation score in the post-test by close to half the standard deviation.

And lastly the survey results were divided between the different approaches that the students attending the drama intervention took, the information focused approach and the drama focused approach. This was done to see if the difference in the quality of their argumentation that was seen in the scripts, was also present in the survey results. These results were tested using a Kruskal Wallis test, this resulted in a p-value of 0,006. This suggests that at least two of the group differ significantly from each other. Afterwards a post hoc test adjusted by the Bonferroni correction was done, the results of this are shown in table 12.

*Table 12: Kruskal Wallis post hoc test using Bonferroni correction. Comparing the average level of argumentation in the pre- and post-tests for the groups taking the different approaches to creating their scripts (information focused and drama focused).*

<b>Group</b>	<b>P-value</b>
Drama pre-test – Drama post-test	0,273
Drama pre-test – Information pre-test	0,080
Drama pre-test – Information post-test	0,002
Drama post-test – Information pre-test	1,000
Drama post-test – Information post-test	1,000
Information pre-test – Information post-test	1,000

The only groups that significantly differ from each other are the drama approach pre-test and the information approach post-test, all the other groups show no significant difference. So the approach the students took did not result in a significant improvement in their quality of argumentation measured in the surveys.



**CONCLUSION**

Using drama as a teaching tool to address socio-scientific issues in the classroom can help foster the quality of argumentation in students in the lower phase of secondary education. By using drama as a teaching tool the students not only have to research their topic, but they also have to find different stakeholders, try to relate to them and then construct an argument involving their views. Trying to relate to stakeholders, and then constructing an argument involving them forces students to approach an issue from different perspectives. And by using different stakeholders different types of arguments also arise. Because of this drama also offers room for arguments of an emotional or financial nature. And lastly, in trying to resolve their argument the students come into contact with the complexity of their issue.

When using drama as a teaching tool with students in the lower phase of secondary education it is important to have a stronger focus on researching and understanding the topic. Because these students often don't have enough knowledge to build proper arguments, so in order to best foster argumentation this should be taken into account.

## **DISCUSSION**

The advantages drama can offer compared to traditional education are: the ability to relate to the different stakeholders, the possibility to approach socio-scientific issues from multiple perspectives allowing insight into their complexity, and opportunities to use different types of arguments. Below it will be discussed to what extent these advantages were seen during the intervention and the control lessons, which parts of the lessons contributed the most to utilise these advantages, which challenges the students and teacher faced, and lastly suggestions will be made on how to best utilise drama as a teaching tool to foster argumentation in future lessons and studies.

### **Relating to stakeholders**

During the script writing sessions of the intervention the students were not just researching their topics, but they were also looking for stakeholders and discussing how to best play these stakeholders during their scripts. This is a noticeable difference between the traditional lessons and the drama lessons. During the traditional lessons different stakeholders did occasionally come up, as part of the information they would present, but these stakeholders were treated as information, not as characters. But during the drama lessons the students discussed their stakeholders extensively, what backgrounds they had, how they would look, and how they would talk. These discussions show that the students are trying to relate and empathise with the stakeholders, which is an important advantage that drama offers. Because the students have to role-play their stakeholders they are encouraged to try to relate to them. And being able to better relate to the relevant stakeholders helps to create a more realistic understanding of the socio-scientific issue they are working on (Ødegaard, 2003; Colucci-Gray, Camino, Barbiero & Gray, 2006).

Due to the fact that each group consisted of multiple students, and they had to include both laymen and scientific stakeholders, each group had to try to relate to stakeholders with different opinions and from different backgrounds. This forces the students to not only view their socio-scientific issue from a scientific perspective, but also from the perspectives of laymen, business stakeholders or farmers. And in turn each of these stakeholders had different investments in the issue, leading to arguments of a different nature. Activists or laymen had emotional involvements, farmers and CEO's had a financial investment, and a scientific character often used descriptive arguments to support one side of an argument. In this way role-playing different stakeholders offered the students opportunities to use different types of arguments, and get first-hand experience of the complexity of socio-scientific issues. This experience is a crucial step towards being able to better understand socio-scientific issues (Ødegaard, 2003; Ødegaard & Kyle, 2000).

### **Different approaches to drama**

The groups working on their scripts took different approaches to the assignment, with some groups focusing more on researching their specific topic, and some groups focusing more on the drama aspect by figuring out stakeholders to play and creating a scenario for their performance. With regards to the quality of argumentation the groups that focused on researching their topic scored higher. This suggests that in order to foster argumentation in students, it is important that there is a focus on researching the topic.

Even though relating better to stakeholders is one of the advantages that drama offers, and this helps students to relate to real world experiences, this is not the most important part to help foster argumentation. According to the results in this study researching the topic and having a strong knowledge base seems to be a more important factor when it comes to fostering argumentation. It is likely that this is very depended on the age of the students. When drama is used in university students as seen in other studies, it can be expected that they have enough knowledge already. However with the students that took part in this study, who were between the ages of 12 and 15, their starting knowledge might not be satisfactory to construct proper arguments. So in order to make sure that these students are able to benefit optimally from drama, there needs to be a focus on

building enough knowledge on their topic. Otherwise the students can get carried away with creating exciting scenarios and stakeholders for their scripts and they end up without enough knowledge to properly create an argument. This ties in closely with the 'Reality Principle' described by O'Neill (1985). Because even though the drama is imagined and created, in this case by the students, it still needs to be realistic and logical, in order for the audience to make sense of it. And creating an illogical play not only makes it difficult for an audience to follow, but it will also undermine the learning process for education drama. The learning goal for the students is to improve their argumentation and understanding of socio-scientific issues that happen in the real world, so their play needs to be resembling the real world in order to maximise their learning outcome.

### **Drama and classroom management**

Drama requires a different role from the teacher than traditional education does. Drama offers a lot of freedom to the students, which can make it a challenging teaching method (Braund, 2015; Dorion, 2009). Because of this it is important for the teacher to guide the students not only in researching and understanding the topic, but they also need to be guided in the creation of a script. Creating a script can be a new assignment for students, so this might be something that attracts the most attention. However, as mentioned above, making sure the students have enough knowledge about their topic is essential to properly create an argument. So the role for the teacher with this teaching method is to find the correct balance between the informational and creative aspects of the assignment. With younger students, as seen in this study, their starting knowledge is lower, so there has to be a stronger focus on the informational aspect. But with university students, as seen in other studies, there can be more room to focus on the creative aspects that drama offers.

Another challenge that teachers might face during drama lessons is the atmosphere in the classroom. The script writing process involves a lot of discussion among the students, and in this study it also included the students impersonating stakeholders. This can get quite noisy at times. So to make sure all groups are able to be productive, it is important that the teacher manages the volume of these discussions properly, and keeps the students focused on their own group and script as much as possible.

### **Argumentation**

Arguments of a high level are present in the final scripts, so achieving a high level of argumentation by using drama as a teaching tool is possible. And according to the results from the surveys the intervention group increased their level of argumentation significantly as well. So it is definitely possible to increase the level of argumentation of students between the ages of 12 and 15 by using drama as a teaching method.

None of the scripts, however, contained level 5 arguments: an extended argument containing more than one rebuttal. This doesn't suggest that it is not possible to reach extended arguments by using drama, but instead it is likelier to be a result of the restrictions of the assignment, and the age of the students. The students in this study were all between the ages of 12 and 15, and did not yet possess a lot of knowledge on the socio-scientific issues they worked on. And this, in combination with the limited amount of time they had to perform their final scripts, puts restriction on the extent to which they can create an argument. To create an extensive argument they would need enough knowledge to construct it, which takes time to research. And they would need enough time to perform it during their final play. In order to reach higher level argumentation with students of this age group it might be necessary to have them spend more time researching their assignments, and to free up more time for the final performances. Whether or not this is the most valuable use of the teaching time is debatable of course. Level 4 arguments already contain the core of a good argument: a claim, counter-claim and a rebuttal. And the complexity of socio-scientific issues, and the relation with stakeholders was already present in the scripts as well. So the students already came into contact

with the main parts of argumentation and socio-scientific issues. So while further improvement of their quality of argumentation is possible with drama, this is restricted within the possibilities that education offers.

Besides increasing the level of argumentation drama also offers the students opportunities to experience and use arguments of a different nature, as seen in previous research by Littledyke, Ross and Laking (2000). So even ignoring the increase in quality of argumentation, it can be argued that the experience they get with different types of arguments already helps students to get a better view of argumentation relating to socio-scientific issues. In society all the stakeholders have different backgrounds and have different investments in every issue. This leads to arguments containing emotional or financial claims that might not always relate to the information they learn in school. In biology class they might learn that plastics are not environmentally friendly, but this is only a small aspect to the complete socio-scientific issue of plastic pollution. And of course a drama performance in biology class doesn't capture the full extent of an issue like this either. But drama does offer the students a good opportunity to experience the complexity of such an issue, with the different stakeholders, different types of arguments, and without a simple solution that satisfies everyone.

