

# **Techno-moral vignettes in socio-scientific issues-based education on synthetic biology**

**Name:** Alexandra M. Slegers

**Student number:** 3349276

**Date:** 28 March, 2014

**Number of ECTS:** 30

**Supervisor:** Dr. Marie-Christine P.J. Knippels

**Course coordinator:** Dr. Dirk Jan Boerwinkel

**Second examiner:** Prof. Dr. Arend J. Waarlo

**Institute:** Freudenthal Institute for Science and Mathematics Education, Utrecht University,  
Utrecht, the Netherlands

**Journal:** International journal of science education

**Audience:** Researchers in science education

**Journal guidelines:** Journal specific formatting style, UK English

**RESEARCH REPORT****Techno-moral vignettes in socio-scientific issues-based education on synthetic biology**

Alexandra M. Slegers<sup>a</sup>

<sup>a</sup>*Master student Science Education and Communication, Utrecht University, Utrecht, the Netherlands*

Forming an opinion on developments in science and technology like synthetic biology and the issues (socio-scientific issues) that arise because of these developments is a skill people have to develop. A way of introducing these issues are techno-moral vignettes, or future scenarios. This study aimed to investigate if techno-moral vignette-related learning and teaching activities are a promising way to introduce synthetic biology-related socio-scientific issues in classroom settings to start up the opinion-forming process. To reach this goal a design based research approach was adopted to develop a lesson based on the first steps of the opinion-forming process for secondary education. The lesson was put into practice in two case studies, one class of senior general secondary level and one class of pre-university level. The techno-moral vignette *'Mother's day'* was used and students had to work on different assignments. This was combined with a questionnaire and interviews with students and the teacher to get more in-depth data. Results showed that the designed learning and teaching activities are a promising way of introducing synthetic biology-related socio-scientific issues, since different emotions, questions, values and beliefs were evoked. Most students were also able to deduce a dilemma from the vignette. It can be concluded that the designed techno-moral vignettes-related learning and teaching activities are appropriate in starting up the opinion-forming process on synthetic biology related socio-scientific issues. In this way science education can contribute to scientific literacy and citizenship education.

*Key-words: Design based research; Techno-moral vignettes; Opinion-forming; Citizenship education, Socio-scientific issues, Synthetic biology*

## Introduction

Science and technology have been developing rapidly in the past decades. Particularly biotechnology has received much attention. An important landmark was the unravelling of the structure of DNA (1953). The discovery of the relatively simple, universal structure of DNA has led to many technological applications, e.g. sequencing the human genome which can help with the identification of genes that cause disease. This led to the development of more specific treatments. A research field that stems from biotechnology is synthetic biology (SynBio). An important landmark in this field was the creation of a bacterial cell that functions with a synthetic genome by Craig Venter and his team (Gibson et al., 2010). The goal is to use this synthetic organism to discover what the minimum number of genes is needed for life to exist (Smith, 2010; Stemerding & Rerimassie, 2013). In SynBio, genetics and engineering are combined in order to “*design and engineer biologically based parts, novel devices and systems, as well as redesigning existing, natural biological systems*” (Kitney et al., 2009 p. 13). Ultimately, the goal of SynBio is to create applications which will benefit society (Kitney et al., 2009).

Developments in SynBio can have great influence on society and give rise to new issues and questions. Evaluation of certain themes, i.e. biosafety<sup>1</sup>, abuse and bioterrorism, intellectual property, and ethics and society is therefore necessary (Messer, 2007). Some questions raised in these themes are: ‘Is the current risk assessment system for genetically modified organisms prepared for future developments in SynBio? Should we become more worried about bioterrorism with the development of new biological systems? Should discoveries made in SynBio be patented or should they be available for everyone?’

The issues raised by the developments in SynBio can be described as socio-scientific issues (SSIs). Socio-scientific issues are issues that are both related to science and society (Ratcliffe, 1997). SSIs are open-ended, complex, controversial dilemmas without a definitive answer (Sadler, 2004). They require either a degree of moral reasoning or an evaluation of ethical concerns (Zeidler & Nichols, 2009). They are developments in science that, potentially, have an impact on society (Sadler, 2004) and they have a very short lived character (Ratcliffe

---

<sup>1</sup> Biosafety can be defined as ‘containment principles, facility design, practices and procedures to prevent occupational infections in the biomedical environment or release of the organisms to the environment’ (American Biological Safety Association, n.d.). It should not be confused with the term biosecurity which can be defined as ‘active methods to avert biological terrorism or other disease breakouts’ (Matishak, 2009).

& Grace, 2003). Something that is a socio-scientific issue at this moment does not have to be one in the future.

To be able to decide on or at least follow discussions about SSIs and questions that hold a scientific background, a scientific literate society is desired (KNAW, 2003). Scientific literacy is of great importance for citizenship education (Van den Hoogen & Tatje, 2013). In an education act passed in 2005, the Dutch government indicated that schools should spend time on citizenship education (Bron, 2006). An important aspect of citizenship education is opinion-forming and informed decision-making (Wetenschappelijke Raad voor het Regeringsbeleid, 1992).

New developments in science like SynBio also give rise to impacts that need to be considered. Impacts can be divided into hard impacts or risks and soft impacts which can be described as unpredicted side effects of technological developments on society and individuals (Boerwinkel, Swierstra & Waarlo, 2012), e.g. the effects mobile phones and the internet have on our lives. Hard impacts usually concern our health, safety or the environment and can either be positive or negative (Swierstra & Te Molder, 2012). Soft impacts have largely been ignored in risk studies even though the public can also be interested in these types of impacts of emerging technologies (Swierstra & Te Molder, 2012).

Different didactics are available to discuss SSIs in the classroom. Sadler and Nichols (2009) suggest socio-moral discourse, argumentation and debate, and discussions to be used when teaching SSIs. With these methods the focus is on hard impacts and not soft impacts, which creates a need to develop and test new approaches.

A promising way of introducing SynBio-related SSIs and starting up the opinion-forming process in secondary biology education is the use of techno-moral vignettes. Techno-moral vignettes are future scenarios that invite the reader to image how science and technology may improve our lives (Swierstra & Boenink, n.d.). The Rathenau Institute developed 17 vignettes in order to prepare the public for SSIs that the developments in SynBio can raise. These vignettes have been designed in order to stimulate the public debate on SSIs and to stimulate people to use their imagination to predict how science and technology may influence our future lives (Swierstra & Boenink, n.d.). Boerwinkel et al. (2012) indicated that narratives can be obtained from practices in for instance genetic testing that have started recently and from which future developments are probable. Future scenarios can be seen as narratives which makes them more realistic. Since SynBio is a research field that is still in its infancy but is rapidly developing (Stemerding & Rerimassie, 2013) future scenarios seem a promising way to introduce SynBio-related SSIs to students.

Techno-moral vignettes put an emphasis on soft impacts rather than on the hard impacts. They invite the reader to imagine and consider ways where technological improvements might change ideals, values, ideas and maybe even our world (Boerwinkel et al., 2012). By using SynBio related SSIs in the classroom, students come in contact with soft impacts and learn to consider these impacts in forming an opinion. However, techno-moral vignettes have not been adapted for education and there is no experience with the effectivity in stimulating opinion forming on the soft impacts of technology in classroom settings.

In a previous study by De Ruijter, Knippels and Waarlo (2013) the techno-moral vignettes developed by the Rathenau Institute were assessed in order to see if they hold educational potential to introduce SynBio-related SSIs. Three vignettes were suggested to be used in a learning and teaching strategy (LTS), because they cover a broad range of applications in SynBio and evoked a broad range of questions, values, emotions and reasoning types (De Ruijter et al., 2013).

Since the educational potential of techno-moral vignettes has been assessed with individual students (De Ruijter et al., 2013), the next step is to determine if the techno-moral vignettes can be used in a classroom setting. The aim of this study is therefore to investigate whether techno-moral vignette-related learning and teaching activities (LTAs) are a promising way for introducing SynBio-related SSIs in a classroom setting to support the opinion-forming process and contribute to biology education for techno-scientific citizenship. It is a first step in empowering students for public engagement in science and technology. If the LTAs prove promising to introduce SynBio-related SSIs and support the opinion-forming process, further steps to develop a learning and teaching strategy to support the opinion-forming process on SynBio-related SSIs can be taken.

## **Theoretical framework**

### *Synthetic biology*

SynBio can be defined as “*the design and construction of new biological parts, devices and systems and the re-design of existing natural biological systems for useful purposes*” (syntheticbiology.org). It is an emerging field of research that has been developing rapidly and is well known by scientists in the European Union (EU) (Stemerding & Rerimassie, 2013), however 83% of the Europeans has never heard of this field of research (Gaskell, 2011). Synthetic biologists can be divided into different camps, e.g. on the distinction between natural-unnatural (Benner & Sismour, 2005). Another way to classify the different sides in SynBio research is based on the approaches used to construct biological components. This gives a better

distinction of practices involved in synthetic biology and offers a better insight into certain underlying tensions between the approaches (O'Malley, Powell, Davies & Calvert, 2007). Three categories can be formed based on this distinction, i.e. DNA-based device construction, genome-driven cell engineering and protocell creation. These categories have different aims, methods, techniques, and constructs. They also interact with each other in different ways (Table 1).

Table 1. Categories of synthetic biology (adapted from O'Malley et al., 2007)

	<b>DNA-based device construction</b>	<b>Genome-driven cell engineering</b>	<b>Protocell creation</b>
<b>Aims</b>	To transform biology into engineering; To construct functioning biological components (also called 'BioBricks') from the bottom up	To synthesize minimal but entire genomes and insert them in cells; To control cellular production processes	To construct viable approximations of cells; To understand non-synthetic biology and the origin of life
<b>Methodological principles</b>	Design and fabricate; Engineering principles; Bottom-up approach	Bioinformatics-based engineering combining bottom-up and top-down strategies	Intermediate and bottom-up approaches; Theoretical modelling and experimental construction
<b>Techniques</b>	Synthesis of DNA devices and insertion in cells	Bioinformatics analysis of genome engineering, and insertion in living cells	Construction of rudimentary cells & cellular sub-systems, using synthesized and existing components
<b>Constructs and exemplars</b>	Toggle switch; Repressilator; Artemisinin metabolic pathway	Viral genome synthesis; 'Transformation' of organism/species via genome replacement	Containers such as micelles and vesicles with genetic & metabolic components
<b>Interactions with other approaches</b>	Components for minimal cells and protocells	New DNA synthesis techniques; Cellular platforms for device insertion	Essential genes and biochemical systems for cellular life; Chassis

SynBio is a research field with many promises like the development of biosensors that can be used in the detection of environmental factors like toxins or the production of cheaper active substances needed for medication, e.g. artemisinin. However, there are also risks and ethical concerns that need to be considered. The debate on issues generated by the developments in SynBio is just starting to unfold and will determine the course the development of the field will follow (Stemerding & Rerimassie, 2013).

### *Future scenarios*

Possible futures of SynBio are described in techno-moral vignettes developed by the Rathenau Institute (Rathenau Institute, n.d.). They are short stories that should not be seen as predictions, but as possible scenarios based on current developments. Since SynBio is a research field that is still developing and we thus have no way of knowing what the future holds, techno-moral vignettes seem a promising way to try to imagine and consider ways in which SynBio might change values, ideas and ideals. Using narratives and future scenarios can help students with envisioning different perspectives on a subject and in achieving empathetic involvement (Boerwinkel et al., 2012). In strategy formation and policy making, vignettes and scenarios have already proven to be helpful tools (Boenink, 2010). Also in environmental education future scenarios have been used (Lloyd & Wallace, 2008).

Even though future scenarios seem promising there are opponents who argue that we cannot predict the future and that we therefore should not attempt to do so. However, by imagining possible future scenarios, these possible changes become more concrete. When something is concrete you can better reflect on it (Boerwinkel et al., 2012). Boerwinkel et al. (2012) also present several reasons why we should not just ‘stick to the facts’. For instance, technological development is impossible without researchers considering possible aims and goals involved. And with these aims and goals comes the fact that one needs to speculate for “any goal-oriented behaviour requires some speculation (Boerwinkel et al., 2012 p. 8)”.

As mentioned before, a previous study by De Ruijter et al. (2013) assessed the educational potential of the vignettes to introduce SynBio-related SSIs. Firstly, the most promising vignettes for education were selected based on seven criteria, extracted from an interview with the designer of the 17 vignettes and Boerwinkel et al. (2012):

- Time distance: not too far ahead;
- Application triggers societal debate;
- The impacts include changes in routines;
- Stakeholders react ‘predictable’;
- Diversity of (biological) topics;
- Likely student reactions;
- Close to students' daily life (De Ruijter, Knippels & Waarlo, 2014).

The selection yielded five suitable techno-moral vignettes for use in secondary education, i.e. “*Reinventing the dodo*”, “*Mother’s day*”, “*Frustrated housewife*”, “*Bioluminescent street lamps*” and “*The Make-Your-Stool-Smell-Nice pill*” (De Ruijter et al.,

2013). Next, the selected vignettes were presented to and discussed with ten upper secondary biology students of the fifth grade of the pre-university level (average age = 16.3) to see if they evoked questions, emotions and underlying values. The authors also evaluated which reasoning types were used by the students. The study showed that the vignettes are helpful in imagining future developments, raised many normative and factual questions, appealed to emotions, brought up values and evoked different types of moral reasoning. This proved the educational potential of the vignettes. The current study will use this educational potential and bring the techno-moral vignettes to the classroom by developing learning and teaching activities to start up the opinion-forming process while using these techno-moral vignettes.