### Surveys

In the results of the surveys an increase in quality of argumentation was observed in the intervention group. This suggests that the use of drama as a teaching tool did lead to an increase in the quality of argumentation with these students. The same effect was not observed in the control group.

Unfortunately the post-test with the control group had a lot of responses with very little effort that weren't valid to use for this research. So the data acquired from the control group survey is not as valid as the data from the intervention group. However, even when we look at the groups that did fill out the survey seriously we don't see the same increase in quality of argumentation that is visible in most of the groups that attended the intervention.

The most noticeable difference between the arguments seen in the pre- and post-tests was the amount of students from the intervention groups suggesting to use scientific research as backing for their opinions. This difference could be explained by the use of scientific stakeholders in the scripts. All of the groups included a scientific stakeholder. This resulted in most of the scripts containing a scientist or doctor getting involved in an argument, and these stakeholders often used scientific data or research to back up their claims or the claims of different stakeholders. As a result of this the students got experience with using research or data to back up their claims, which is also seen in the post-test. This result is not seen in the control group, even though most of the presentations in the control group also contained scientific research and data. So just using scientific data in your presentation does not lead to an increase in the use of this data to construct arguments at a later time. This suggests that the main factor that leads to the increased use of scientific data as backing in an argument is not the knowledge of data, but instead the experience of having already constructed an argument in their play containing scientific data as backing.

And lastly no difference in the use of emotional arguments was seen between the different groups and the pre- and post-tests, even though drama is a teaching method that allows for arguments of a different nature (Littledyke, Ross & Laking, 2000). The lack of difference here could possibly be explained by the choice of topic for the surveys. The nature reserve that the students had to construct an argument about had been in the news a lot, and is very emotionally loaded. So at the start of the lessons series some of the students probably already formed emotional arguments about the topic, due to seeing it in the news, or maybe discussing it with parents of classmates. This initially made it seem like a very suitable topic, but in hindsight this might not have been the best choice of topic.

**General**

Motivation for students to actively take part in the lessons dipped a bit towards to end, because the summer break was near and quite some students had things to wrap up for other courses as well. This was especially visible with the poor response quality in the control group post-test survey. So unfortunately the results from that part of the survey have less responses, and are less valid as a result.

The script writing lessons were quite noisy, which made it difficult to get good quality audio recordings during lessons. So unfortunately audio recordings during the lessons were not possible. A lot of field notes were taken to compensate for this lack of data.

This study was done in cooperation with Van Duin (2019) who studied the use of drama in secondary education to increase motivation for environmental issues. Both studies used the same classes and the same lesson series, however where in this study there is a focus on its effect on argumentation, in the study done by Van Duin (2019) there is a focus on motivation. The fact that two different studies made use of the same classes and lessons did not cause any issues or interference with the research or the lessons themselves.

**Implications**

When you want to foster argumentation as part of improving scientific literacy, drama is a possible way to do this, so more drama in science education would be beneficial. To best foster argumentation it is important to put a focus on creating an argument in the scripts, and making sure the topic is researched enough to do this. How much focus is needed on this depends on the age and starting knowledge of the students, of course. Relating to stakeholders is a strong aspect of drama, but the real value for argumentation comes from arguments with backed up content and good information. It's great to see that students are excited to perform and create a play, but to get the most out of this teaching method a focus on research and argumentation is also needed.

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**APPENDIX****A****Pre- and post surveys argumentation**

In het nieuws is er de laatste tijd veel te zeggen over 'De Oostvaardersplassen', een natuurgebied in Flevoland waar veel grote grazers voorkomen. De discussie gaat over het bijvoeren van de dieren. Het doel van het gebied is om 'wilde natuur' na te bootsen, dus is bijvoeren normaal niet de bedoeling. Veel demonstranten vinden dit echter zielig voor de dieren, omdat er meer dieren zullen sterven als er niet wordt bijgevoerd. Daar zien zij liever dat de dieren wel worden bijgevoerd.

Beantwoord de volgende vragen met betrekking to de onderstaande stelling. Let op: bij vraag 2 en 3 gaat het er niet om wat jouw eigen mening is, maar over de mening van een ander.

**Stelling:** “De dieren in De Oostvaardersplassen moeten worden bijgevoerd”

- 1 Ben jij het eens met de stelling of niet? Leg uit waarom jij het eens of oneens bent.
- 2 Stel dat iemand het niet eens is met jouw mening, welke mogelijke argumenten kunnen zij hier dan voor hebben?
- 3 Als iemand het niet met jou eens is, zoalsbij vraag 2, met welke argumenten kan jij deze persoon dan proberen to overtuigen?
- 4 Als jou gevraagd wordt om jouw argument (bij vraag 1 en 3) te ondersteunen met bewijsmateriaal, wat voor bewijs zou jij dan leveren?

## B

### Translated transcripts of the final script presentations

#### 2C Bee mortality

Farmer: What a beautiful day. Let's start by spraying some pesticides on my crops, that way I will get rid of the pests.

Bee: I'd like to get some nectar, bzzzzz, these flowers are so nice!

*The bee starts dying due to the pesticides*

Activist 1: Dang it! Who is killing this bee? The person who is responsible for this is in big trouble! Did you do this farmer?

Farmer: I don't know, maybe? I just sprayed my crops with pesticides, but I had no idea that was also toxic for bees.

Activist 1: I really want to punch you right now!

Activist 2: Hold up. That's not why we're here. We're here because you shouldn't be killing these bees, they actually help with food production and oxygen.

Activist 1: And you also poison our food by spraying it with these neonicotinoids. If you use this on your crops, you're using it on our food!

Civilian: What, you're poisoning our food?

Farmer: You don't have to get mad, they're only bees. And the pesticides will disappear on their own, I think.

Activist 2: But it's not just farmers who kill bees, but also stupid civilians.

Civilian: What are you saying? I'm not the dumb one!

Activist 1: So why are bees being killed then, are they annoying?

Civilian: Well, they do sting and buzz a lot.

Activist 2: Bees are not annoying, they're actually very useful. They pollinate apple trees, for example, and because of this we can eat apples.

Civilian: So what can we do with the bees then, to prevent killing them?

Activist 1: You could for example use ladybugs to fight aphids, instead of pesticides. And we can better inform people about bees, for example tell them that when you don't harm them, they will leave you alone.

Civilian: I think that's a great idea!

## 2D Medicine pollution

Parents: Good morning, we are mr. and ms. Groenendijk and we are here to get some antibiotics for our baby.

Doctor: Okay, if you give these to your baby twice a day, then she won't get sick.

Activist: Wooh! Stop giving these antibiotics, it's polluting the drinking water!

Doctor: Why?

Activist: Well, okay. The antibiotics are creating toxic substances in the excrement. And then through the sewers that ends up in our drinking water. Only 7% is filtered out in the sewers! And the rest just stays in the water, and the we drink that, and my dog Boefie too. So because of this humans and animals can ingest toxic substances.

Doctor: But what do you want then? Increasing the risk of mortality in babies, adults and animals? All the antibiotics have good reason.

Scientist: When we give the baby antibiotics this goes through the stomach to the excrement. And then when the baby pees parts of the medicine are still present in the pee. And that gets filtered in the sewers, but only 7% of the substance gets filtered out.

*The filtering process is shown in front of the class*

Scientist: Okay, and here you see the water with the medicine leftovers in it, and here you see the water without. So you can see that there's parts of the medicine still in the water.

Activist: Look at my dog, he drank water with medicine leftovers in it, and now he ingested medicine and antibiotics that he didn't need. Because of this he got very sick. And in the wild there are a lot of animals who have problems with this too. They drink something, there's medicine leftovers in it, and they become sick and die. Such a shame! So we are poisoning the world. Every year more than 140 tons of medicine end up in the water through the sewers. This causes a lot of issues for aquatic animals, namely: damage to the tissue, and change to the behaviour or sex.

Doctor: But we have to keep taking medicine as well, otherwise we're in more risk. Do you want people to have an increased risk at death, because we're not giving them antibiotics? For a lot of crucial diseases we use antibiotics. I mean, has anyone here ever gotten an infection?

Scientist: Yes.

Doctor: Well, without antibiotics you probably would have been dead already, do you understand that?

Scientist: Yes I do. But we also have to consider the issues with the environment and think about our future. Is there a solution to this?