### *Socio-scientific issues*

Issues generated by the developments in SynBio can be described as socio-scientific issues (SSIs). As mentioned before, SSIs are related to science and society (Ratcliffe, 1997) and are open-ended, complex, controversial dilemmas without a definitive answer (Sadler, 2004).

Two types of SSIs can be distinguished, type A and type B (Ratcliffe & Grace, 2003). In type A controversy arises through “the social application of well-established science” (Ratcliffe & Grace, 2003 p. 17). These types of SSIs focus on the implications of scientific evidence and not on the evidence itself (De Ruijter et al., 2013). Type B SSIs discuss “the implications of ‘science-in-the-making’ and the nature of the scientific evidence” (Ratcliffe & Grace, 2003 p. 17). SynBio-related SSIs can be categorised as type B SSIs since they entail ‘science-in-the-making’ and discuss the nature of the scientific evidence.

Numerous science educators argue that SSIs should be included in the science curriculum in order to make classroom science more reflective of the society it exists in and develop responsible citizens who are able to make well-informed decisions (Sadler, 2004). Sadler (2011) formulated essential and recommended guidelines with regard to design elements, learning experiences, classroom environment and teacher attributes that should be taken into account when developing SSI-based education. Other researchers have argued that SSIs and scientific literacy are connected. By studying SSIs it is thought that scientific literacy can be fostered (Zeidler & Nichols, 2009).

### *Scientific literacy*

Scientific literacy is the broad and functional knowledge the public should have on science to be able to “live more effectively with respect to the natural world” (DeBoer, 2000, p. 594). Scientific literacy can be defined as: “...*the knowledge and understanding of scientific concepts*



*and processes required for personal decision making, participation in civic and cultural affairs, and economic productivity.*” (National Science Education Standards, p. 22 as cited by Van den Hoogen & Tatje, 2013).

A scientific literate individual knows how to ask questions and how to find answers to these questions. It enables that individual to, to a certain extent, read and understand scientific articles, and discuss the validity of the conclusions. They are also able to determine the quality of scientific information based on the methods used (National Science Education Standards, as cited by Van den Hoogen & Tatje, 2013). This implies that the students have to have enough scientific knowledge to be able to decide and/or follow the discussion on SSIs (Boerwinkel, Veugelers & Waarlo, 2009). A goal of science education is to help students to become scientifically literate.

Scientific literacy can be interpreted in different ways (Laugksch, 2000). These interpretations have not only been based on research but also on personal views of researchers (Laugksch, 2000). In this study the term ‘functional scientific literacy’ is used because it is the type of literacy that comes closest to citizenship education (Boerwinkel et al., 2009). The term ‘functional scientific literacy’ comes from Shamos (1995) who suggested that there are three forms of scientific literacy, i.e. ‘cultural scientific literacy’, ‘functional scientific literacy’ and ‘true scientific literacy’. ‘Cultural scientific literacy’ is a form that is believed to be held by adults who have been educated and believe that they are relatively literate (Shamos, 1995). ‘True scientific literacy’ is the highest form of scientific literacy which is probably difficult to attain for most members of society (Shamos, 1995). ‘Functional scientific literate’ individuals are able to read, write and talk about science (Shamos, 1995). Students should learn to become ‘functional scientific literate’ individuals during their education. They should learn certain skills that will enable them to explore scientific issues that might arise in the future (Ratcliffe & Grace, 2003).

Our study will contribute to ‘functional scientific literacy’ by having students read and talk about science during the lesson. Scientific literacy is considered important for citizenship education (Van den Hoogen & Tatje, 2013) and they hold some common grounds. For instance the recognition of values and the use of these values in moral argumentation are important in both approaches (Boerwinkel et al., 2009).

### *Citizenship education*

Time in school should be spend on “active citizenship and social integration” as indicated by the Dutch government in an education act passed at the end of 2005 (Bron, 2006). Competences

needed for citizenship are (1) being able to collect and critically assess information, (2) being able to form a well-informed opinion or make a well-informed decision, and (3) act based on an opinion or decision (Boerwinkel et al., 2009). These competences can be attained by spending time on citizenship education in schools. However, citizenship education should not become a separate course but should be integrated in different school subjects (Boerwinkel et al., 2009). Since science education, at the moment, does not really spend a lot of time on this type of education there is an opportunity there.

Three distinctions in citizenship education can be made: the adapting citizen, the individualistic citizen and the critical-democratic citizen (Veugelers, 2007). These distinctions have been made based on the different goals of citizenship education (Boerwinkel et al., 2009). The idea of a critical-democratic citizen will be used in this study since the characteristics of this type of citizen fit best with the description of “active citizenship” (the willingness and capability to partake in and actively contribute to society (Bron, 2006)). According to Veugelers (2007, p. 107) “a critical-democratic citizen attaches great importance to autonomy and social awareness and relatively little to discipline”. An objective that can be assigned to autonomy is “forming an opinion” and social awareness holds the objectives “taking others into account, or showing respect for people with different views, and solidarity with others” (Veugelers, 2007, p. 106).

So a critical-democratic citizen is someone who can form an opinion but respects the views of others in forming this opinion. This study aims to contribute to becoming a critical-democratic citizen by giving students an opportunity to develop their own opinion, but also discuss and consider what others think.

### *The opinion-forming and informed decision-making process*

New technologies have created a world in which you can learn of news within moments of that news originating. This also entails that you can come into contact with a lot of issues and problems that you have to decide upon. Now more than ever citizens are expected to be able to make reasonable decisions concerning SSIs (Van der Zande, Waarlo, Brekelmans, Akkerman & Vermunt, 2011). In general every student is able to make a decision in occurring dilemmas, but one of the aims in education is to help students make an informed decision. A decision becomes informed when it “is made by a reasonable individual using relevant information about the advantages and disadvantages of all the possible courses of action, in accord with the individual’s beliefs” (Bekker et al., 1999 p. iii).

In an educational setting it is not always necessary to make a decision, but one should be able to form an opinion on an issue or problem. The steps in the opinion-forming process are quite similar to the steps of the decision-making process. The difference between opinion-forming and decision-making is that opinion-forming is more aimed at attitude formation whereas decision-making implies that you have to *do* something after making a decision.

Much research has been done on the opinion-forming and informed decision-making process and different emphases have been shown. Some research shows an emphasis on teaching students the skill of forming an opinion (Kortland, 1996; 2001; Knippels, Severiens & Klop, 2009). These studies used a more rationalistic approach. Other research aims at students becoming aware of beliefs and values they and others have (Van der Zande, 2011) and in these studies emphasis is on emotions or intuitions.

Researchers from the rationalistic approach have proposed different models, but they can all be traced back to the normative decision model (Kortland, 1996; 2001) depicted in Figure 1. This is a very broad model which is too elaborate to use in the lesson designed in this study. Benefits for using this model are:

- It forms a framework which can be used with every new, complex issue,
- It can be used as a checklist,
- It can give structure to the process (Kortland, 2001).

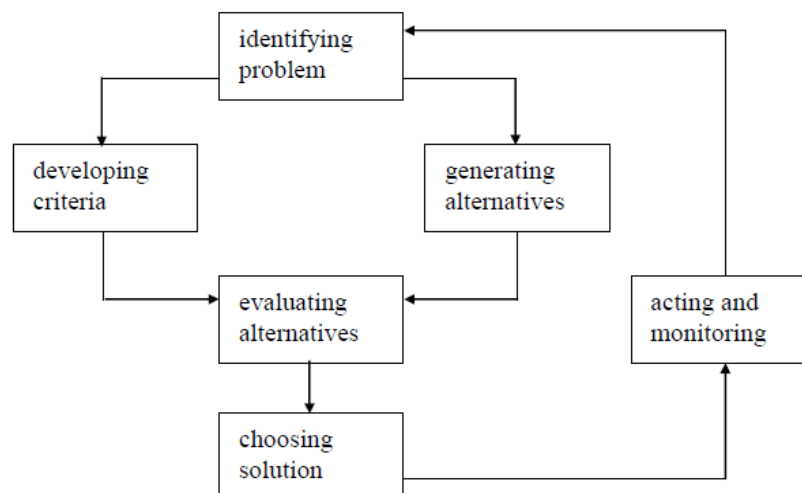


Figure 1. A model of a normative decision-making process (Kortland, 2001)

Aside from the steps one can take in the rational opinion-forming and decision-making process Van der Zande, Waarlo, Brekelmans and Vermunt (2009), Van der Zande (2011) and

Roeser (2011a) indicate that emotions play an important role in making decisions. This has been shown by neurological research in which people who had suffered neurological damage in brain areas associated with experiencing emotions were not capable of making socially acceptable decisions (Damasio, 1994). We especially trust our emotions and intuitions when making difficult decisions (Van der Zande et al., 2009). Emotions show underlying moral values which can help in the process of forming an opinion or making a decision (Roeser, 2011a). Haidt (2001) argues that an opinion is usually formed by an immediate, intuitive response after which arguments are formulated to underpin the intuition or emotion. So in order to form a well-informed opinion, emotions should be taken into account.

From these different studies basic commonalities in order to arrive at a well-informed opinion on moral issues like SSIs can be formulated as done by Knippels et al. (2009, p. 2061). These commonalities are:

- A) Students need to be capable of recognising and extracting the, or a, moral question of the dilemma,
- B) Students have to develop an awareness of the arguments and values that they and others use,
- C) Students should be able to think through the consequences of a potential decision,
- D) Students should be able to assess where to find and how to use the information needed to guide this process,
- E) Students should be aware of all the steps that need to be taken in order to arrive at a well-informed opinion.

So for a lesson module on opinion-forming on moral issues to ensure a well-informed opinion, these commonalities should be included. Since this is an exploratory study, it is not possible to include all the commonalities in one lesson. Therefore only commonality A and B were implemented as part of the first steps of the opinion-forming process.

The different emphases of research over the past years have been summarized in a figure by Prof. Dr. Waarlo (personal communication, 2013) depicted in Figure 2. This figure shows that emotions, values and beliefs, and knowledge and reasoning are linked. Emotions are indicators of underlying values and beliefs. These emotions form the basis of the 'gut reaction' one can have when hearing or reading about a problem or issue. Together these emotions, values and beliefs frame your knowledge and reasoning. Everyone has developed a different frame which has to be taken into account in discussing controversies (Schön & Rein, 1994). Frame reflection ensures that the frames of the different stakeholders in a discussion or discourse are included and considered. By taking the different frames into account it should become easier to

have a dialogue (Schön & Rein, 1994). With frame reflection you do not explicitly pay attention to the emotions, beliefs and underlying values that one holds. What is most important is that the participants in a discussion know and accept that there are different frames possible and need to be considered.

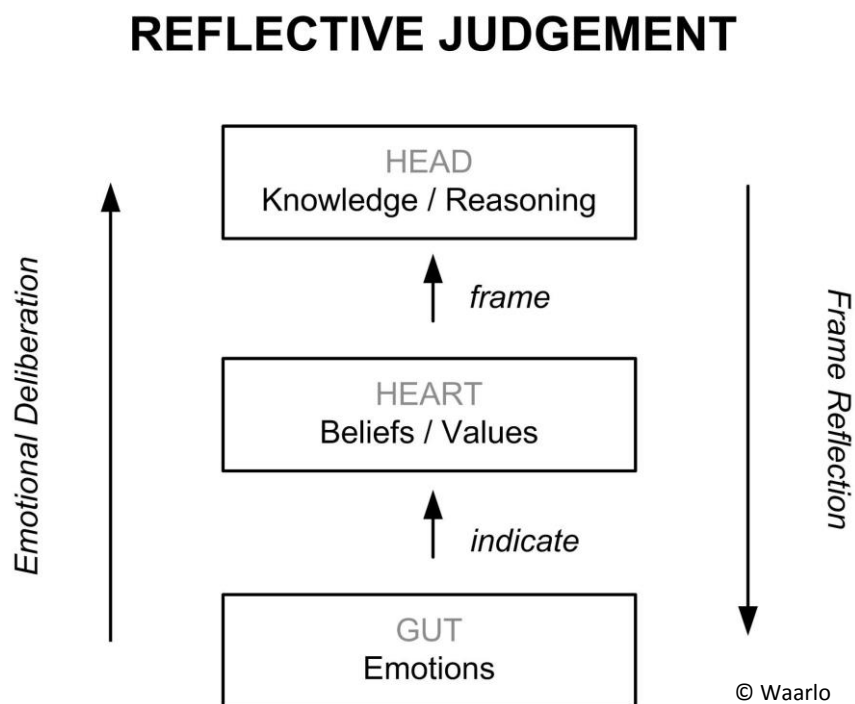


Figure 2. Reflective judgment (Waarlo, 2013)

The arrows between the different blocks in this figure show that emotions are associated with beliefs and values one holds. These beliefs and values influence the perception and use of knowledge in reasoning. Emotional deliberation starts from emotions and intuitions technology evokes (Roeser, 2011b; 2012). Frame reflection aims at clarifying, sharing and articulating frames discussants use so as to enable productive dialogues and collaborative reframing (Schön & Rein, 1994). When everyone sticks to his or her own frame a meaningful discussion is impossible.

The emotional deliberation approach indicates that emotions should explicitly be taken into account in order to have a genuine discussion about concerns surrounding an issue or problem (Roeser, 2011b; 2012). By taking emotions into account from the beginning, genuine ethical concerns can be revealed. At the same time, biases and irrational emotions or concerns can be addressed and possibly resolved by providing extra information. This can eventually help close the gap that often exists between experts and laypeople. Experts consider the public

as being emotional, which equals irrational, whereas the experts are seen as scientific and thus rational (Roeser, 2011a). Therefore, the recognition of emotions by the students is considered as one of the first steps in the opinion-forming process needed to form a well-informed opinion.

In summary, the first steps of the opinion-forming process that will be taken into account in this study can be formulated as follows. Students should be able to (1) recognize a dilemma in a techno-moral vignette, (2) show the first notions of realising which emotions they and others have regarding the dilemma, and (3) show underlying values and beliefs they have concerning the dilemma. These steps can be seen as steps that need to be taken before emotional deliberation is a possibility.

### **Research question**

As mentioned before, the main goal of this study is to uncover whether techno-moral vignettes-related learning and teaching activities are a promising way of introducing SynBio-related SSIs in a classroom setting to support the opinion-forming process, and in this way contribute to ‘functional scientific literacy’ and ‘critical-democratic’ citizenship. It needs to be taken into account that emotions and underlying values and beliefs play a critical role in the opinion-forming process (Van der Zande et al., 2009; Van der Zande, 2011; Roeser, 2011a). Therefore, the following research question and sub-questions will be addressed in this study:

**What techno-moral vignette-related learning and teaching activities are helpful in starting up the opinion-forming process in upper secondary school students?**

- 1) What kind of dilemmas do upper secondary school students deduce from a techno-moral vignette?
- 2) What types of emotions and questions are raised by these learning and teaching activities in upper secondary school students?
- 3) Which values are evoked in upper secondary school students when discussing a selected techno-moral vignette?

### **The designed lesson**

Based on the defined first steps of the opinion-forming process an introductory lesson was designed to start up the learning process on SSI raised in techno-moral vignettes. Learning activities and learning materials (Appendix 1) were designed guided by the defined first steps of the opinion forming process, and a hypothetical learning trajectory (HLT) was constructed. The following section consist of a description of and justification for the choices made designing the learning activities, learning materials and the HLT with regard to the formulated first steps. Table 2 gives a detailed version of the HLT.

The lesson started with an introduction by the teacher on the purpose of the lesson and what the students could expect. The introduction was followed by an explanation by the teacher of some difficult concepts that played an important role in the lesson (i.e. future scenarios and synthetic biology) (see LA1 in Table 2). This way students understood what they were going to be reading (the future scenarios) and in which field of research these developments might be possible. It was decided to explain the concept ‘future scenarios’ rather than ‘techno-moral vignettes’, because that latter concept was deemed to, perhaps, be too difficult for the students to understand.

After this general introduction, students were asked to read the techno-moral vignette ‘*Mother’s day*’ (Appendix 2). The techno-moral vignette was introduced in this stage of the lesson since it is important to present the issue first (Sadler, 2011). The selected vignette was one of the three techno-moral vignettes suggested for further development of a learning and teaching strategy by De Ruijter et al. (2013). In the techno-moral vignette, a juvenation cure was created which claimed to stop your telomeres from shortening and thus stop the ageing process. People could only take the cure if they did not have any children and if they had been sterilised. This vignette was chosen because it was thought to be closest to the everyday lives of students. At the moment we are already dealing with people getting older and older and the consequences that have to be taken because of that. For this reason students can probably easy relate to the dilemma raised in the techno-moral vignette. Moreover, it was chosen because this vignette evoked most values in the study by de Ruijter et al. (2013).

Next, students had to work on different assignment worksheets (LA2-LA6). A structure in which students first had to think for themselves (e.g. ‘would I take this live extending cure?’) (LA3-LA5), then discuss their opinion with their neighbour (LA4), and then have a group discussion (LA6) (think, pair, share) was used. This way, students were able to make up their mind before they had to discuss with their peers. Making up your mind before you go into a discussion can help make the discussion more equal between students.

Table 2. Hypothetical learning trajectory

Learning and teaching activity (LA)	Activity		Hypothesized learning result	Outcome
	Teacher	Students		
<b>LA1:</b> General introduction to assignment and difficult concepts, i.e. future scenarios, synthetic biology.	Introduce lesson, what is expected of students during lesson.	Students listen to explanation teacher.	Students gain insight into what future scenarios/vignettes are and show a rough understanding of what SynBio is.	This outcome of this goal was not tested during the lesson. Students were asked if they understood everything that the teacher had explained and they indicated they did.
<b>LA2:</b> Introduction to techno-moral vignette  Students have to read the techno-moral vignette and are asked to write down if they have any questions on the vignette and if they would take the cure presented in the vignette.	Teacher is available for questions and pays attentions to the different questions and opinions raised by the students after having read the techno-moral vignette.	Students answer question 1 in the assignment.	Students are able to raise questions when reading the vignette, they do not just take the story for granted.	Students wrote down a lot of questions that appeared during or after reading the vignette.
		Students answer question 2 in the assignment.	Students are able to formulate an initial opinion on a dilemma presented in a techno-moral vignette.	Students were able to formulate an opinion about the vignette.
<b>LA3:</b> Articulation of emotions raised by techno-moral vignette.  Students are asked to express which emotions were evoked by the techno-moral vignette and if they can explain where those emotions come from.	Teacher is available for questions and pays attentions to the different emotions raised by the students after having read the techno-moral vignette.	Students answer question 3 and 4 in the assignment.	Students show a realisation that emotions play a role in forming an opinion about the vignette.	Many emotions were named by the students. Some students didn't write down any emotions. Students gave brief explanations on where they thought the emotions arose from.
<b>LA4:</b> Formulate problem/dilemma presented in the techno-moral vignette and reflect on it with neighbour.  Students had to write down what they thought was the problem/dilemma present in the techno-moral vignette. After this, they had to discuss their viewpoint with their neighbour.	Teacher is available for questions and pays attentions to the different problems/dilemmas deduced by the students from the techno-moral vignette	Students answer question 5 and 6 in the assignment, and discuss the dilemma with their neighbour	Students learn to formulate what they think is the problem/dilemma of the future scenario.  Students also gain insight in the fact that someone else can deduce a different or the same problem/dilemma from a techno-moral vignette.	About half of the students followed the instruction to formulate a dilemma as an (un)pleasant choice between two things. Other students did not follow the assignment but formulated arguments for or questions on the dilemma.  Students discussed with their neighbour what they thought the problem/dilemma of the vignette is.



Table 2 continued. Hypothetical learning trajectory

Learning activity	Activity		Hypothesized learning result	Outcome
	Teacher	Students		
<p><b>LA 5:</b> Write down your opinion.</p> <p>Students had to define what their viewpoint on the actual problem/dilemma of the techno-moral vignette was and if emotions play a role in this viewpoint.</p>	Teacher is available for questions and pays attentions to the different opinions on the problem/dilemma from the techno-moral vignette	Students answer question 7 in the assignment	Students have to define what they think of the problem/vignette before entering in discussion. This will help with being able to express their point of view during the discussion.	Students usually formulate something similar to what they formulated at LA 3 which indicates if they would take the cure or not.
<p><b>LA 6:</b> Reflect on your opinion and that of others.</p> <p>Students had group discussion on the techno-moral vignette in which they could explore how others felt about the problem/dilemma presented in the techno-moral vignette.</p>	Teacher is available for questions and pays attention to the different things named during the discussion. Can also help with the discussion when a group appears to be stuck.	Students have a discussion in groups of 4-5 students.	Students will see different points of view and opinions on the problem/discussion.	Students had discussions with each other. Some discussion seemed to be more serious than others, but everyone appeared to be listening to each other.
<p><b>LA 7:</b> Create need for information.</p> <p>The teacher reflects on different group discussions with the entire class. Students' attention is directed to different viewpoints, opinions, emotions and questions raised. The need for more detailed (scientific) information was raised.</p>	Guide class reflection on which viewpoints, opinions, emotions and questions are raised by the techno-moral vignette.	Students participate in reflection by reacting to things teacher indicates.	Students gain insight that a lot of questions can be raised by one scenario. They will also realise that different point of view and opinions on one problem/dilemma can exist and that different emotions are involved.	The questions that were raised by students were not discussed during the lesson, so this goal wasn't reached (miscommunication with teacher?).

The quality of the discussion can also be raised this way. This structure helped with achieving commonality B, i.e. students have to develop an awareness of the arguments and values that they and others use, from Knippels et al. (2009).

Learning activity 2 (LA2 in Table 2) was designed to give students the opportunity to formulate questions they might have after reading the techno-moral vignette. Questions are important to ensure the educational potential of the techno-moral vignettes.

In the next learning activity (LA3 in Table 2) students had to write down which emotions they felt arise when reading the techno-moral vignette. In order to realise which emotions are raised, they need to be articulated. Since this can be difficult, students were given examples of emotions and feelings that could be raised to help them articulate what they were feeling. Students also had to consider where they thought the emotions and feelings came from (a gut feeling or not) to make them aware of the fact that emotions are a gut reaction to a problem, issue or dilemma. Being able to formulate which emotions are felt after reading the techno-moral vignette is part of the second step in the opinion-forming process as formulated, i.e. students show the first notions of realising which emotions and underlying values and beliefs they have regarding the dilemma.

Learning activity 4 (LA4 in Table 2) was designed to support the step: students recognize a dilemma in a techno-moral vignette. This is a step that is important in forming an opinion on a moral issue (commonality A, Knippels et al., 2009). If students are unable to recognize the dilemma present in the techno-moral vignette, they would not know between what they had to choose and would have to form an opinion about.

Since this is just an introductory lesson and it was not expected that students were all able to formulate or deduce the proper dilemma from the techno-moral vignette yet, they were given the actual dilemma and they had to formulate their opinion on this dilemma (learning activity 5, LA5 in Table 2). This was done in order to ensure that students knew what the actual dilemma of the techno-moral vignette is so they could use that dilemma in the group discussion in learning activity 6. First, students had to formulate their opinion individually, to give them the opportunity to make up their mind before they had to start the discussion on the techno-moral vignette.

Learning activity 6 (LA6 in Table 2) was designed in order for students to have a discussion with their peers on the techno-moral vignette and the dilemma presented in this vignette. By having them discuss their opinions, emotions and viewpoints students were given the opportunity to discover how others felt about the techno-moral vignette. They were also able to express more of their own emotions, questions, viewpoints and opinions, since it is often

easier to talk about something than to write it down. With this activity the formulated steps two and three of the opinion-forming process will be addressed, e.g. students show the first notions of realising which emotions they and others have regarding the dilemma and students show underlying values and beliefs they have regarding the dilemma.

The last learning activity (LA7 in Table 2) was designed to address the questions students formulated at the start of the lesson and to ensure a need for information in the students. Students were introduced to a some viewpoints, opinions, emotions and questions raised by the techno-moral vignette during the discussion. During this learning activity, the teacher introduces more viewpoints, opinions, emotions and questions raised by the vignette in order for students to realise that they need more (scientific) information before they can form a well-informed opinion on the subject.

## **Methodology**

### *Design based research*

A design based research approach was adopted for this study. This type of research consists of roughly three phases: an exploration, a design and a test phase. It typically consists of multiple cycles in which the design is constructed, tested, assessed, adjusted, retested, and so on.

*Exploration phase.* In the exploration phase the research field or research domain and its learning and teaching difficulties are determined. The educational practice is also explored during this phase. In order to deal with the determined difficulties, ideas to solve these difficulties are formulated during this phase. The end result is the formulation of a research question and design criteria for learning activities. In this study a literature study was implemented to review what recent publications disclose on opinion-forming in order to define a theoretical starting point. Also ideas from other studies were obtained which could help with the design of learning activities. Students' prior knowledge was determined by consulting the teacher. Based on the literature the before mentioned research question and sub-questions were formulated.

*Design phase.* In this phase the actual learning and teaching activities and accompanying learning materials are developed based on the insights from the explorative phase. Also expectations on the thinking and understanding of students during these activities are formulated (Simon, 1995). These three things combined form the hypothetical learning trajectory (HLT) of the lesson. The learning activities, learning materials and expectations on

thinking and learning of students were formed based on the insights from the explorative phase. The resulting HLT can be found in Table 2. The activities were formed in an iterative way. A concept version of the lesson material and the teacher manual was discussed multiple times with the second author and the participating teacher to increase validity. Feedback was implemented.

The designed learning activities were tested in a 50-minute pilot lesson in a class of pre-university level ( $n = 25$ ; 14 females, 11 males; average age = 16.2) on 6 December, 2013 since the educational potential of the techno-moral vignettes was tested in this grade (De Ruijter et al., 2013). After this pilot lesson, the designed learning activities were refined in order to accommodate the students' apparent needs, and the teacher manual (Appendix 1) was adapted for the teacher. The refined lesson was tested during the test phase of this study.

*Test phase: the HLT in practice.* The designed HLT was tested in two case studies (Yin, 2009). The aim of the study was to uncover if the HLT met the expectations and if the activities designed start up the opinion-forming process on SSIs raised in techno-moral vignettes. The HLT was tested in two upper secondary biology classes during a 50-minute lesson.

*Participants.* The designed learning activities were put into practice in a Dutch high school in Ede (Gelderland) that was selected based on convenience sampling. The school has a Christian signature which meant that the Bible plays an important role in everyday events. The students' regular biology teacher (age = 40; 10 years of experience) taught all lessons, as part of the standard biology curriculum. Table 3 gives an overview of the characteristics of the two classes in which the HLT was conducted. The HLT was tested in both classes on 17 December, 2013.