Activist: Yes, there is a solution that reduces the issues. Namely that we don't throw away our medicine, and that we separate it from different waste. We have it collected or take it away ourselves. This already reduces the medicine waste a lot. And then we still have the issue with the urine, because this 140 tons of waste isn't just solved by separating the medicine waste. So I suggest that the doctor discovers a new type of medicine that isn't as polluting.

Doctor: Yes, I could try that. But I'm also busy with other things, like cancer and AIDS.

Activist: Yes, I know. We from Greenpeace will make sure that medicine is collected. And if then the doctor and hospital director make sure they start separating medicine too, then that will reduce the pollution a lot. And if mr. and ms. Groenendijk tell all their friends to do the same, then that will also help.

Ms Groenendijk: So if all of us follow these steps and separate our medicine waste, then it should all be alright?

All: Yes!

## **2D Bee mortality**

Civilian: Hey, why are all the fruits and vegetables so expensive?

Beekeeper: Yes, that is a result of bee mortality!

Civilian: Bee mortality? What is that about?

Beekeeper: Well, I can't really explain that in the supermarket, but you can join me at my apiculture.

*They walk to the apiculture*

Beekeeper: So here you can see all my beehives. I still have a pretty large colony, but that's not the case for all beekeepers any more. Because it's not going well with the bees at all.

Civilian: That doesn't sound good. But how does all of this relate to the price of fruits and vegetables?

Beekeeper: Oh, oh, oh. You really didn't pay attention in school, did you? The bees make sure people have fruits and vegetables. Join me, and I'll show you the queen of my colony.

Civilian: Woh! That is a large bee!

Bee queen: Hello, I am the queen of this colony. And itzzzz not going very well withzzz me. My worker beezzz are now at work, but every day a lot of them die, because of pesticides, industrial agriculture, and weird people swatting bees.

Civilian: That sounds interesting.

Beekeeper: If you would like to know even more, you should go to my brother Lars. He is working at the university and knows everything about bees.

Civilian: The I'll make sure to visit!

Professor Lars: Hello boy!

Civilian: Hello, I've been sent here by your brother. I'd like to learn about a solution to help the bees.

Lars: Well, then you've come to the right place, just like my brother I love bees.

Civilian: So what can I do to prevent bee mortality?

Lars: We should stop using so much industrial agriculture. Instead of having one huge field with one crop, we should make different lanes with different crops on it. Then the bee can choose which crops he pollinates.

Civilian: But what can I do myself?

Lars: My assistant is making packages for kids and adults so that they can help the bees.

Assistant: Hello, I'm the assistant. And I have something nice for you. A package with flower seed, and a box you can use to make a bee hotel.

Civilian: Uhm.... flower seeds and a bee hotel... so what do I have to do with this?

Assistant: Just read the manual that's included!

Civilian: Okay okay, thank you. Are there also solution then this and reducing agriculture?

Lars: yes, for sure. On the way here you would have seen a lot of grass, if we plant more flowers there, then that will also help the bees.

Civilian: Okay. And I also heard from the queen of a colony that a lot of pesticides are used. Is there something that can be done against that?

Assistant: We can do something against that for sure. If you plant a lot of different crops, instead of just one. Then whenever a plague happens, the farmer won't lose all their crops! So he wouldn't need to use as many pesticides.

Lars: And my assistant and I would like to show another solution, one that many nature lovers aren't so happy with.

Assistant: This is the robot bee. It can do everything a normal bee can do, except for making honey.

Civilian: Can such a small thing do everything a bee can do? And how long can it fly?

Lars: This one can fly for about 3 hours, but we're still making one that can fly even longer.

Narrator: 1000 years later..... All the bees have gone extinct, but luckily there are still the robot bees, and they're buzzing around nicely!

## 2D Microplastics

Martine: Good evening everyone, I am Martine van Nieuwkerke, and welcome to 'De Biologie Draait Door' (a biology related talk show). Today we're going to talk about microplastics, and we have a few special guests here with us. Professor Einstein, Emma a volunteer from the plasticsoup foundation, and ms. Van der Linge the CEO of Andrélon. Please give them a big hand! Professor Einstein, would you explain to use what microplastic is exactly?

Einstine: But of course. Microplastics are tiny plastic particles that can not dissolve, and they are always smaller than 5 mm. You can find them in the seas and rivers. Research shows that the majority of microplastics are created by the breakdown of larger plastics, such as plastic parts of clothing.

Martine: Thank you professor. Now on to Emma. Emma, why did you start the plasticsoup foundation?

Emma: It is just fascinating what kind of plans the plasticsoup foundation has. Every minute at least 20 000 kilos of plastic ends up in the sea, of which the larger parts float, and the smaller parts drift lower in the water, the microplastics. We call the the plasticsoup. Plastic does not belong in the ocean. Fish, birds, seals, dolphins, they see this as food and eat it, or get stuck in it. Plastic has a very nasty quality, it does not dissolve. In nature plastic breaks down and falls apart, but it always stays plastic. Animals can not digest this, so if they eat it they could die. I want to prevent this, and the plasticsoup foundation wants to prevent this too.

Martine: Thank you for those beautiful words. Now on to ms. Van der Linge. What do you think of microplastics?

Van der Linge: I don't really have any issues with it. Plastics are much cheaper to work with than most other materials. Because of this I can produce a lot of it for cheap. Take plastic scrub products as an example. These are much cheaper than and softer than natural scrub products. Because of this you can use more of it, and so we can sell more of it. And besides that it lasts longer, so my products work fine! Otherwise I would have to change 90% of my formulas, and that would mean making all my products a lot more expensive. As a result of this people with less money would also have to spend more on it. Which results in them having less money for other things.

Martine: Thank you. Emma, would you like to respond to this?

Emma: I don't agree with this. Because it is the case that we invest by buying plastic free products. For example if you wash your hair with products containing plastics, then those can't be filtered out in the sewers, and the small particles end up flushing out to sea. Fish could eat this, and maybe this fish will end up on your plate. To make this clear I asked professor Einstein to show an experiment. We would like the help from a volunteer from the audience for this. Who wants to help us?

*An experiment is shown where plastic particles end up in sea*

Martine: Thank you for you help. What do you think about Emma's argument?

Volunteer: Well, I really hope this fish doesn't end up on my plate!

Martine: So what do you think of microplastics?

Volunter: To be honest, I am against using them. But I notice that I use them more often than I'm aware of. For example I use them in shower products and cosmetics, but also in a lot of packaging that could end up as microplastic.

Martine: And how do you think we could prevent these microplastics?

Volunteer: That's a difficult question! But maybe by not using packaging that has plastics in it, and only use recyclable packaging? Or maybe by increasing tax on products like these?

Matine: Thank you. Professor Einstein, how much danger does this pose for aquatic animals exactly?

Einstine: How much damage plastics can do is not known yet. But we do know that animals can get stuck in larger plastics. And that larger amounts of microplastics can clog up their digestive system, causing death in animals.

Matine: And how could people be at risk because of this?

Einstine: Well, for example in mussels and fish we have found microplastics in their bodies, and if we eat these then it also ends up in our bodies. And we know that microplastics can cause issues with breathing and food uptake in smaller animals. But we think this effect is relatively small for the moment. So how much damage these plastics can do to us,

that's not yet known. Because there has not been enough research into this phenomenon just yet.

Martine: Thanks all, that was the show for today! Thanks for watching, and see you tomorrow!

## 2C Medicine pollution

News presenter: Hello all, and welcome to the news. We will be talking about preventative medicine usage. And we will see what effects this has on the environment. We will now switch over to Lars, who is interviewing on the streets.

Lars: Hello dear civilian, do you take any medicine?

Civilian: Yes, I take lots of medicine. Especially against headaches. Aspirin, Ibuprofen and also antibiotics. It depends on how I feel during the day.

Lars: Do you also take medicine preventative?

Civilian: Yes, I mostly take it preventative. I just really don't want to get a headache, because then I can't function normally any more. No, for example, I have already taken ibuprofen, because if I get a headache when I go to school, I might as well stay home. I can't go without these things, I'd get a headache!

Lars: And what kind of influence do you think this has on the environment?

Civilian: I don't know exactly. But even if it is a bad influence, I wouldn't care that much. Because I need to function and I don't feel like taking less Aspirin, and I don't think it would be made illegal that quickly. So I will keep taking them.

Lars: And what do you think about the issues this causes for animals?

Civilian: Those animals don't matter to me. I also love to eat meat and fish!

Lars: Thank you. Now we will switch over to Jelle, a fisherman.

Jelle: Good afternoon.

Lars: Hello Jelle. Could you tell us a bit about the amount of fish you've been catching lately?