Table 3. General overview of the case studies

<b>Stream</b>	<b>Grade</b>	<b>Abbreviation used</b>	<b>Average age students (years)</b>	<b>Number of students</b>
Senior general secondary education	4	H4	15.4	$n = 17$ 14 females; 3 males
Pre-university education	5	V5	16.1	$n = 25$ 16 females; 9 males

### *Data collection and processing*

Different types of data were collected during and after the implementation of the HLT and were used for the analysis of the lesson.

- Classroom observations: During each lesson, the implementation of the HLT was observed by the first author. An observation scheme based on the activities of the HLT (Appendix 3) was used to make notes on how the teacher and students executed the different activities.
- Reflection with teacher: After each lesson the first author reflected on the lesson with the teacher based on her observation notes and guided by the teacher's experiences, to discuss what went smoothly and what was found difficult. After the completion of both case studies, a 10-minute semi-structured interview (Appendix 4) with the teacher was held which was audio-taped. The interview was aimed to uncover what the teacher expected of the lesson, how she thought the lessons went and if she had any ideas for the development or improvement of the lesson.
- Students' worksheets: Worksheets filled in by students were collected after each lesson.
- Students' discussions: Discussions between groups of four to five students held during the lesson as a part of the HLT were audio-taped.
- Student questionnaires (Appendix 5) and interviews (Appendix 6): Students filled in a questionnaire after each lesson. The intention of this questionnaire was to get information on students' age, gender and their subject combination. It also asked for students' opinion on the lesson, what they had learned and if they wanted to see any improvements. From each class two students were asked to participate in a 10-minute semi-structured interview. The goal of the interviews was that students could elaborate on the answers they had given in the questionnaire to get more in-depth data.

Observation notes, worksheets and questionnaires were typed out after the data was collected. The audio-tapes of the discussions and interviews were transcribed verbatim and line numbers were added.

### *Data analysis*

Data analysis was guided by the desired learning outcomes of the HLT and the first steps in the opinion forming process defined in this study. Transcripts of the discussions, interviews and the typed out data from the worksheets were analysed.

*Implementation of the lesson.* The assessment of the success of the HLT was guided by the different curriculum levels (Akker, Hameyer & Kuiper, 2003). Table 4 depicts the different curriculum levels and which data sources are used to assess the different levels.

Table 4. Curriculum levels (adapted from Akker et al., 2003)

			<b>Data source</b>
<b>INTENDED</b>	<i>Ideal</i>	Vision (rationale or basic philosophy underlying a curriculum)	
	<i>Formal/Written</i>	Intentions as specified in curriculum documents and/or materials	Teacher manual
<b>IMPLEMENTED</b>	<i>Perceived</i>	Curriculum as interpreted by its users (especially teachers)	Observation notes, transcript teacher interview, transcripts student interviews
	<i>Operational</i>	Actual process of teaching and learning (also: curriculum-in-action)	Observation notes, transcript teacher interview
<b>ATTAINED</b>	<i>Experiential</i>	Learning experiences as perceived by learners	Questionnaire, transcripts student interviews
	<i>Learned</i>	Resulting learning outcomes of learners	Students worksheets, transcripts discussion

The case studies were analysed in order to determine if the implemented curriculum matched the intended curriculum. This was done based on the observation notes made by the first author of the lessons and the interview with the teacher. Other questions of the interview with the teacher were used to evaluate, clarify and determine how the teacher interpreted the intended curriculum level, if the implemented curriculum level was explicit and realisable and what the attained curriculum level of the students was after the lesson. Also student interviews were used to determine what they thought of the lesson and in this way determine the attained experiential curriculum.

Overall, the execution of the lesson was mostly done according to the intended formal/written curriculum level (Table 3). However, at the end of the lesson, the teacher had neglected to discuss questions and points of view raised during the discussion.

*Analysis questions.* Student questions were collected from the worksheet and filtered from the discussion transcripts. Questions from the discussion transcripts were selected in the same way

as De Ruijter et al. (2013), i.e. if a quote was spoken in a questioning way or if students indicated “I do not know...”, “I wonder...” or “I want to know...”. A list of 205 questions arose from these data sources (77 from the senior general secondary education students and 128 from the pre-university level students). To categorize these questions the categorizing system of de Ruijter et al. (2013) was revised and used by an independent researcher and the first author to independently assign the different questions to the categories (Appendix 7). At first there was only a 68.8% agreement between coders for the senior general secondary level students and a 70.3% agreement between coders for the questions from pre-university level students. This led to a slight revision of categories, and the questions that could not be assigned to one category the first time were classified again. This resulted in a 77.9% agreement between coders for the questions from the senior general secondary level students. The questions from the pre-university level students reached 79.7% intercoder agreement.

*Analysis emotions.* Students’ emotions were extracted from the worksheets and discussion transcripts. Quotes were indicated as an emotion when an actual emotion or feeling was mentioned. In order to recognize and categorize the emotions and feelings mentioned by the students the six basic emotions from Evans (2001) were used. These were supplemented with feelings students named multiple times that did not fit the categories of Evans (Appendix 8). Both the first author and an independent researcher independently classified the list of 88 emotions (38 from the senior general secondary education students and 50 from the pre-university level students) to the different categories. Agreement between coders for the emotions from the senior general secondary level students was 94.7% and for the emotions from pre-university level students was 88%.

*Analysis dilemmas.* The answers students had given to the question ‘What do you think is the dilemma of this vignette’ were gathered and listed. From this list of dilemmas categories were formed inductively (Appendix 9). The list of 42 dilemmas (17 from the senior general secondary education students and 25 from the pre-university level students) was assigned independently to the different categories by the first author and an independent researcher. There was a 94.1% agreement between coders for the dilemmas formulated by senior general secondary level students and an 84% agreement between coders for the dilemmas formulated by pre-university level students

*Analysis values and beliefs.* Quotes from the discussions that indicated a value or belief were selected and extracted from the transcripts. Based on the *prima facie* duties by W.D. Ross (as cited in Audi, 2004), virtues from Beauchamp and Childress (2001) and a list of values by Dr. P. Van der Zande (personal communication) categories were formed (Appendix 10). The list of 152 selected quotes (46 from the senior general secondary education students and 106 from the pre-university level students) were assigned independently to these categories by the first author and an independent researcher. Intercoder agreement was 60.9% for senior general secondary level students and 72.6% for pre-university level students. Two categories appeared to have been mixed up by the independent researcher and these quotes were assigned to their categories through intersubjective agreement. This resulted in an 82.6 % agreement between coders for the senior general secondary level students and a 78.3 % agreement between coders for the pre-university level students.



## Results

### Dilemmas

When asked to formulate the dilemma of the vignette most students were able to give an answer. Only one student didn't write down anything. Although, many students formulated the dilemma as a choice between a longer life with many disadvantages versus a short life with advantages (Table 5, category 1), most students did not formulate a choice between two (un)pleasant things but wrote down questions and gave arguments why the cure should not be introduced (Table 5, category 4). Examples of this are:

H4L2: *Should we introduce a cure, should it be available for everyone?*

H4L9: *Is it a good idea?*

H4L14: *Lonely people because you have to decide between two difficult choices.*

V5L8: *Overpopulation, what to do with these people. Will they get health care etc.?*

V5L9: *I think that the choices are to take it or not to take it.*

V5L23: *A lot of people will want this; however there just is not enough money and space*

Table 5. Categories of dilemmas formulated by the senior general secondary level students (H4) and the pre-university level students (V5)

Dilemma categories		Example	Occurrence	
			H4 (n = 17)	V5 (n = 25)
1. Duration of life	a. Long life <i>versus</i> short life	H4L8: <i>Longer unhappy or shorter happy?</i>	5	5
	b. Long life <i>versus</i> having children	H4L11: <i>People cannot have or get children, but they can live longer.</i>	2	2
	c. Long life <i>versus</i> healthcare	H4L17: <i>If you would give up health care to live longer and have no children.</i>	2	0
	d. Long life <i>versus</i> dying quickly	H4L16: <i>Would you do it and live long or do not do it and die quickly.</i>	1	0
	e. Long life gives problems <i>versus</i> people want to live	V5L6: <i>People do not want to die but a longer life only causes more problems and loneliness.</i>	0	2

Table 5 continued. Categories of dilemmas formulated by the senior general secondary level students (H4) and the pre-university level students (V5)

Dilemma categories		Example	Occurrence	
			H4 (n = 17)	V5 (n = 25)
1. Duration of life	f. Long life <i>versus</i> not going against nature	V5L13: <i>Choice between a long life or not going against nature.</i>	0	2
	g. Long life <i>versus</i> no overpopulation	V5L14: <i>No overpopulation versus older people/live longer.</i>	0	2
2. Overpopulation <i>versus</i> who should get cure		V5L15: <i>Overpopulation, and who can have it, facilities for elderly care.</i>	0	1
3. Not a dilemma		H4L14: <i>Lonely people because you have to choose between two difficult choices.</i>	7	10
4. No dilemma formulated		-	0	1

### Emotions/feelings

Every student had emotions or feelings that were raised after reading the techno-moral vignette. The emotion most raised was agitation (Figure 3). Another emotion often raised is surprise (Figure 3).

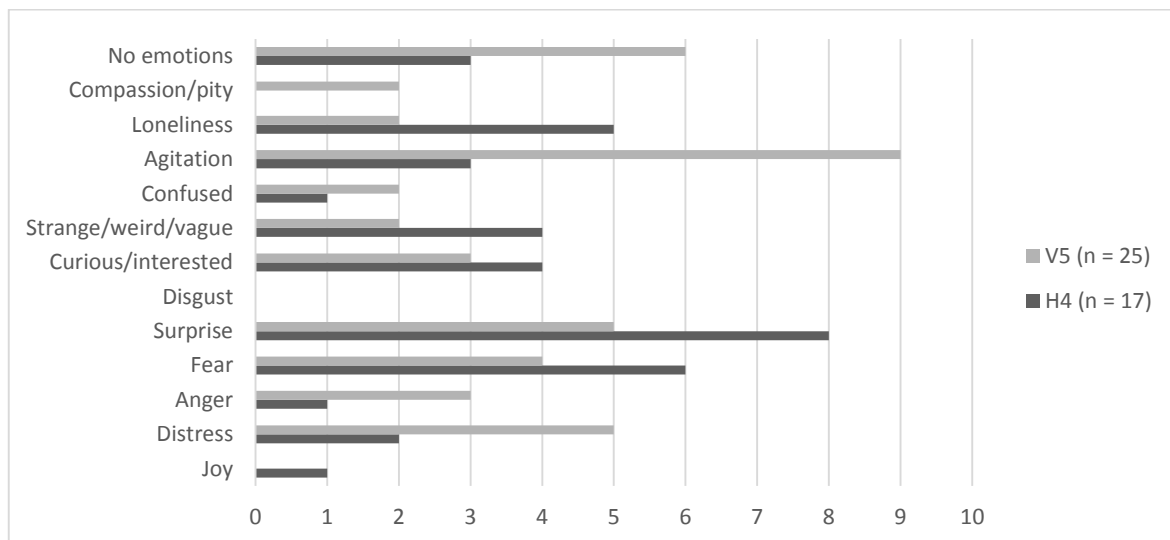


Figure 3. Emotions raised in the senior general secondary level students (H4) and the pre-university level students (V5). Total number of questions raised in both classes 88 (H4: 38 and V5: 50). Eight questions (one in H4 and seven in V5) could not be assigned to a category since they were not emotions

Students also became aware of other emotions that might be evoked when reading the technomoral vignette. This can be illustrated by a group discussion between four girls. Three of the four girls had not indicated that one of the emotions raised was curiosity. However when the fourth girl indicated that she was curious the other three girls also indicated that they were curious as well.

### *Values and beliefs*

Eleven different values and beliefs were raised in students during the discussions (Table 6). In pre-university level students the values and beliefs most raised are justice, non-maleficence, autonomy and protect dignity of life. For the senior general secondary level students non-maleficence, justice and protect dignity of life are raised most. The other values and beliefs are raised as well, but to a much lesser extent.

Table 6. Values and beliefs raised in the senior general secondary level students (H4) and the pre-university level students (V5). Based on Ross (as cited in Audi, 2004), Beauchamp & Childress (2001) and Dr. P. Van der Zande (personal communication)

Values	Example	Occurrence	
		H4 (n = 17)	V5 (n = 25)
1. Autonomy	H4D2M2: <i>But it is your own choice.</i>	3	17
a. Responsibility	V5D2M2: <i>Then the responsibility of the choice they are making lies with them.</i>	0	9
b. Capacity of giving and receiving love	H4D1M2: <i>Because I mean without children... M1: You do not have a life.</i>	1	1
c. Right of (not) knowing	V5D3 M3: <i>... and all the pros and cons, everything, should be told to the person who would want it [the cure].</i>	3	3
d. Right of (not) treating	H4D2M3: <i>Imagine that you are 15, that you have cancer and that you would be able to live longer because of the change [the cure].</i>	2	3

Table 6 continued. Values and beliefs raised in the senior general secondary level students (H4) and the pre-university level students (V5). Based on Ross (as cited in Audi, 2004), Beauchamp & Childress (2001) and Dr. P. Van der Zande (personal communication)

Values	Example	Occurrence	
		H4 (n = 17)	V5 (n = 25)
2. Beneficence	V5D6: <i>And, yeah, I would do this, agree that the cure can be used, for instance someone's heart does not work properly and we can take out heart cells and clone these. The clone would then already be old, but we could keep it young and then we could have a new young heart...</i>	0	4
3. Non-maleficence	V5D2M1: <i>And anyway, they should research the consequences better. If the cure does not cause any other diseases or if other processes stop working.</i>	18	24
4. Justice	H4D3M3: <i>Rich people will go to a planet that they made livable. Rich people and smart people [the rest will stay behind on an overpopulated planet].</i>	11	29
5. Protect dignity of life	H4D1M1: <i>Yes, with human lives uhhhh I think it going a bit too far.</i>	8	16

### Questions

Students had many questions after reading the techno-moral vignette. The senior general secondary level students raised, on average, 4.3 questions per student. Pre-university level students raised 5.2 questions per student on average. The questions can be labelled as factual or normative. These categories can be subdivided into eight subcategories (Table 7). Some of these subcategories are again divided into sub-subcategories. Factual questions are the questions most raised, especially with the senior general secondary students. Most questions of senior general secondary students were on vignette content (31.1%) and repeated questions from the assignment (28.6%). For the pre-university level students questions raised were more evenly distributed over the different categories. A lot of questions raised by the pre-university level students are normative questions. Of the total amount of questions raised 25% was normative in this group of students.