Jelle: I can, and it's not going well at all. We used to work one hour for a normal income, but these days that has doubled already.

Lars: Okay. Do you also know what causes this?

Jelle: No, I don't really.

Lars: This is caused by medicine usage, mostly preventative usage.

Jelle: Oh, you're right! I read something about that recently.

Lars: Thank you for your time. Now we're going to switch over to an environmental activist. What do you think about preventative medicine usage?

Activist: Well, as an activist I think this is horrible, because of what's happening with all the aquatic animals. And especially taking medicine preventative, you just can't do that! You should only use it when you really need to!

Lars: So do you take any medicine yourself?

Activist: Yes, but only when I really need to. Even when I have a little headache, I won't take medicine, because I really care about the animals.

Lars: Thank you. So now over to Jasper, the scientist. I will ask you a few question about the environment, and what you think about preventative medicine usage.

Jasper: Irresponsible!

Lars: And do you take any medicine yourself?

Jasper: Only when I really need to.



Lars: We just heard a civilian say that he doesn't care at all, and he takes medicine preventatively all the time. What is your opinion on this.

Jasper: Very irresponsible. You should really think about these things more!

## 2C Bird mortality

Presenter: This is a new episode of 'Bad luck with the neighbours'. This is the incident from the past week. You can see that a bird is eating a caterpillar, but the caterpillar has been contaminated with pesticides, and because of this the bird dies. The incident took place in Hengelo. We now switch over to our reporter on the scene.

Reporter: Hello, today we're here with Bertha and Aagje, our two neighbours for this week. They are in conflict about the caterpillars. First we'll ask Aagje. What do you think the issue is?

Aagje: These caterpillars are destroying my entire hedge, that's why I use pesticides. But my neighbour does not agree.

Reporter: Okay, thank you. No we'll ask Bertha what her issue is.

Bertha: I'm a huge animal lover, so I have a lot of birds nesting in my garden. And because my neighbour is using pesticides on these caterpillars my birds are exposed to these pesticides too. They ingest the pesticides when eating them. And now the birds in my garden are dying! That's why I wanted to participate in this show.

Aagje: These caterpillars just need to go! My entire hedge is being destroyed while I try so hard to maintain it! And if my neighbour is such an animal lover, why doesn't she get her birds food herself, instead of letting them eat the caterpillars!

Reporter: Okay, let's bring in a biologist.

Leonie: Hello all, I'm Leonie, and I've been a biologist for a long time now. I graduated at Wageningen university. And now let's take a look back in time. Since 2017 bird mortality as a result of pesticides has been an issue. In 2015 we counted 11500 tomtits (a species of birds), in 2016 we counted 115000 tomtits, and in 2017 we only counted 79000 tomtits. So the amount of tomtits is decreasing, and a large cause for this is the use of pesticides to combat caterpillars, because birds are also exposed to this and die.

Reporter: Okay, I think that is all very clear. So now let's try to find a solution.

Bertha: Well, that seems clear to me, no more pesticides! And just replacing the hedge with a different one!

Aagje: And who will be paying for all of this?

Bertha: You!

Aagje: No! You think this is an issue, I don't mind my hedge, and I don't mind my pesticides either.

Bertha: So you want all birds to die then!?

Reporter: Alright, this is getting out of hand. Let's switch over to the studio.

Presenter: Welcome back to the studio. After a commercial break our guest will join us to talk about a solution.

*Commercial break*

Presenter: We're now here in our studio with our neighbours Bertha and Aagje. And of course our own biologist Leonie.

Reporter: Aagje is in favour of using pesticides, and it doesn't matter to her whether the birds die or not. Bertha on the other hand is against using pesticides, because they result in her birds dying after eating the caterpillars. Her garden is filled with dead birds, and Aagje's garden smells of pesticides.

Presenter: I think I would know, just get rid of the pesticides.

Leonie: Well, there are alternatives as well. Pesticides that make sure Aagje isn't troubled by caterpillars, but without also killing the birds. And they might even cause less smell in your garden.

*Bertha and Aagje continue arguing*

Presenter: Well, I think that has been enough for today. Next week we'll be back with another episode of 'Bad luck with the neighbours'!

## C

### Dutch transcripts of the final presentations

2D Duurzame vakantie:

Verteller: De burger gaat een duurzame fietsvakantie doen naar Saint Quantin. Hij doet er in het totaal 3 dagen over om er naar toe te fietsen. De eerste dag fiets die van Utrecht naar Antwerpen, en doet daar 6 uur over. Dan verblijft die in Antwerpen 1 nacht in een bed en breakfast. De dag daarna fiets die 10 uur door naar Frankrijk, dus dat wordt aardig doorfietsen. Daar verblijft hij weer in een bed en breakfast. Dan blijft hij die volgende dag een tijd voordat hij in de middag doorfietst naar Saint Quantin, daar doet hij dan 4 uur over. Daar verblijft hij in een slaapboerderij, in een woning die daarbij staat. Daar verblijft hij 3 dagen, en dan neemt hij dezelfde route weer terug.

Burger: Hallo, ik ben de burger! Mij lijkt deze vakantie erg leuk. Je komt echt een stukje dichterbij de natuur. In de ochtend kan je zelf je eitjes rapen, je kan een kaas-maken-cursus doen, en in de avond kan je koken met de verse producten van het land. Op deze reis leer je ook heel veel leuke nieuwe mensen kennen. Op de BnBs en natuurlijk ook op de slaapboerderij. Door het fietsen krijg je ook echt een voldoening op het einde van de dag, alleen vind ik het wel een nadeel dat je zo ontzettend lang moet fietsen.

Wetenschapper: Ja dat klopt. Maar als je deze vakantie met een middelgrote auto zou doen die op LPG of diesel rijdt, dan is de gemiddelde uitstoot zo'n 550 kg CO<sub>2</sub>. Even ter vergelijking, de jaarlijkse uitstoot van CO<sub>2</sub> is van een gemiddeld huishouden 4160.

Burger: Maar is de duurzaamheid dan het enige voordeel?

Wetenschapper: Nee, je bespaart ook nog eens heel veel geld. Want benzine is natuurlijk super duur.

Burger: Oke! En boer Hendrik, vertel eens wat over je boerderij.

Hendrik: Je slaapt hier op een duurzame hotelboerderij, genaamd Le Femme Hotel, in Saint Quantin. We gebruiken 100% biologische producten, zoals de vrij uitloop eieren, melk van eigen koeien, en brood van onze bakkerij van zelf verbouwd graan. We gebruiken zonnepanelen op de daken voor energie, zoals de verwarming in de blokhutten waar je slaapt.

Burger: Maar hoe spoel je dan de wc door, dat kost toch ook hartstikke veel water?

Hendrik: Ja dat kopt. Daarom gebruiken wij ook regenwater om onze wc door te spoelen.

## 2D Medicijnenophoping in water

Ouders: Goedemorgen, wij zijn mr. en mevr. Groenendijk en wij komen antibiotica halen voor onze baby.

Dokter: Oke, als je dit tweemaal per dag geeft dan wordt ze niet ziek.

Activist: Wooh! Stop met het geven van deze antibiotica het drinkwater wordt erdoor vervuult!

Dokter: Waarom?

Activist: Nou, oke. De antibiotica zorgt voor giftige stoffen in de ontlasting. En dat komt via de riolen in onze waterbassins. Het wordt er maar voor 7% uit gefilterd! En de rest blijft gewoon in het water, en dat drinken wij, en Boefie (hond). Waardoor mensen en dieren schadelijke stoffen binnen krijgen.

Dokter: Maar wat wil je dan? Baby's, volwassenen en dieren het risico geven dat ze sterven? Alle antibiotica heeft een goede reden.

Wetenschappers: Wanneer we de baby antibiotica geven gaat dit via de maag naar de ontlasting. En dan gaat de baby plassen, en stukken van het medicijn zitten dan nog in de ontlasting. En dat wordt dan gefilterd in het riool, maar er wordt dan maar 7% van de schadelijke stoffen uitgehaald.

*Het filteren wordt laten zien aan de klas*

Wetenschappers: Oke, en hier zie je nu het water zonder medicijnresten en het water met medicijnresten. Je kan dus zien dat er nog allemaal stukken van het medicijn inzitten.

Activist: Kijk naar mijn hond, hij heeft water met medicijnresten gedronken waardoor hij allemaal medicijnen en antibiotica heeft gekregen die hij niet nodig had. Hierdoor is hij ernstig ziek. In het wild zijn er ook heel veel organismen die dit probleem hebben. Ze drinken iets, daar zitten medicijnen in, dan worden ze ziek en gaan ze dood. Beetje zonde! We zijn dus de wereld aan het vergiftigen. Jaarlijks komt er meer dan 140 ton medicijnen via het riool in het water. Voor waterbeesten zorgt dit voor de volgende problemen, namelijk: beschadiging van het weefsel, en verandering van geslacht of gedrag.