Table 7. Students' questions of the senior general secondary level students (H4) and the pre-university level students (V5) categorized. Adapted from De Ruijter et al. (2013)

	Category		Example	Number of questions	
				H4 (n = 17)	V5 (n = 25)
<b>Factual questions</b>	1. Vignette content	a. Something unclear	H4L4: Why did the woman have to cry?	11	5
		b. Application and regulation	V5L13: Why has this 'rejuvenation cure' been allowed?	13	20
	2. General biology knowledge		H4L12: How is it possible that telomeres shorter slower?	1	3
	3. Synthetic biology knowledge	a. Functioning	V5D3M1: Yeah, but what would happen if you would stop taking the cure?	8	18
		b. State	H4D2M2: Has it already been tried?	4	2
	4. Questions from assignment		H4D1M2: Do you or do you not agree with each other?	22	9
	5. Effects on society		V5L16: What will the effect of this be on the world population?	4	16
6. Clarifying questions		H4D4M1: Why do you think, do you feel curious? Why do you feel like that?	10	19	
7. General knowledge		V5L4: What is the status of poverty in the Netherlands?	0	2	
<b>Normative questions</b>	8. Desirability	a. Do we want this?	V5L22: Should we be trying to extent life?	4	28
		b. How far can this go?	V5D4M: Yeah what can be done and what cannot. Where do you draw the line?	0	6

## Conclusion and discussion

The research conducted was aimed to discover if learning and teaching activities (LTAs) making use of techno-moral vignettes can be used to introduce SynBio-related SSIs in a classroom setting in order to support the opinion-forming process and in this way contribute to biology education for techno-scientific citizenship. Therefore the following research question and sub-questions were formulated: **What techno-moral vignettes-related learning and teaching activities are helpful in starting up the opinion-forming process in upper secondary school students?**

- 1) What kind of dilemmas do upper secondary school students deduce from a techno-moral vignette?
- 2) What types of emotions and questions are raised by these learning and teaching activities in upper secondary school students?
- 3) Which values are evoked in upper secondary school students when discussing a selected techno-moral vignette?

The design of the LTAs was guided by three defined first steps of the opinion-forming process. One of the steps was that students should be able to recognize a dilemma in a techno-moral vignette. The designed LTA (LA4 in Table 2) to achieve this step gave students an explanation what a dilemma is (a difficult choice between two (un)pleasant things) to help them formulate the dilemma presented in the techno-moral vignette. Students had a difficult time formulating a proper dilemma. The moral question underlying the vignette was: *'are we allowed to artificially extend life by use of a cure that increases telomerase production in cells in order to counter the aging process?'*. Despite the given explanation what a dilemma is, a total of 17 out of 43 students did not formulate a choice between two (un)pleasant things. Instead, they wrote down arguments and questions on the dilemma of the vignette. It is probable that the students understand what the underlying dilemma in the vignette is, they just do not know how to formulate it correctly. Dilemmas that were formulated by students mainly had to do with the duration of life, live longer versus a shorter life, being able to have children and receive healthcare, etc. It can therefore be concluded that the LTA designed to make students able to recognize a dilemma in a techno-moral vignette was in part successful. The LTA should be adapted in further research in order to determine if all students were able to recognize the dilemma, since the results from the 17 students who did not formulate a proper dilemma were assumed to have recognized the dilemma.

Many different emotions and feelings were articulated in different LTAs (LA3 and LA6 in Table 2). The emotions that were evoked most are surprise, agitation and fear. The emotion joy was only expressed by one student and no students felt disgusted by the possible future development presented in the techno-moral vignette. A lot more types of emotions were raised in this study than in the study of De Ruijter et al. (2013), probably due to the learning activity designed. In this study twelve different types of emotions or feeling were raised, whereas in the study of De Ruijter et al. (2013) the techno-moral vignette '*Mother's day*' evoked one or two emotions. The learning activity can therefore be seen as effective in raising emotions. Students are probably more capable of articulating what emotions are evoked when reading the techno-moral vignette since they are given some examples of emotions or feelings that might arise. By having students discuss different emotions raised during the discussion in LA 6 (Table 2) they also become aware of different emotions that might also be raised when considering a dilemma. Reactions like "*Well I am also curious*" indicate this. The fact that emotions were expressed is an important finding since emotions play an important role in forming an opinion according to Van der Zande, et al. (2009), Van der Zande (2011) and Roeser (2011a). By showing that emotions were evoked by the LTAs, the potential of those LTAs can be judged positively as one of the first steps for the development of an educational structure on opinion-forming starting from emotions. This is important in order to make emotional deliberation in opinion-forming a possibility in education.

The designed lesson did evoke values and beliefs in LA 6 as was intended and the learning activity can be seen as successful to make a first step in the opinion-forming process. Students had to be able to show values and beliefs they had concerning the dilemma as one of the first steps of the opinion-forming process. The values and beliefs autonomy, non-maleficence and justice were raised most in the students. Since values and beliefs had to be deduced from the discussion transcripts it is implied that the students are not yet aware that values and beliefs play an important role in forming an opinion. It was beyond the scope of this research to make the students aware of this. However, students should be made aware of this in future research since recognizing values and using these values during moral argumentation is important in both scientific literacy and citizenship education (Boerwinkel et al., 2009). The fact that values and emotions are shown in students reasoning during discussions can be seen as a positive thing since raising emotions and values is an important part of the emotional deliberation approach to opinion-forming. It can therefore be concluded that the designed techno-moral vignettes-relates LTAs contribute to scientific literacy and citizenship education.

To give students a chance to learn and develop these skills can be seen as goals of science education.

The techno-moral vignette raised a lot of questions. Most were factual questions, even though normative questions arose as well. During the pilot lesson, students wrote down almost no questions. After the pilot lesson a learning activity in which the students had to write down their questions was added. This learning activity (LA2 in Table 2) helped students to articulate the questions they had, which apparently they had plenty. It is good to see that questions were raised since this indicates that students want to know more about the vignettes and underlying SynBio knowledge before they form an opinion. The fact that students are motivated to want to know more about the vignettes gives an incentive to develop a learning and teaching strategy. If no questions were raised students would not have been interested in the techno-moral vignettes and its SSI and continuing on this subject would be pointless. An opportunity to make classroom science more reflective of the society it exists in and develop responsible citizens who are able to make well-informed decisions (Zeidler, 2004) by using SSIs would have been missed.

Overall can be said that the LTAs that have been developed are helpful in starting up the opinion-forming process. They evoke questions, emotions, values and beliefs and make about half of the participating students recognize dilemmas considering SynBio-related SSIs.

### *Methodological reflection*

Prior knowledge of students on forming an opinion based on emotions, values and beliefs was not checked before the start of the lesson. During the interviews students were asked if they had any experience with education on forming an opinion. It was thought that the experience of students with forming an opinion would not influence the research much, therefore it was not checked. The students' prior knowledge on general biology knowledge was checked since that could be of influence on the students' understanding of the techno-moral vignette.

The school at which the research was conducted is a high school with a Christian profile. This can be a factor of influence on the results. Since values and beliefs are influenced by the environment you grow up in, it is plausible that the values and beliefs of these students have been influenced. In order to make sure that there was or was no influence, it would have been better if the research had been conducted on different schools with different profiles.

Even though the first author and the teacher had several discussions about the lesson and how it should be implemented some things were not implemented as supposed to. This might have to do with the fact that the teacher did not understand what was intended in the



teacher manual. This could be a possibility since the manual was sent to the teacher and the researcher only asked if the teacher understood everything presented in the manual. It is therefore advised to thoroughly discuss the manual with the teacher step by step and to maybe even have a practice lesson in which the teacher can practice what he or she is supposed to do to ensure that the lesson is fully executed as intended.

It was quite difficult to distinguish voices during the transcription of the audiotaped discussions. A better idea might have been to also video-tape the discussion so that one can see who is talking. This would help determining which students participated in the discussion and which student has certain values and beliefs. This can help in a next step that could be taken, making students aware of the values and beliefs they and others have.

Quotes indicating questions, emotions, values and beliefs that had to be categorized were extracted from the discussion transcripts by the first author only. Even though the selection of these quotes has been done as precise as can, it might therefore be possible that some quotes have been missed.

More information could have been obtained from the interviews with the teacher and students. The questions that were asked during the interview were quite general and direct questions. If different questions had been asked, more information about how the teacher and students judged the lesson could have been obtained. Questions to improve the teacher interview could be: ‘How does this lesson differ from usual lesson on this subject/topic?’, ‘Is the developed lesson an improvement considering existing lessons?’ and for the student interviews: ‘How does this approach differ from approaches usually used during class?’ ‘What or who made you wonder during the assignment?’

### *Limitations of study*

A fairly small research was conducted for this study. It was only executed in two classes on one school. There is a very good possibility that if the research is conducted on different schools, different results will be achieved. Also since the small scale of the study, the contribution of it to the development of scientific literacy is probably minimal. Students were given a chance to read and talk about science, but not to write about science. For students to become functional scientific literate individuals, more time should be spend on reading, writing and talking about science.

Only one of the suggested three vignettes (De Ruijter et al., 2013) was used during this study. Each vignette raised different values, questions and emotions as De Ruijter et al. (2013) showed during their study so there is a possibility that different vignettes give different results

which can lead to different recommendations. There is also the possibility that the chosen vignette does not appeal to all students. By using multiple vignettes more students can be interested. Therefore it would be advisable to test the learning activities with the other vignettes to assess if these give the same results.

The developed lesson is just a first exploration of learning activities making use of SynBio-related SSIs raised in techno-moral vignettes and how your emotions, values and beliefs play a role in forming an opinion about the developments mentioned in these vignettes. Further research is needed to determine if students can be made more aware that emotions, values and beliefs play an important role in forming your opinion about technological development.

Most of the activities quite literally asked for students to formulate their emotions, questions or the dilemma they had deduced from the techno-moral vignette. The fact that students were able to give an answer to these questions does not immediately imply that the students realise what the first steps in the opinion-forming process are or that they are able to apply these steps when they have to form an opinion about a matter outside the classroom. Attention should be given to making students become aware of the steps in the opinion-forming process in order for the learning activities to contribute to citizenship education and for students to become critical democratic citizens.

#### *Implications for further research and educational use*

There are some recommendations that can be made for further research. First, only one lesson with different learning activities was developed during this study. A next step would be to develop more lessons on the subject and to eventually develop a learning and teaching strategy (LTS). By developing a LTS the entire opinion-forming process can be addressed. This way students can be helped in how to form an opinion on SSIs that might arise in the future.

The lesson developed during this study was designed as the introductory lesson of a lesson module. The aim of this lesson was for students to become aware of the fact that techno-moral vignettes revolve around dilemmas which can raise different emotions, questions, values and beliefs. We can imagine that the goal of a following lesson is to answer the questions that were raised by the techno-moral vignettes and for students to learn to recognize which emotions, values and beliefs they and others have regarding the SynBio-related SSI raised in the techno-moral vignettes. Also, in another lesson attention should be paid to the quality of the arguments that students use to ensure dialogical inquiry and justification.

The questions raised can be answered by the teacher, but the students can also be given an assignment to find out more information needed to give answer to certain questions. Making students learn which emotions, values and beliefs they and others have can for instance be done by having students learn what values and beliefs are and how they are related to emotions. After this students could be given the assignment to determine which values and beliefs they think have played a role in forming their opinion. They could also be asked to determine where these values and beliefs came from. Once students have determined which values and beliefs they think they themselves have, they should discover which values and beliefs others have. This might be done in a discussion or dialogical inquiry. A next step should make students aware that emotions and their underlying values and beliefs are the first steps in forming an opinion and that they should always be taken into account.

The broader goal of education in general can be described as educating students to become ‘critical-democratic citizens’ who are ‘functional scientific literate’. These citizens can form an opinion and at the same time respect the views of others (Veugelers, 2007), are able to read, write and talk about science (Shamos, 1995) and take emotions, values and beliefs into account when forming an opinion (Van der Zande et al., 2009; Van der Zande, 2011; Roeser, 2011a). The results of this study showed that techno-moral vignettes can contribute to these requirements. By developing a LTS surrounding techno-moral vignettes, science education can contribute to citizenship education and scientific literacy.

## References

- Akker, J. van den, Hameyer, U., & Kuiper, W. (Eds.) (2003). *Curriculum landscapes and trends*. Dordrecht: Kluwer Academic Publishers.
- American Biological Safety Association (n.d.). *Biosafety and the profession*. Retrieved from: <http://www.absa.org/biosafety.html> on 30 December, 2013.
- Audi, R. (2009). *The good in the right: A theory of intuition and intrinsic value*. Princeton University Press.
- Bakker, A. (2004). *Design research in statistics education: on symbolizing and computer Tools* (Doctoral dissertation, Center for Science and Mathematics Education, Utrecht, The Netherlands). Retrieved from <http://dspace.library.uu.nl/bitstream/handle/1874/893/full.pdf?sequence=2> on 5 March, 2014
- Beauchamp, T. L., & Childress, J. F. (2001). *Principles of biomedical ethics*. Oxford university press.
- Benner, S.A., & Sismour, A.M. (2005). Synthetic biology. *Nature reviews genetics*, 6, 533-543. doi: 10.1038/nrg1637
- Bekker, H., Thornton, J.G., Airey, C.M., Connelly, J.B., Hewison, J., Robinson, M.B., Lilleyman, J., MacIntosh, M., Maule, A.J., Michie, S., & Pearman, A. D. (1999). Informed decision making: an annotated bibliography and systematic review. *Health Technology Assessment*, 3(1), 1-156.
- Boenink, M. (2010). Imagining the future: How vignettes and scenarios might improve ethical reflection on synthetic biology for health purposes. *Sybhel workshop ethical & clinical applications of synthetic biology: an interdisciplinary dialogue*, 55-64. Retrieved from: <http://sybhel.org/wp-content/uploads/2010/11/Bilbao-Booklet-Imre.pdf#page=55> on 21 October, 2013.
- Boerwinkel, D.J., Swierstra, T., & Waarlo, A.J. (2012). Reframing and articulating socio-scientific classroom discourses on genetic testing from an STS perspective. *Science and Education*, 1-23. doi: 10.1007/s11191-012-9528-7
- Boerwinkel, D. J., Veugelers, W., & Waarlo, A. J. (2009). Burgerschapsvorming, duurzaamheid en natuurwetenschappelijk onderwijs. *Pedagogiek*, 29(2), 155-172.
- Bron, J. (2006). *Een basis voor burgerschap: een inhoudelijke verkenning voor het funderend onderwijs* (Report no. BP/3528/D/06-020). Enschede: SLO. Retrieved from: [http://www.slo.nl/downloads/archief/Een\\_20basis\\_20voor\\_20burgerschap.pdf/](http://www.slo.nl/downloads/archief/Een_20basis_20voor_20burgerschap.pdf/) on 12 September, 2013.

- Damasio, A.R. (1994.) *Descartes' error – emotion, reason and the human brain*. New York: G.P. Putman's Sons.
- DeBoer, G. E. (2000). Scientific literacy: Another look at its historical and contemporary meanings and its relationship to science education reform. *Journal of research in science teaching*, 37(6), 582-601.
- De Ruijter, C., Knippels, M.C.P.J., & Waarlo, A.J. (2013). Techno-moral vignettes: A useful tool to introduce synthetic biology related socio-scientific issues? (Master's thesis, Freudenthal Institute for Science and Mathematics Education, Utrecht, The Netherlands). Retrieved from: <http://dspace.library.uu.nl/handle/1874/278453> on March 6, 2014
- De Ruijter, C., Knippels, M.C.P.J., & Waarlo, A.J. (2014). Synopsis ERIDOB 2014, personal communication.
- Evans, D. (2002). *Emotion: The science of sentiment*. Oxford University Press.
- Gaskell, G. et al. (2011). The 2010 Eurobarometer on the life sciences. *Nature biotechnology*, 29, 113-114.
- Gibson, D.G., Glass, J.I., Lartigue, C., Noskov, V.N., Chuang, R.Y., Algire, M.A., Benders, G.A., Montague, M.G., Ma, L., Moodie, M.M., Merryman, C., Vashee, S., Krishnakumar, R., Assad-Garcia, N., Andrews-Pfannkoch, C., Denisova, E.A., Young, L., Qi, Z.Q., Segall-Shapiro, T.H., Calvey, C.H., Parmar, P.P., Hutchinson III, C.A., Smith, H.O., & Venter, J.C. (2010). Creation of a bacterial cell controlled by a chemically synthesized genome. *Science*, 329(5987), 52-56.
- Haidt, J. (2001). The emotional dog and its rational tail: a social intuitionist approach to moral judgement. *Psychological Review*, 108 (4), 814-834. doi: 10.1037//0033-295X.108.4.814
- Kitney, R., Calvert, J., Challis, R., Cooper, J., Elfick, A., Freemont, P. S., Haseloff, J., Kelly, M., & Paterson, L. (2009). *Synthetic Biology: scope, applications and implications*. London: The Royal Academy of Engineering. Retrieved from: [www.raeng.org.uk/synbio](http://www.raeng.org.uk/synbio) on 17 October, 2013.
- Knippels, M.C.P.J., Severiens, S.E., & Klop, T. (2009). Education through Fiction: Acquiring opinion-forming skills in the context of genomics. *International Journal of Science Education*, 31(15), 2057-2083. doi: 10.1080/09500690802345888
- Koninklijke Nederlandse Akademie van Wetenschap (2003) *Biologieonderwijs: een vitaal*

- belang*. Amsterdam: Biologische Raad. Retrieved from:  
<https://www.knaw.nl/nl/actueel/publicaties/biologieonderwijs-een-vitaal-belang> on 20 October, 2013.
- Kortland, J. (1996). An STS case study about students' decision making on the waste issue. *Science education*, 80 (6), 673-689. doi: 10.1002/(SICI)1098-237X(199611)
- Kortland, J. (2001). *A problem-posing approach to teaching decision making about the waste issue*. Utrecht: Cdβ Press.
- Laugksch, R. (2000). Scientific literacy: a conceptual overview. *Science and Education*, 71 (1), 117-34.
- Lloyd, D. & Wallace, J. (2008). Imaging the future of science education: the case for making future studies explicit in student learning. *Studies in Science Education*, 40(1), 139-177. doi: 10.1080/030572604085602051
- Matishak, M. (2009, September 9). White House, scientists discuss biological threats. *Global security newswire*. Retrieved from: <http://www.nti.org/gsn/article/white-house-scientists-discuss-biological-threats/> on 30 December, 2013.
- Messer, P. (2007) *Synthetische biologie: Nieuw leven in het biodebat*. Den Haag: Rathenau Instituut. Retrieved from:  
[http://www.rathenau.nl/uploads/tx\\_tferathenau/BAP\\_Synthetische\\_biologie\\_sept\\_2007.pdf](http://www.rathenau.nl/uploads/tx_tferathenau/BAP_Synthetische_biologie_sept_2007.pdf) on 12 September, 2013.
- O'Malley, M.A., Powell, A., Davies, J.F., & Calvert, J. (2007). Knowledge-making distinctions in synthetic biology. *BioEssays*, 30, 57-65. doi: 10.1002/bies.20664
- Ratcliffe, M. (1997). Pupil decision - making about socio - scientific issues within the science curriculum. *International Journal of Science Education*, 19(2), 167-182. doi: 10.1080/0950069970190203
- Ratcliffe, M., & Grace, M. (2003). *Science education for citizenship: teaching socio-scientific issues*. Maidenhead, Philadelphia: Open University Press.
- Rathenau Institute (n.d.). *SynBio futures*. Retrieved from:  
<http://www.rathenau.nl/themas/thema/project/synthetische-biologie/synbio-futures.html> on 24 October, 2013.
- Roeser, S. (2011a). Emotions should play an important role in debates about risky technologies [TED<sup>x</sup> talk]. Retrieved from:  
<http://www.youtube.com/watch?v=Js6n7iwl2Co> on 14 October, 2013.
- Roeser, S. (2011b). Nuclear Energy, Risk, and Emotions. *Philosophical Technology*, 24, 197-

201. doi: 10.1007/s13347-011-0027-6
- Roeser, S. (2012). Moral emotions as guide to acceptable risk. In S. Roeser., R. Hillerbrand, P. Sandin, & M. Peterson (Eds.), *Handbook of Risk Theory* (pp. 819-832). Springer Science + Business Media B.V. doi: 10.1007/978-94-007-1433-5\_32
- Sadler, T. D. (2004). Informal reasoning regarding socioscientific issues: A critical review of research. *Journal of research in science teaching*, 41(5), 513-536. doi: 10.1002/tea.20009
- Sadler, T. D. (2011). Socio-scientific issues-based education: What we know about science education in the context of SSI. In: Sadler (Ed.) *Socio-scientific Issues in the Classroom* (pp. 355-369). Springer Netherlands.
- Schön, D.A. & Rein, M. (1994). *Frame reflection*. New York: Basic Books.
- Shamos, M. H. (1995). *The myth of scientific literacy*. New Brunswick, New Jersey: Rutgers University Press.
- Simon, M.A. (1995). Reconstructing mathematics pedagogy from a constructivist perspective. *Journal for research in mathematics education*, 144-145.
- Smith, I. (2010, May 20). Craig Venter creates synthetic life form. *The Guardian*. Retrieved from: <http://www.theguardian.com/science/2010/may/20/craig-venter-synthetic-life-form> on 30 December, 2013.
- Stemerding, D. & Rerimassie, V. (2013). *Discourses on synthetic biology in Europe*. Den Haag: Rathenau Instituut. Retrieved from <http://www.rathenau.nl/en/publications/publication/discourses-on-synthetic-biology-in-europe.html> on 23 October, 2013.
- Swierstra, T., & Boenink, M. (n.d.). What are techno-moral vignettes? Retrieved from: <http://www.rathenau.nl/themas/thema/project/synthetische-biologie/what-are-tech-moral-vignettes.html> on 12 September, 2013.
- Swierstra, T., & te Molder, H. (2012). Risk and Soft Impacts. In: S. Roeser, R. Hillerbrand, P. Sandin, M. Peterson (eds.), *Handbook of Risk Theory. Epistemology, Decision Theory, Ethics, and Social Implications of Risk* (pp. 1049-1066). Springer Science + Business Media B.V. doi: 10.1007/978-94-007-1433-5\_42
- Syntheticbiology.org . Retrieved from <http://syntheticbiology.org/> on 3 March, 2014
- Van den Hoogen, W.J. & Tatje, B. (2013). A theoretical and empirical research on opinion forming and hands-on activities in science centres (Unpublished bachelor thesis), Freudenthal Institute for Science and Mathematics Education, Utrecht, The Netherlands.

- Van der Zande, P. A. M. (2011). *Learners in dialogue: teacher expertise and learning in the context of genetic testing* (Doctoral dissertation, Center for Science and Mathematics Education, Utrecht, The Netherlands). Retrieved from:  
<http://dspace.library.uu.nl/handle/1874/205394> on 5 March, 2014
- Van der Zande, P. (n.d.). Personal communication
- Van der Zande, P., Waarlo, A.J., Brekelmans, M., Akkerman, S.F., & Vermunt, J.D. (2011). A knowledge base for teaching biology situated in the context of genetic testing. *International journal of science education*, 33(15), 2037-2067. doi: 10.1080/09500693.2010.525797
- Van der Zande, P., Waarlo, A.J., Brekelmans, M., & Vermunt, J.D. (2009). Geïnformeerde besluitvorming met hoofd en hart. In W. Pieters, (Ed.), *Gevoel voor kennis* (Vol.5) (pp. 250-267). Amsterdam University Press: Aksant.
- Veugelers, W. (2007). Creating critical-democratic citizenship education: empowering humanity and democracy in Dutch education. *Compare: A Journal of Comparative and International Education*, 37(1), 105-119. doi: 10.1080/03057920601061893
- Waarlo, A.J. (2013). Personal communication.
- Wetenschappelijke Raad voor het Regeringsbeleid (1992). *Eigentijds burgerschap*. WRR publicatie Den Haag: Sdu. Retrieved from:  
[http://www.wrr.nl/fileadmin/nl/publicaties/PDFoverige\\_uitgaven/Eigentijds\\_Burgerschap.pdf](http://www.wrr.nl/fileadmin/nl/publicaties/PDFoverige_uitgaven/Eigentijds_Burgerschap.pdf) on 17 October, 2013.
- Yin, R.K. (2009). *Case study research: design and methods*, 4th edn. Thousand Oaks, CA: Sage.
- Zeidler, D.L. & Nichols, B.H. (2009). Socioscientific issues: theory and practice. *Journal of Elementary Science Education*, 21(2) (Spring 2009), 49-58. doi: 10.1007/BF03173684



## Appendix 1 – Teacher manual including student worksheet

# Docentenhandleiding

---

Het overkoepelende doel van deze les is het verder ontwikkelen en bewust worden van de eerste stappen in het meningsvormingsproces. In deze handleiding zijn de volgende onderdelen opgenomen:

1- De lesopzet

met daarin de leerdoelen voor deze les, een tijdsplanning, een overzicht van de verschillende activiteiten en extra uitleg rondom de verschillende lesonderdelen.

2- Werkblad

met daarop de opdracht voor de leerlingen.

Deze les is ontwikkeld in het kader van het onderzoeksproject van mijn master Science Education and Communication aan de Universiteit Utrecht.