Dokter: Maar we moeten wel medicijnen blijven slikken, zonder zijn er meer risico's. Wil je dan dat er allerlei mensen dood gaan door het niet geven van antibiotica? Voor heel veel belangrijke ziektes gebruiken we dit. Ik bedoel, heeft iemand van jullie ooit wel eens longontsteking gehad?

Wetenschapper: Ja.

Dokter: Nou, zonder antibiotica waren jullie misschien al lang dood geweest, snappen jullie dat?

Wetenschapper: Ja hoor. Maar we moeten ook denken aan de problemen met het milieu en aan de toekomst. Dus is hier een oplossing voor te verzinnen.

Activist: Ja er is wel een oplossing die het probleem een beetje vermindert. Namelijk dat we onze medicijnen niet op straat gooien, en dat we ze scheiden van het andere afval. En dat we het apart laten ophalen of zelf wegbrengen. Dit zorgt al voor een hele vermindering van de vervuiling door medicijnen. En dan hebben we nog het urine probleem, want die 140 ton is niet alleen weg doordat we ons afval gaan scheiden. Dus ik stel voor dat mevr. dokter heel erg snel een niet vervuilend

medicijn gaat uitvinden!

Dokter: Ja dat kan ik proberen. Maar ik ben ook erg druk met anderen dingen, zoals kanker en aids.

Activist: Ja dat weet ik. Wij van Greenpeace zullen dan ook zorgen dat de medicijnen worden opgehaald. En als de dokter dan naar de directie van het ziekenhuis stapt en zorgt dat zij de medicijnen gaan scheiden dan zal dit de vervuiling al een stuk verminderen. En als mr. en mevr. Groenendijk dan tegen al hun vrienden zeggen dat ze hun medicijnen apart moeten inleveren, dan zal het ook weer een stuk verminderen.

Mevr. Groenendijk: Dus als we met zijn allen deze stappen volgen en medicijnen gaan scheiden, dan moet het toch goed komen?

Allen: Ja!

2D bijensterfte

Burger: Waardoor zijn alle groenten en fruit zo duur geworden?

Imker: Ja, dat komt door de bijensterfte!

Burger: Bijensterfte? Wat houdt dat eigenlijk in?

Imker: Ja, dat kan ik je in de supermarkt niet zo goed vertellen, kom maar mee naar mijn imkerij.

*Naar imkerij*

Imker: Dit zijn al mijn bijenkasten. Ik heb nog een vrij grote kolonie, maar dat geldt niet voor alle imkers. Dat komt doordat het niet zo goed gaat met de bij.

Burger: Dat is niet zo goed. Maar wat heeft dat nou eigenlijk te maken met de gestegen prijs van mijn groente en fruit?

Imker: Oh, oh, oh, jij let echt niet op in de les hè? De bijen zorgen ervoor dat de mensen groeten en fruit hebben. Kom, dan laat ik je de koningin van mijn kolonie zien.

Burger: Zo! Dat is een grote bij!

Koningin: Hallo, ik ben de koningin, en het gaat niet zzzzo goed met mij. Mijn werkers zzzijn nu aan het werk, maar elke dag gaan er meer werkers dood, door bestrijdingsmiddelen, intensieve landbouw, en rare sloebers die bijen dood slaan.

Burger: Dat was interessant.

Imker: als je meer wilt weten ga dan maar even langs bij mijn broer, professor Lars. Hij werkt aan de oer universiteit en weet alles over de bijen.

Burger: Dat ga ik even doen!

Professor: Hallo jongen!

Burger: Hallo, ik ben gestuurd door jouw broer. Hij stuurde mij om te leren over de oplossing voor de bijensterfte.

Professor: Dan zit je bij mij aan het juiste adres. Net als mijn broer ben ik verliefd op bijen.

Burger: Maar wat kan ik nou tegen de bijensterfte doen?

Professor: we moeten minder intensieve landbouw. Dus geen groot veld met hetzelfde gewas, maar stroken met verschillende gewassen gebruiken. Zodat de bij kan kiezen uit welke gewassen hij bestuift.

Burger: Maar wat kan IK daar nou tegen doen?

Professor: Mijn assistent maakt pakketten voor kinderen en volwassenen zodat zij bijen kunnen helpen.

Assistent: Hallo, ik ben de assistent. En ik heb wel wat leuks voor u. Een pakket met bloembollen en waarmee je een bijenhotel kan maken.

Burger: Uhm... bloembollen en een bijenhotel... maar hoe zet ik dan zo'n bijenhotel in elkaar?

Assistent: er zit gewoon een handleiding bij hoor!

Burger: oke oke. Dankjewel. Maar zijn er ook nog andere oplossingen behalve het verhelpen van intensieve landbouw?

Professor: Oh, jazerker. Op de weg hier naar toe zag je vast allemaal kort gras. Als we daar meer bloemen laten groeien komen er al een stuk meer bijen op af.

Burger: Oke. En ik hoorde van de koningin van een kolonie dat er ook veel bestrijdingsmiddelen zijn. Kan daar nog iets tegen gedaan worden?

Assistent: Daar kan zeker wat tegen gedaan worden. Als je allemaal stroken hebt met verschillende gewassen, en er komt een plaag bij. Dan is de boer niet zijn hele oogst kwijt! Dus dan hoeft hij ook niet zoveel bestrijdingsmiddelen te gebruiken.

Professor: En mijn assistent en ik willen nog graag een oplossing laten zien die natuurliefhebbers liever niet hebben.

Assistent: Dit is de robotbij. Deze bij kan alles wat de normale bij ook kan, behalve honing maken.

Burger: Kan zo'n klein ding alles wat een normale bij kan ook doen? Hoe lang kan die dan vliegen?

Professor: Deze kan 3 uur vliegen, maar we willen er eentje maken die langer kan vliegen.

Verteller: 1000 jaar later: Alle bijen zijn uitgestorven, gelukkig vliegen de robotbijen nog lekker rond.

## 2D Exoten

Verteller: De Amerikaanse rivierkreeft wordt met het vliegtuig naar Europa gebracht.

Europese kreeft: Ik ben de Europese kreeft en ik word aangevallen door de Amerikaanse kreeft.

*Kreeften vechten, Europese kreeft sterft*

Professor: Ik ben de professor, en ik ga nu de dode kreeft onderzoeken. De kreeft is dood, en hij is geïnfecteerd door de Amerikaanse kreeft. En de Europese kreeft zal uitsterven als de Amerikaanse kreeft te veel in Europa komt.

Burger: Maar waarom is de Amerikaanse kreeft zo gevaarlijk?

Professor: Zoals ik al zei, de Europese kreeft kan dan ziektes krijgen door de Amerikaanse kreeft, waar de Europese kreeft niet tegen kan. En de Amerikaanse kreeft jaagt zo op de Europese kreeft. En als dit zo doorgaat zal de Europese kreeft uitsterven.

Kok: Ik heb misschien wel een oplossing. Ik kan de kreeften gebruiken voor mijn restaurant om ze lekker op te eten.

Professor: Dat zou kunnen werken, maar dan moeten we wel goed op de Amerikaanse kreeft jagen.

*Kok vangt Amerikaanse kreeft*



## 2D Microplastic

Martine: Goedenavond allemaal ik ben Martine van Nieuwkerke, en welkom bij de Biologie Draait Door! Vandaag gaan we het hebben over microplastics en we hebben een aantal bijzondere gasten bij ons. Professor Einstine, Emma vrijwilliger van plasticsoep foundation, en mevr. Van der Linge baas van Andreelon. Geef ze een daverend applaus! Professor Einstine, zou u ons kunnen uitleggen wat microplastic is?

Einstine: Maar natuurlijk. Microplastics zijn kleine stukjes plastic die niet kunnen oplossen, en ze zijn altijd kleiner dan 5mm. Je kan ze vinden in de zeeën en de rivieren. Onderzoek toont aan dat de overgrote meerderheid van microplastic komt door de afbraak van grotere stukken plastic, zoals kunststof kleding.

Martine: Dankjewel professor. Dan gaan we nu door naar Emma, Emma waarom de plasticsoep foundation?