**Contactinformatie:**

Sandra Slegers

[a.m.slegers@students.uu.nl](mailto:a.m.slegers@students.uu.nl)

Freudenthal Instituut voor Didactiek van Wiskunde en Natuurwetenschappen

Universiteit Utrecht

## Lesopzet

<b>Datum:</b> 6 december 2013		<b>Klas:</b> 5 vwo	<b>Stof:</b> OLA rondom techno-morele vignetten	<b>Duur:</b> 50 minuten
<b>Voorkennis:</b> de leerlingen hebben voorkennis over de inhoud van de cel. Ze weten dat het uit verschillende celorganellen bestaat. Daarnaast hebben ze biotechnologie behandeld in een eerder hoofdstuk. Ook is het hoofdstuk erfelijkheid behandeld (Mendelse genetica, kruisingsschema's, etc.). Transcriptie/translatie van DNA is nog niet behandeld.				
<b>Leerdoelen:</b>				
<ul style="list-style-type: none"> <li>• De leerling kan aan het einde van de les noteren wat hij/zij denkt dat het dilemma is van een toekomstscenario.</li> <li>• De leerling kan aan het einde van de les uitleggen welke emoties het dilemma/probleem van een toekomstscenario bij hem/haar oproept.</li> <li>• De leerling kan aan het einde van de les zijn/haar eigen emoties en de emoties van anderen meenemen in het vormen van een mening rondom een dilemma in een toekomstscenario.</li> <li>• De leerling kan aan het einde van de les zijn/haar mening over een dilemma in een toekomstscenario uitleggen.</li> </ul>				
<b>tijd</b>	<b>OIVTR</b>	<b>Activiteit docent</b>	<b>Activiteit student</b>	
0-5	Oriëntatiefase	Opstarten les	Naar docent luisteren	
5-15	Informatie overdrachtsfase	Introduceren vignetten: waar gaan ze eigenlijk over? Waarom zijn ze ontworpen?	Naar docent luisteren, vragen stellen, notities maken	
15-35	Verwerkings- & toepassingsfase	Leerlingen helpen wanneer nodig	Lezen vignet en maken van de opdrachten.	
35-37	Reflectiefase	Afsluiten opdracht, kort behandelen aantal vragen/opmerkingen die gemaakt zijn tijdens les door leerlingen en uitleggen wat de volgende stap is (invullen van vignet)	Op eigen plek gaan zitten en naar docent luisteren	
37-47		Beschikbaar zijn voor eventuele vragen	Invullen enquête	
47-50		Les afsluiten.	Enquête inleveren	

Aangeven bij introductie dat ze vandaag meedoen aan een les die ontworpen is in het kader van mijn masteronderzoek. Daarna dat ze gaan werken met toekomstscenario's gerelateerd aan de nieuwste ontwikkelingen in de synthetische biologie (SynBio kan worden omschreven als *het ontwerp en de bouw van nieuwe biologische onderdelen, apparaten en systemen en het herontwerpen van de bestaande natuurlijke biologische systemen voor nuttige doeleinden*), om hun bewust te maken van het feit dat hun emoties, waarden en normen een rol spelen bij het nemen van een besluit en dat dit niet alleen gebaseerd is op de argumenten die ze hebben (deze argumenten worden juist gebaseerd op/gekleurd door die emoties, waarden en normen). Ook uitleggen wat toekomstscenario's zijn. Ze zijn bedacht/ontwikkeld rondom recente wetenschappelijke ontwikkelingen in SynBio om een bredere maatschappelijke discussie mogelijk te maken. Hierin staan mogelijke toepassing en gevolgen van synthetische biologie. Ze zijn ontwikkeld rondom dit onderwerp omdat dit op het moment een snel ontwikkelend veld is waarvan we niet weten hoe het zich precies gaat ontwikkelen. Ze zijn een aantal jaar geleden ook ontwikkeld rondom een onderzoeksveld dat op dat moment een 'hot' item was (nanotechnologie). De scenario's zijn dus geschreven om mensen bewust te maken van snelle ontwikkelingen in technologie en wetenschap en wat voor een invloed dit zou kunnen hebben op hun leven

→ Dilemma / morele vraag vignet is: *Mogen we/is het toegestaan om leven kunstmatig te verlengen door gebruik van een behandeling die de telomerase productie in cellen verhoogd om op die manier het proces van ouder worden tegen te gaan?*

## Werkblad

### Naam:

Lees het toekomstscenario en het stukje tekst dat er boven staat door. Beantwoord daarna de eerste vragen. Heb je vragen over het toekomstscenario? Noteer deze dan en stel ze zo nodig aan je docent.

Synthetische biologie kan bijdragen aan een gezonder en langer leven door het stellen van vroege diagnoses te vergemakkelijken, kanker te voorkomen en de darmflora te verbeteren, maar ook door het verouderingsproces meer direct tegen te gaan. Sinds enige tijd is het bekend dat telomeren, structuren aan het einde van onze chromosomen, gerelateerd zijn aan het verouderingsproces. Bij elke celdeling worden de telomeren korter. Dit leidt er uiteindelijk toe dat DNA replicatie wordt voorkomen, met celdood tot gevolg. Van het enzym telomerase is bekend dat het, het verkorten van de telomeren tegenwerkt. Verschillende bedrijven zijn momenteel bezig om synthetische moleculen te produceren die in staat zijn de telomerase productie in cellen te verhogen. Hoe effectief dit het verouderingseffect zal tegenwerken, is momenteel nog onduidelijk.

<http://www.sierrasci.com/proof/index.html>

## MOEDERDAG

‘Heb je je tekeningen, Lisa?’ ‘Ja, mam.’

‘Richard, de bloemen liggen in de achterbak, toch?’ ‘Ja, schat.’

‘Gordel om, Jonathan?’ Ze hoorde een klik, gevolgd door ‘Ja, mam.’

Richard start de motor. ‘We gaan eerst naar jouw moeder, toch?’

Moeder Sarah: ‘Ja, we zullen koffiedrinken en lunchen in haar verzorgingshuis. Ik heb cake en broodjes meegenomen, dus het zal echt een feestmaal voor haar zijn! Na de lunch gaan we naar jouw ouders.’

Lisa: ‘Gaan we ook naar oma Smith? Ik heb ook een tekening voor haar.’

‘Ja, we zien haar na de lunch, liefje.’

Lisa: ‘Mam, ik begrijp het niet. Van de meester moesten we allemaal vijf tekeningen maken. Maar ik heb toch maar twee oma’s?’

‘Ja, oma Smith is de moeder van papa en grootmoeder is mijn moeder. En ik ben jouw moeder natuurlijk, maar dat weet je.’ Sarah glimlachte.

‘Dan heb ik nog twee tekeningen over,’ zei Lisa.

‘Misschien is dat omdat veel kinderen tegenwoordig ook overgrootmoeders hebben. Maar jij kan je tekeningen aan de dames geven die naast oma wonen. Ze zullen dat leuk vinden, omdat ze geen kinderen hebben die bij hun op bezoek komen,’ antwoordde Sarah.

‘Je bedoelt degenen die er helemaal niet oud uitzien?’ vroeg Lisa.

‘Ja, degenen die grappig ruiken’, murmelde Jonathan.

Richard ging er niet tegenin. Per slot van rekening had Jonathan gelijk. Hij dacht aan de dames die naast zijn schoonmoeder woonden. In tegenstelling tot haar, moesten zij een kamer delen. Ze waren één van de eersten geweest die de verjongingskuur kochten waarvan beweerd werd dat het het verkorten van je telomeren zou stoppen. De therapie was toen nog niet zo perfect als vandaag de dag, maar de trendsetters hadden er wat tijd mee gekocht. Als hij het zich goed herinnerde waren ze nu 110 en 112. De regering destijds was zo bang geweest dat de therapie zo effectief zou zijn, dat wijdverspreid gebruik tot overbevolking zou leiden. Dat is waarom de verkoop van het product strikt gereguleerd en gelimiteerd werd tot mensen die geen kinderen hadden of die gesteriliseerd waren. Nu deze vrouwen hulpbehoevend werden, kwamen ze op de tweede plaats. Gezien de uitpuilende bejaardentehuizen, wordt alleen basale zorg vergoed. Niemand had erop geanticipeerd dat deze mensen die 'succesvol verouderden' (zoals ze dat noemen) op den duur toch verzorging nodig zouden hebben. Als je extra zorg wilde, moest je dat zelf betalen. Hij was blij dat zijn ouders hun geld niet hadden gependeed aan die verjongingstherapieën. Ze zullen minder oud worden, maar ze kunnen zich in ieder geval genoeg zorg veroorloven. Sarah's moeder had minder geluk, maar die had tenminste een kamer voor haarzelf.

Richard schrok op toen de jonge stem van de navigator aankondigde 'je hebt je bestemming bereikt.' Het verzorgingshuis zag er nog slechter uit dan bij eerdere bezoeken. Kennelijk hadden ze geen eens geld voor basaal onderhoud. Nadat Lisa haar oma had begroet, ging ze naar de twee buurvrouwen.

Ze was heel snel terug en keek teleurgesteld.

'En, wat zeiden ze? Vonden ze je tekeningen leuk?' vroeg Sarah.

'Eigenlijk weet ik dat niet. Eén mevrouw begon te huilen en zei, 'je bent een heel lief meisje, waarom heb ik me niet eerder gerealiseerd dat ik zo van kinderen houd?' Het was een beetje ongemakkelijk om bij haar weg te gaan. En de andere mevrouw zei helemaal niets. Ze legde mijn tekening alleen maar op een grote stapel tekeningen in haar kast.

**Vragen rondom toekomstscenario**

- 1) Welke vragen roept dit toekomstscenario bij je op?
  
- 2) Zou jij zo een verjongingskuur nemen? Waarom wel of niet?
  
- 3) Noteer welk gevoel dit toekomstscenario bij je oproept (bijvoorbeeld: blij, verdrietig, verrast, angstig, onrust, boos, etc.). Het kan zijn dat er meerdere gevoelens naar boven komen.
  
- 4) Waarom maakt dit verhaal dat je je zo voelt?
  
- 5) Wat denk jij dat het achterliggende probleem/dilemma is dat een rol speelt bij dit toekomstscenario? Een dilemma is een lastige keuze tussen twee (on) aangename zaken.
  
- 6) Overleg met degene die naast je zit. Wat denkt hij/zij dat het achterliggende probleem (dilemma) is? Noteer dit.

Je hebt zojuist het (officiële) achterliggende probleem/dilemma van dit toekomstscenario gekregen. Wetenschappelijk onderzoek heeft laten zien dat je emoties, en je normen en waarden een grote rol spelen bij het vormen van je mening over zo een probleem/dilemma. Hier gaan we nu verder op in.

- 7) Hoe denk jij over het achterliggende probleem/dilemma? Vind je dat het moet kunnen of vind je dat het niet kan? Leg uit waarom je dat vindt. Spelen daar ook bepaalde emoties een rol bij of juist niet?

In de volgende opdracht gaan we in groepjes overleggen. Wacht met het vormen van deze groepjes tot je docent dat aangeeft. Zorg er voor dat je per groepje een audiorecorder hebt en dat deze aan staat.

**Opdracht – Bediscussieer in groepen****Namen groepsleden:**

Ga in groepjes in discussie over het dilemma. Zijn jullie het met elkaar eens? Of juist niet? En waarom zijn jullie het dan juist wel of niet eens? Gebruik hierbij de volgende vragen als leidraad van jullie gesprek.

- Zitten er veel verschillen tussen de emoties die bij jullie zijn opgeroepen?
- Waarom wel/niet?
- Hoe denk je dat dit komt?
  
- Zitten er veel verschillen tussen de mening die je hebt over het probleem/dilemma?
- Waarom wel/niet?
- Hoe denk je dat dit komt?

Noteer na het gesprek tot welke conclusie jullie zijn gekomen.

## Appendix 2 – Techno-moral vignette ‘*Mother’s day*’

Synthetic biology may contribute to healthier and longer lives by facilitating early diagnosis and prevention of cancer, improving our intestinal flora, but also by countering the ageing process more directly. Telomeres (structures at the end of our chromosomes involved in cell division) have been known for some time to be related to ageing. With each cell division, the telomeres become shorter, ultimately leading to inhibition of the capacity for replicating, and thus to cell death. The enzyme telomerase is known to counteract this shortening of telomeres. Several companies are now constructing synthetic molecules able to increase telomerase production in cells. How effective this will be in countering the ageing process is still being contested.

<http://www.sierrasci.com/proof/index.html>

### Mother's Day

‘Do you have your drawings, Lisa?’ ‘Yes mom.’

‘Richard, the flowers are in the trunk, right?’ Yes dear.’

‘Seatbelt on, Jonathan?’ She hears a click, followed by ‘Yes mom.’

Richard starts the engine. ‘We are going to your mother first, right?’

Mom Sarah: ‘Yes, we will have coffee and lunch in her nursing home. I brought cake and sandwiches, so it will really be a festive meal for her! After lunch we go to your parents.’

Lisa: ‘Are we going to see granny Smith too? I have drawings for her too.’

‘Yes, we will see her after lunch, dear.’

Lisa: ‘Mom? I don’t understand. Teacher said we should all make five drawings. But I have only two grandmothers, right?’

‘Yes: Granny Smith is the mother of daddy. Grandmother is my mother. And I am your mother of course, but you know that,’ Sarah smiled.

‘Then I have two drawings left,’ Lisa said.

‘Perhaps that’s because many children nowadays have great-grandmothers too. But you can give a drawing to the ladies living in the quarter’s next to grandma’s. They would like that, since they have no children to visit them,’ Sarah answered.

‘You mean the ones who don’t look old at all?’ Lisa asked

‘Yea, the ones that smell funny’, Jonathan mumbled.