Emma: Het is gewoon fascinerend wat voor plan de plasticsoep foundation heeft. Iedere minuut beland er maar liefst 20 000 kilo plastic in de oceaan, waarvan grote delen op het water zijn, en kleine delen in het water, de microplastics. Dit noemen we plasticsoep. Plastic hoort niet in de zee thuis. Vissen, vogels, zehonden, dolfijnen, die zien dit aan als voedsel en eten het op, of raken erin verstrikt. Plastic heeft een nare eigenschap: het vergaat niet. In de natuur en zee valt het langzaam uit elkaar, maar het blijft plastic. Dieren kunnen dit niet verteren, dus als ze het opeten kunnen ze eraan dood gaan. Ik wil dit voorkomen, plasticsoep foundation wil dit voorkomen.

Martine: Dank voor je mooie woorden. We gaan nu naar mevr. Van der Linge. Wat vindt u van microplastics?

Van der Linge: Ik heb er niet zo veel problemen mee. Ze zijn veel goedkoper om mee te werken dan veel andere producten. Hierdoor kan ik er goedkoop veel van produceren. Neem als voorbeeld plastic scrub balletjes. Deze zijn veel goedkoper en zachter dan natuurlijke scrub balletjes. Hierdoor kan je er meer van gebruiken, en ga je er dus ook meer van kopen. Daarnaast is het ook langer houdbaar, en mijn producten werken prima! Anders zou ik 90% van mijn formules moeten veranderen, en dit zou betekenen dat ik mijn producten veel duurder zou moeten maken. Hierdoor zouden ook mensen met minder geld hier meer aan moeten besteden. Waardoor ze minder geld over kunnen houden voor belangrijke dingen zoals eten.

Martine: Bedankt. Emma wat heeft u hierop te zeggen?

Emma: Ik ben het hier niet mee eens. Het is namelijk zo dat we investeren door microplastic vrije producten te kopen. Bijvoorbeeld als je met microplastic producten je haar wast, die niet kunnen worden opgevangen door de rioolfilters, de deeltjes zijn te klein en spoelen door naar de zee. Vissen eten dit op, en dit is misschien wel de vis die op jouw bord terecht komt. Om dit duidelijk te maken heb ik professor Einstine gevraagd dit in een proefje te laten zien. Hierbij zou zij graag de hulp willen van een vrijwilliger uit het publiek, wie wil?

*Proefje waarin te zien is dat veel plasticdeeltjes in zee eindigen*

Martine: Bedankt voor u hulp. Wat vindt u ervan wat Emma zojuist vertelt heeft?

Vrijwilliger: Nou ik hoop niet dat dat visje op mijn bord terecht komt.

Martine: En wat vind u van microplastics?

Vrijwilliger: Ik ben eigenlijk tegen, maar ik merk dat ik ze veel vaker gebruik dan waar ik mij eigenlijk bewust van ben. Ik gebruik ze bijvoorbeeld in cosmetica en doucheproducten, maar ook in verpakkingen die uiteindelijk microplastic kunnen worden.

Martine: En hoe denkt u dat we microplastics kunnen voorkomen?

Vrijwilliger: Moeilijke vraag hoor. Maar misschien door geen verpakkingen met microplastic meer te gebruiken, en alleen opnieuw te gebruiken verpakking te gebruiken. Of misschien de belasting verhogen op deze producten?

Martine: Dankjewel. Professor Einstine, hoe schadelijk is dit plastic precies voor zeedieren?

Einstine: Hoe schadelijk het plastic precies is, dat weten we niet. Maar we weten wel dat dieren verstrikt kunnen raken in grotere stukken plastic. En door al het plastic kunnen dieren hun maag of darm verstopt raken, waardoor ze overlijden.

Martine: En gaan mensen daar ook last van hebben?

Einstine: Nou, bij mossels en vissen zijn microplastics in hun lichaam teruggevonden, en als wij die eten komt dat dus ook in ons lichaam terecht. En we weten dat microplastics kleine diertjes kunnen beïnvloeden met bijvoorbeeld hun ademhaling of voedselopname. Maar we denken dat de invloed nog klein is. Hoe schadelijk de deeltjes precies voor ons zijn, daar is de wetenschap nog niet uit. Dit komt omdat het een nieuw fenomeen is waar nog weinig onderzoek naar is gedaan.

Martine: Dankjewel allemaal, dat was het voor vandaag! Bedankt voor het kijken en tot morgen!

## 2D Vogelsterfte

Jannie: Hallo ik ben Jannie, en ik ben hier om een bestrijdingsmiddel te kopen tegen de buxusrups, om mijn buxus te beschermen.

Medewerker: Hallo, hoe kan ik u helpen?

Jannie: Ik ben hier om een bestrijdingsmiddel te kopen om mijn buxus te beschermen.

Medewerker: Ik zal het voor je pakken.

Activist: Ho ho, weet je niet hoe slecht dat is voor het milieu?

Jannie: weet je niet hoe slecht het is als ik het niet gebruik voor mijn planten?

Vogelgek: De buxusrupsen smaken niet meer zo goed door al dat gif...

Jannie: Hé, vogelgek, ben je nou tegen een dode vogel aan het praten?

Vogelgek: Hé, dat gif! Moordenaar! Hoe kan je dat nou doen?

Jannie: Nou en? Ik geef toch elke dag een paar vogels aan mij slang, dat is goedkoper dan voer kopen.

Vogelgek: Een slang heeft veel liever muizen.

Jannie: Nou en, bemoei je er niet mee.

Activist: Morgen is er een presentatie over precies dit onderwerp, laten we daar met zijn allen naar toegaan.

*1 dag later*

Professor: Welkom bij de presentatie over het onderzoek of bestrijdingsmiddelen invloed hebben op de populatie koolmezen.

Activist: Ik vind het heel goed dat hier een onderzoek naar komt, omdat mensen dan kunnen zien dat het veel vogels vermoord en het milieu vervuuld.

Buxuskweker: Hier wil ik iets op inbrengen, want hoe moet ik anders mijn gewassen beschermen?

Gewasbeschermer: Maar dan gaat ook mijn bedrijf failliet, wat moet ik dan?

Iedereen: Een andere baan zoeken natuurlijk!

Professor: Dan wil ik nu graag het onderzoek uitleggen. Dit is het aantal koolmezen, en dit is de tijd in jaren. En zoals je kan zien is er een flinke daling! We kunnen nog niet aantonen of dit komt door de bestrijdingsmiddelen, maar wat we wel weten is dat het zeer schadelijk is voor de dieren.

Vogelgek: De koolmees wordt bedreigt omdat mensen de buxusrups bestrijden met deze middelen.

Activist: Dit veroorzaakt bij mensen longschade, en ook voor dieren is het zeer schadelijk.

Jannie: Dus als ik het goed begrijp heeft het veel invloed op het milieu en verdwijnen er veel diersoorten?

Professor: Dus nu kunnen we concluderen dat bestrijdingsmiddelen een grote invloed hebben op het leven op aarde.

Buxuskweker: Maar wat kan dan een oplossing zijn voor het probleem?

Professor: We zouden het middel kunnen aanpassen zodat het minder schadelijk is.

## 2C Duurzame vakantie

Burger: Mijn tank met diesel is leeg, en ik heb haast want ik ben onderweg naar Frankrijk. Kan je hem even bijvullen?

Tankbediende: Ja hoor.

Bioloog 1: Sorry dat ik u stoer meneer. Maar weet u wel wat er gebeurt als u zo'n eind gaat rijden met zo'n slechte auto?

Burger: En wat boeit dat? Het gaat er toch om dat je nu geniet, niet straks?

Bioloog 2: Uhm, en uw kleinkinderen dan?

Burger: nou, zo snel gaat dat niet hoor?

Bioloog 1: Als iedereen met zo'n levenswijze leeft dan is de lucht later een grote vuilnisbelt.

Tankbediende: Hallo! Ik heb niet de hele dag de tijd, verder nog iets?

Bioloog 2: Mag ik vragen waar u verblijft in Frankrijk?

Burger: In het Orient hotel.

Bioloog 1: En hoe duur mag dat dan wel niet wezen?

Burger: Zo'n 20 000 euro per nacht.

Tankbediende: Zo zo, dan kan je nu dus ook wel even tanken!

Burger: Ja, vol gooien graag.

Bioloog 2: Wacht wacht, gaan jullie echt met die auto naar Frankrijk rijden?

Burger: Ja

Bioloog 2: Zo veel uitlaatgassen is precies hetzelfde als 3 dagen achter elkaar constant roken!

Bioloog 1: Dus je kan veel beter een elektrische auto kopen, dat is veel beter voor het milieu!

Burger: Ja, maar dat is wel weer duur.

Bioloog 1: dan ruil je je hotel maar in voor een elektrische auto en ga je met een tent op vakantie.

Tankbediende: Of je verspilt je tijd hier niet en rekt gewoon af.

Bioloog 2: Mag ik wat vragen? Heeft u ook een gerecycled flesje?

*Tankbediende pakt flesje*

Bioloog 2: Uh, nee nee. Dat is niet gerecycled.

Tankbediende: Nou, dat is wel een beetje overdreven hè.

Bioloog 1: In de toekomst moet dat dus wel zo zijn.

Burger: Het moet ook niet gekker worden hè? Waarom verspillen jullie je tijd aan het bezig houden met het milieu?

Bioloog 2: Nou, wij zijn bioloog. En wij willen dat iedereen goed om gaat met het milieu.

Tankbediende: Wat maakt dat ene flesje nou weer uit?

Bioloog 1: Als iedereen er zo over denkt dat zijn we later nog niet beter.

Bioloog 2: En weet u wel hoeveel plastic er in zee ligt? Wel 5 ton aan plastic ligt er in zee.

Burger: Ja dus?

Bioloog 1: nou, dat is slecht voor de dieren. En de vissen die jij later opeet hebben dan plastic in hun maag, dus jij dan ook.

Tankbediende: Ik zou op zich over 30 jaar nog wel plasticloze vis willen eten.

Burger: Dat lijkt mij ook wel handig.

Bioloog 2: Nou daar kan je zelf al heel veel aan doen. Zelf beter om gaan met het milieu en anderen er ook van proberen over te halen.

Burger: Nou wat kan ik er dan aan doen?

Tankbediende: Misschien geen plastic in de zee gooien?

Bioloog 1: Nou dat is niet het enige wat je kan doen. Je kan ook met de fiets op vakantie gaan, in een tent slapen, niet te lang douchen, afval scheiden en recyclen.

Tankbediende: En waar het allemaal mee begon: een andere auto kopen.

Burger: Nou dan ga ik wel niet op vakantie!

Biologen: Nee nee, dat hoeft ook weer niet. U kunt ook met de fiets op vakantie gaan naar een camping, of met het openbaar vervoer. Of een duurzame auto en een goedkoper hotel waar je niet te lang gaat douchen. En vooral niet naar buiten gaan en het licht aan laten staan. En ook niet te veel activiteiten gaan doen waarmee je het milieu te veel beschadigt.

Burger: Ik cancel het hotel wel. En ik ga wel langs huis en ga dan met de fiets op vakantie naar een camping.

Bioloog 1: Goed zo, en overtuig anderen hier ook mee!

Burger: Ja ja dat doe ik.

## 2C Medicijnenophoping in water

Journallezer: Hallo welkom bij het journaal, we gaan het nu hebben over medicijnen die worden geslikt preventief. En kijken wat voor invloed dat heeft op het milieu. We schakelen over naar Lars in de woonwijk.

Interviewer: Zo hallo beste burger. Slikt u medicijnen?

Burger: Ja, ik slik ontzettend veel medicijnen. Vooral tegen mijn ernstige hoofdpijn. Aspirientjes, ibuprofen en soms ook wel antibiotica. Hangt af van de dag en hoe ik mij dan voel.

Interviewer: En slikt u ook preventief?

Burger: Ja, ik slik vooral preventief. Ik wil gewoon geen hoofdpijn hebben, dan kan ik niet meer functioneren. Nu ook bijvoorbeeld. Ik heb ibuprofen geslikt, want als ik met hoofdpijn hier op school zit ga ik gewoon naar huis. Ik kan niet zonder die dingen, dan krijg ik hoofdpijn!

Interviewer: En wat voor invloed denkt u dat dit heeft op het milieu?

Burger: Ik weet niet precies wat voor invloed het heeft, ik weet ook niet of het slecht is. Maar stel dat het slecht is dan zou dat mij ook weinig uitmaken. Want ik wil gewoon kunnen functioneren, ik heb geen zin om geen aspirientjes meer te slikken, en ik denk ook niet zo snel dat dat wordt verboden. Dus ik blijf lekker mijn medicijnen slikken.

Interviewer: En wat vindt u ervan dat het voor de dieren heel slecht is?

Burger: De dieren maken mij niets uit. Ik vind vlees en vis ook heerlijk.

Interviewer: Dankjewel. We schakelen nu over naar Jelle de visser.

Jelle: Goedenmiddag

Interviewer: Hallo Jelle de visser. Wat vindt u van uw vangst de laatste tijd?

Jelle: Ja, dat gaat heel slecht. Vroeger moesten we 1 uur werken voor normale inkomsten, en nu is dat al het dubbele.

Interviewer: En weet u ook waardoor dat komt?

Jelle: Nee, eigenlijk niet.

Interviewer: Dat komt door het medicijngebruik, en vooral het preventief medicijngebruik.

Jelle: Oh ja, zo iets had ik gelezen inderdaad.

Interviewer: Bedankt voor uw tijd. Dan schakelen we nu over naar de milieuactivist. Wat vindt u van het preventief slikken van medicijnen?

Milieuactivist: Ja als milieuactivist vind ik het natuurlijk vreselijk wat er allemaal met de beesten gebeurt in de oceaan. En vooral dat er veel preventief wordt geslikt, dat kan gewoon niet! Je moet het alleen gebruiken als het echt nodig is.

Interviewer: Slikt u ook medicijnen?

Milieuactivist: Ja, maar alleen als het nodig is. Zelfs als ik een klein beetje hoofdpijn heb dan slik ik het niet, omdat ik met hart en ziel van alle beesten houd.

Interviewer: Dankjewel. Dan schakelen we nu over naar Jasper de wetenschapper. Ik ga u een paar vragen stellen over het milieu. Wat vindt u van het preventief slikker van medicijnen.

Jasper: Onverantwoordelijk.

Interviewer: En slikt u zelf dan medicijnen?

Jasper: Alleen als het nodig is.

Interviewer: Net hoorde wij de burger zeggen dat het hem niks uitmaakt, en dat hij preventief medicijnen slikt. Wat vindt u?

Jasper: Heel erg onverantwoordelijk. Je moet daar beter over nadenken.



## 2C Bijensterfte

Boer: Wat is het een mooie dag. Even mijn plantjes bespuiten met gif, dan ben ik tenminste af van het ongedierte hè?

Bij: Ik heb zijn in nectar, bzzzzz, wat zijn de bloemetjes toch lekker!

*Bij sterft door gif*

Activist 1: Potverdomme! Wie heeft deze bij vermoord? Degene die dit gedaan heeft is nog lang niet jarig! Heb jij dit gedaan boer?

Boer: Weet ik niet, misschien? Ik heb net de plantjes bespoten met gif, maar wist niet dat dat voor de bijen niet goed was.

Activist 1: houd me tegen, ik wil die boer een ram voor zijn kop geven!

Activist 2: Dat is niet de reden waarom we hier zijn. Wij zijn hier omdat je de bijen niet moet doden, bijen zorgen juist voor extra eten en voor zuurstof.

Activist 1: Ook vergiftig je ons eten door het besproeien met neonicotinoïden. Als je onze plantjes hiermee bespuit, bespuit je eigenlijk ook ons voedsel met dit gif!

Burger: Wat vergiftig jij het eten?

Boer: Je hoeft niet boos te worden, het zijn maar bijen. En het gif dat gaat vanzelf wel weer weg denk ik.

Activist 2: Niet alleen de boeren maken bijen dood. Ook domme burgers maken bijen dood.

Burger: Wat zeg jij, ik ben niet dom!

Activist 1: Waarom zijn de bijen eigenlijk zo irritant?

Burger: Ze zoemen en steken mij altijd.

Activist 2: Ze zijn niet irritant. Bijen zijn juist heel handig. Ze bestuiven bijvoorbeeld appelbomen, zodat wij appels kunnen eten.

Burger: Wat kunnen wij dan met de bijen doen zonder ze dood te maken?

Activist 1: Je kan bijvoorbeeld lieveheersbeestjes gebruiken tegen bladluizen. En we kunnen mensen informatie geven over bijen, zoals als dat als je ze niks aan doet, ze jou met rust laten.

Burger: Dat vind ik een goed idee.

## 2C Exoten

Burgers: Klopt het dat jij wetenschapper bent, wij willen namelijk wat vragen stellen over exoten?

Wetenschapper: ik heb een grijze eekhoorn meegenomen, en dat is een exoot. En ook die mogen jullie wat vragen stellen.

Burger 1: Hoe beïnvloeden exoten in het algemeen ons milieu?

Wetenschapper: Exoten beïnvloeden ons milieu omdat ze vaak geen vijanden hebben, en een overschot aan voedsel, waardoor ze zich snel voort kunnen planten. Ze eten dus veel van het voedsel, waardoor inheemse soorten minder voedsel hebben.

Burger 2: Wat kunnen we tegen dit soort exoten doen zodat ze ons milieu niet meer beïnvloeden?

Wetenschapper: Eigenlijk is het beste wat we kunnen doen de exoten bestrijden, want ze horen hier eigenlijk niet thuis. Dat is alleen een behoorlijk ingewikkelde taak omdat ze overal kunnen voortkomen.

Burger 1: Je zei dat je een grijze eekhoorn bij je hebt, kunnen wij die nog wat vragen stellen?

Wetenschapper: Ga je gang!

Burger 1: In wat voor leefgebied kom je vaak voor?

Eekhoorn: Ik leef het liefst in het loofbos want daar kan ik goede huisjes maken, die veel beschutting geven. En er is veel voedsel van andere inheemse eekhoorns die dat verzamelt hebben.

Burger 2: En waarom en hoe ben je dan hier gekomen?

Eekhoorn: Mijn moeder heeft dat wel eens vertelt. Een man had mijn overgroot oma gevangen, en die had haar als huisdier. Op een dag verhuisden zij hier naar toe. Op een dag daarna ontsnapte zij met een mannetje van haar soort, toen had ze kinderen gekregen, en daarom ben ik nu hier.

Burger 2: En wat zou jij er van vinden als je naar je oorspronkelijke gebied wordt gebracht?

Eekhoorn: Dat weet ik niet, want ik ben daar nog nooit geweest. Maar ik vind het hier vooral erg mooi, veel mooie huisjes en veel eten.

## 2C Microplastic

Presentator: Welkom allemaal bij deze quiz over microplastic. Wat is microplastic, microplastic zijn hele kleine deeltjes plastic die in de oceaan zitten. Sommige wat groter, en anderen zo klein dat je ze alleen met een microscoop kan zien. Onze zeeën zitten er helaas vol mee! Ik ga jullie nu voorstellen aan onze kandidaten. Robin, Sara, Teun en Lotte! We hebben drie vragen, en ook een winnaar. Vraag 1: Wat veroorzaakt al het microplastic in zee? A Door de mensen die alle microplastic in zee gooien. B Door stortplaatsen van fabrieken en vanaf daar komt het in zee. C Dieren nemen het microplastic mee naar rivieren en zeeën. Sara, waarom heb jij antwoord C gekozen?

Sara: Nou, dat de dieren het meenemen naar zee is gewoon heel logisch. Want veel dieren leven in zee, en mensen kunnen daar niet leven, dus moeten zij het wel meegenomen hebben.

Presentator: Lotte, waarom heb jij antwoord A?

Lotte: Mensen gooien hun lege shampooflessen in rivieren, en via de rivieren komt het bij de zee.

Presentator: Robin waarom heb jij B?

Robin: Alle fabrieken hebben stortplaatsen, en die komen uit in zee. Zo simpel is het.

Presentator: Het goede antwoord is.... antwoord A. Oke, vraag 2! Voor wie is al dat microplastic ontzettend slecht? A voor mensen. B voor dieren. Of C voor allebei? Robin, waarom heb jij antwoord A?

Robin: Omdat het slecht is voor mensen. Want het zit in shampoo wat dan op mijn handen komt, en dat is heel slecht voor je.

Presentator: Lotte waarom heb jij antwoord C?

Lotte: Omdat de vissen microplastic uit zee opeten. En wij eten vervolgens de vissen, dus is het ook weer slecht voor ons.

Presentator: Teun waarom heb jij antwoord C?

Teun: Doordat dieren het eten, en wij eten dieren. Dus we moeten het plastic uit zee halen, en zo min mogelijk microplastics gebruiken.

Presentator: Sara waarom heb jij B?

Sara: De dieren stikken in microplastic en gaan allemaal dood!

Teun: Dieren kunnen helemaal niet in microplastic stikken, het is zo klein!

Presentator: Het goede antwoord is C! Wat voor gevolg heeft het microplastic voor de dieren? A doordat ze het in hun lichaam krijgen waardoor ze ziek worden en kunnen sterven. B ze raken verstrikt in het plastic en kunnen zo sterven. C ze verslikken zich erin. Sara waarom heb jij antwoord B?

Sara: Nou, je ziet het al op het plaatje. Die schildpad zit helemaal vast in dat microplastic! Zo gaat die dood.

Teun: Nee! Microplastic is veel te klein, daar kan je niet in verstrikt raken.

Presentator: Lotte waarom heb jij antwoord A?

Lotte: Ze kunnen ziek worden door plastic wat ze binnen krijgen, en daardoor kunnen ze sterven.

Presentator: Het goede antwoord is A! Dat was onze quiz, en we hebben een winnar. Het is Lotte met 3 punten.

## 2C Vogelsterfte

Presentator: Dit is een nieuwe rupsige aflevering van Pech aan de andere kant van de heg! Dit is het incident van de afgelopen week. Je ziet hier dat de vogel de rups opeet, maar de rups is bestreden met bestrijdingsmiddelen, en daarom gaat de vogel dood. Het incident heeft plaatsgevonden in Hengelo. We schakelen nu over naar onze verslaggever.

Verslaggever: Hallo, vandaag zijn we hier met Bertha en Aagje, de twee burens van deze week. Ze hebben een conflict over de buxusrups. Ik ga nu eerst Aagje interviewen. Wat is volgens u het probleem?

Aagje: De buxusrupsen eten mijn hele heg op, en daarom gebruik ik bestrijdingsmiddelen. Maar ja, daar is mijn buur het niet mee eens.

Verslaggever: Oke bedankt. Nu gaan we kijken wat volgens Bertha het probleem is.

Bertha: Ik ben een hele grote dierenvriend. Ik heb namelijk meerdere vogelnestjes in mijn tuin, en omdat mijn buur die rupsen bestrijdt met die vieze bestrijdingsmiddelen, krijgen mijn vogels het via die rupsen binnen en gaan ze allemaal dood in mijn tuin. En daarom heb ik me ingeschreven voor dit programma.

Aagje: Die rupsen moeten gewoon weg! Mijn hele heg wordt kaal gevreten, terwijl ik de hele dag mijn best doe die heg netjes te houden! En als mijn buur toch zo'n dierenvriend is, waarom koopt ze dan niet zelf voedsel voor die vieze dieren!

Verslaggever: Oke, laten we de bioloog erbij halen.

Bioloog: Hallo allemaal, ik Ben Leonie, en ik ben nu al heel lang bioloog. Ik ben afgestudeerd aan de universiteit van Wageningen. We gaan even terug in de tijd. De vogelsterfte door bestrijding van buxusrupsen is sinds 2017 een groot probleem. Want in 2015 waren er 115 000 koolmezen, in 2016 waren er 115 000 koolmezen, en in 2017 waren er nog maar 79 000 koolmezen. Het aantal koolmezen gaat dus achteruit, en een belangrijke reden hiervoor is het bestrijden van buxusrupsen, omdat de vogels dit vervolgens binnen krijgen en sterven.

Verslaggever: oke, nu het allemaal duidelijk is kunnen we kijken naar een oplossing.

Bertha: Dat lijkt mij wel duidelijk. Geen bestrijding meer, en de buxus vervangen door een nieuwe heg!

Aagje: En wie gaat dat allemaal betalen?

Bertha: Jij!

Aagje: Nee! Jij vindt het een probleem van die struiken, van mij hoeven ze niet weg, en de bestrijdingsmiddelen ook niet.

Bertha: Moeten alle vogels dan dood ofzo!?

Verslaggever: Oke, dit loopt een beetje uit de hand. Laten we terugschakelen naar de studio.

Presentator: Welkom terug in de studio. Na de reclame komen onze gasten het live uitpraten om tot een oplossing te komen.

## *Reclame*

Presentator: We zitten hier nu in de studio met onze burens Bertha en Aagje. En natuurlijk onze bioloog Leonie.

Verslaggever: Aagje is voor de bestrijdingsmiddelen en maakt het niet uit dat de vogels dood gaan. Bertha daarentegen is tegen de vergiftiging waardoor vogels via rupsen overlijden. Haar tuin ligt vol met dode vogels, terwijl Aagje haar tuin stinkt naar bestrijdingsmiddelen.

Presentator: Ik zou het wel weten, weg met de bestrijdingsmiddelen.

Leonie: Nou, er zijn natuurlijke bestrijdingsmiddelen waardoor Aagje geen last meer heeft van de rupsen, en de vogels ook niet zullen sterven. En zelfs uw tuin niet meer stinkt.

## *Aagje en Bertha ruziën*

Presentator: Nou, dit was het wel weer. Volgende week zijn we er weer met een nieuwe aflevering van pech aan de andere kant van de heg.