Richard did not rebut. After all, he was right. He thought about the ladies living next to his mother-in-law. In contrast to her, they had to share a room. They had been among the first people to buy the juvenating cosmeceuticals that were claimed to stop your telomeres from



shortening. The therapy had not been as perfect then as it was today, but it had bought the trendsetters some time. If he remembered it correctly, they were 110 and 112 right now. Back then, the government had been afraid that the therapy would be so effective that widespread use would lead to overpopulation. That's why the sales of the product were strictly regulated and limited to people who had no children and who had been sterilized. Now that these women were in need of assistance, they had come off second end again. Because of the overflowing of homes for the elderly, only very basic care was reimbursed. Nobody had anticipated that people 'ageing successfully' (as they called it) at a certain point would need care nonetheless. If you wanted extra care, you had to pay for it yourself. He was glad his parents had not spent their money on these rejuvenating therapies. They might grow less old, but at least they could afford sufficient care. Sarah's mother was less well off, but at least she had a room of her own.

He was startled when the very young voice from the navigator announced 'You have reached your destination.' The nursing home looked even worse than on previous visits. Apparently they did not have money to do even basic maintenance. After she greeted her grandmother Lisa went to the two neighbors. She was back very soon, looking disappointed

'And, what did they say? Did they enjoy your drawings?' Sarah asked.

'Actually, I don't know. One lady started crying and saying, "you are a very sweet girl, why didn't I realize how much I like children?" It was a bit awkward to get away from her. And the other didn't say anything! She just put my drawing on this huge pile of drawings in her cupboard.'

This work is licensed under a Creative Commons Attribution-NonCommercial-NoDerivs 3.0 Unported License. To view a copy of this license, visit: <http://creativecommons.org/licenses/by-nc-nd/3.0/>.

### Appendix 3 – Observation scheme used during case studies

tijd		Activiteit docent/leerling	Done?	Gewenst resultaat studenten	Aantekeningen (wat doet docent, wat doen leerlingen)
0-5	O	Opstarten les. Wat gaat er deze les geburen?		Rustig worden, gaan zitten, spullen erbij pakken. Duidelijkheid verkrijgen over wat er deze les gaat gebeuren.	
5-15	I	Uitleggen wat toekomstscenario's zijn.		Wat zijn toekomstscenario's	
		Uitleggen waar scenario's over gaan.		Uitleggen waar scenario's over gaan (hangt samen met SynBio)	
		Uitleggen waarom scenario's ontworpen zijn.		Beeld krijgen waarom scenario's geschreven zijn.	
		Uitleggen wat synthetische biologie is.		Begrijpen wat synthetische biologie inhoud.	
		Opdracht uitleggen.		Duidelijk beeld hebben wat er van ze verwacht wordt bij de opdracht.	
15-35	V/T	Leerlingen helpen wanneer nodig (docent)			
		Opdracht 1 (student)		Vragen die ze hebben na het lezen van het scenario noteren.	
		Opdracht 1 (rol docent)			

Opdracht 2 (student)		Mening noteren waarom ze wel of geen verjongingskuur zouden nemen.	
Opdracht 2 (rol docent)			
Opdracht 3 (student)		Noteren welke gevoelens bij hen worden opgeroepen.	
Opdracht 3 (rol docent)			
Opdracht 4 (student)		Aangeven waarom ze denken dat deze emoties worden opgeroepen.	
Opdracht 4 (rol docent)			
Opdracht 5 (student)		Noteren wat zij verwachten dat achterliggende probleem/dilemma is. Merken dat het niet gemakkelijk is om een probleem/dilemma te formuleren.	
Opdracht 5 (rol docent)			
Opdracht 6 (student)		Overleggen met buurman over wat zij denken dat het dilemma is. Op deze manier een beeld krijgen dat een ander misschien een ander probleem dilemma ziet.	

		Opdracht 6 (docent)			
		Opdracht 7 (student)		Wat is hun mening over het dilemma? Spelen emoties daarbij een rol? Waarom wel/niet?	
		Opdracht 7 (rol docent)			
		Discussie (student)		Bediscussieer standpunten en ontdek dat er veel verschillende meningen mogelijk zijn en waar die mogelijk op gebaseerd zijn.	
		Discussie (rol docent)			
35-37	R	Afsluiten opdracht en uitleggen wat de volgende stap is (invullen van vignet)		Weer rustig op hun plek gaan zitten, duidelijkheid krijgen over het invullen van de enquête.	
37-47		Beschikbaar zijn voor eventuele vragen		Invullen van de enquête.	
47-50		Les afsluiten, leerlingen de mogelijkheid geven om spullen op te ruimen en naar de volgende les te gaan		Aangeven wie mee kan/wil doen met de enquête. Spullen opruimen.	

## Appendix 4 – Interview teacher

### Achtergrondinformatie onderzoek

Dank je wel voor het deelnemen aan dit interview. Dit is een onderdeel van mijn master aan de Universiteit Utrecht. Ik onderzoek op welke manier je leerlingen bewuster kan maken van het feit dat emoties, normen en waarden een grote rol spelen bij het vormen van een mening en het nemen van een besluit. Op het moment wordt er vaak alleen aandacht gegeven aan het feit dat je een mening of een besluit goed moet kunnen beargumenteren zonder dat je leert wat daar achter kan zitten. Ik onderzoek dit aan de hand van toekomstscenario's. Deze scenario's zijn bedacht aan de hand van de meest recente technologische ontwikkelingen om een discussie op te wekken. Achter deze toekomstscenario's zit een dilemma waarover je een mening kunt hebben of waarover een besluit genomen moet worden.

Alles wat tijdens dit interview besproken wordt zal anoniem behandeld worden tijdens het onderzoek. Ook zullen de gegevens van dit interview alleen voor mijn eigen onderzoek gebruikt worden. Omdat ik het niet kan bijhouden om alles wat je zegt te noteren zou ik dit interview graag opnemen met een spraakrecorder. Is dat wat jou betreft akkoord?

### Achtergrondinformatie docent

Jaren ervaring:

Leeftijd (?):

### Vragen:

- 1) Wat vond je van de les? Liep het zoals verwacht?
- 2) Denk je dat de les zijn doelen behaald heeft? Waarom wel/niet?
- 3) Zou je zo een les in het curriculum willen hebben? Waarom wel/niet?
- 4) Op welke plek in het curriculum zou je zo een les plaatsen?
- 5) Wat zou je er van vinden als er een lessenserie over meningsvorming rondom socio-scientific issues gemaakt wordt?
- 6) Heb je al eerder les gegeven over meningsvorming?
- 7) Zou je zo een lessenserie gebruiken tijdens je lessen? [Doen je dit toevallig al?]
- 8) Heb je suggesties voor verbetering van de les?

Dat was het interview, nogmaals dank voor het vrijmaken van je tijd en het deelnemen aan het interview. Zijn er nog dingen waarvan jij denkt dat het belangrijk is dat ze behandeld worden? Heb je nog vragen die je kwijt wilt?

## Appendix 5 - Questionnaire

### Achtergrondinformatie

Voor je ligt een enquête over de les die je zojuist gehad hebt. Deze enquête maakt onderdeel uit van mijn onderzoeksproject aan de Universiteit Utrecht. Ik onderzoek op welke manier je leerlingen bewuster kan maken van het feit dat emoties, normen en waarden een grote rol spelen bij het vormen van een mening en het nemen van een besluit. Op het moment wordt er vaak alleen aandacht gegeven aan het feit dat je een mening of een besluit goed moet kunnen beargumenteren, zonder dat je leert wat daar achter kan zitten. Ik onderzoek dit aan de hand van toekomstscenario's (een verhaal zoals je net gelezen hebt). Deze scenario's zijn een mogelijke toekomst en zijn bedacht aan de hand van de meest recente technologische ontwikkelingen om een discussie op gang te brengen. Achter deze toekomstscenario's zit een dilemma waarover je een mening kunt hebben of waarover een besluit genomen moet worden.

De gegevens van deze enquête zullen volkomen anoniem behandeld worden.

Er staan zowel meerkeuze als open vragen in de enquête. Geef alsjeblieft altijd een antwoord. Als je iets niet weet of snapt, leg dan uit waarom je dat niet weet.

### Vragen

#### Algemeen

- 1) Hoe oud ben je?
  -
- 2) Wat is je geslacht?
  - Man
  - Vrouw
- 3) Welk profiel heb je?
  - C&M met als keuzevak (ken) .....
  - E&M met als keuzevak (ken) .....
  - N&G met als keuzevak (ken) .....
  - N&T met als keuzevak (ken) .....

#### Over de les

- 4) Vond je het toekomstscenario realistisch?
  - Ja, want
  - Nee, want
- 5) Heeft het toekomstscenario je aan het denken gezet?
  - Ja, want
  - Nee, want

- 6) Was je je er al van bewust dat je emoties een grote rol spelen bij het vormen van je mening?
- Ja,
  
  - Nee,
- 7) Heb je iets opgestoken van deze les? Zo ja, wat dan? Zo nee, waarom vind je van niet?
- Ja,
  
  - Nee,
- 8) Vond je het een leuke les?
- Ja, want
  
  - Nee, want
- 9) Als je iets zou mogen veranderen aan deze les, wat zou dat dan zijn?

Dank je wel voor het invullen van de enquête. Lever hem alsjeblieft in bij je docent.

## Appendix 6 – Interview student

Datum:

Duur interview:

### Achtergrondinformatie onderzoek

Dank je wel voor het deelnemen aan dit interview. Zoals je al hebt kunnen lezen bij het invullen van de enquête ben ik bezig met het onderzoeksproject van mijn master aan de Universiteit Utrecht. Ik onderzoek op welke manier je leerlingen bewuster kan maken van het feit dat emoties, normen en waarden een grote rol spelen bij het vormen van een mening en het nemen van een besluit. Op het moment wordt er vaak alleen aandacht gegeven aan het feit dat je een mening of een besluit goed moet kunnen beargumenteren zonder dat je leert wat daar achter kan zitten. Ik onderzoek dit aan de hand van toekomstscenario's (een verhaal zoals je net gelezen hebt). Deze scenario's zijn bedacht aan de hand van de meest recente technologische ontwikkelingen om een discussie op te wekken. Achter deze toekomstscenario's zit een dilemma waarover je een mening kunt hebben of waarover een besluit genomen moet worden.

Alles wat tijdens dit interview besproken wordt zal anoniem behandeld worden tijdens het onderzoek. Ook zullen de gegevens van dit interview alleen voor mijn eigen onderzoek gebruikt worden.

Daarnaast wil ik graag benadrukken dat er tijdens dit interview geen goede of foute antwoorden zijn. Dit interview wordt gehouden ter verduidelijking van de enquête die je eerder hebt ingevuld en om meer achtergrondinformatie te verkrijgen.

Omdat ik het niet kan bijhouden om alles wat je zegt te noteren zou ik dit interview graag opnemen met een spraakrecorder. Is dat wat jou betreft akkoord?

### Achtergrondinformatie leerling

Man/vrouw

Leeftijd:

Profiel:

### Vragen rondom enquête

- 1) Ik heb je ingevulde enquête doorgekeken en ik heb een aantal vragen voor je die ik als eerste zou willen behandelen.

Vragen uit de enquête zijn (letterlijk opnieuw stellen):

- Vond je het toekomstscenario realistisch?
- Heeft het toekomstscenario je aan het denken gezet?
- Heb je iets opgestoken van de les?
- Vond je het een leuke les?
- Als je iets zou mogen veranderen aan de les, wat zou dat dan zijn?

Vragen die gebruikt kunnen worden om dieper op de vragen uit de enquête in te gaan.

- a. Wat bedoel je met....?
- b. Waarom vind je dat...?
- c. Zou je kunnen uitleggen waarom...?



- d. Als er iets onduidelijk was, waarom was dit onduidelijk, is er iets wat je wilt weten waardoor het misschien duidelijker wordt?

**Algemene vragen**

- 2) Heb je al ooit eerder les gehad over het vormen van een mening of het nemen van een besluit?
  - a. Zo ja, wat is er dan behandeld?
  - b. Zo nee/ik kan het me niet herinneren, doorvragen of ze ooit hun mening over iets hebben moeten geven en of er dan speciale aandacht is geschonken aan het proces achter dat geven een mening (bijvoorbeeld bij Nederlands (betog) of bij maatschappijleer).
- 3) Wat vind je van het gebruik van een toekomstscenario om je aan het denken te zetten?

Dat was het interview, nogmaals dank voor het vrijmaken van je tijd en het deelnemen aan het interview. Zijn er nog dingen waarvan jij denkt dat het belangrijk is dat ze behandeld worden? Heb je nog vragen die je kwijt wilt?

## Appendix 7 – Instructions used to categorize questions by first instructor and second coder

Lees het vignet ‘Moederdag’.

In dit document zijn de vragen die leerlingen gesteld hebben tijdens de discussies en op het werkblad verzameld en in een tabel gezet. De vragen kunnen ingedeeld worden in verschillende categorieën. Het is de bedoeling dat er achter iedere vraag aangegeven wordt in welke categorie die vraag valt (noteer het nummer van de categorie). Gebruik de onderstaande categorieën. Geef hierbij niet alleen de hoofdcategorie (1, 2, 3, 4, 5, 6, 7, 8, 9) aan, maar geef, indien er subcategorieën zijn, ook de subcategorie aan (bijvoorbeeld: 1a, 3a, etc). Wanneer er subcategorieën aanwezig zijn geef je die er altijd bij. Het wordt dus altijd 1a, 1b en nooit alleen 1.

### 1. Inhoud vignet

- a. Iets is niet duidelijk over de vignet specifieke inhoud (het verhaal zelf). Gaat niet over hoe de synthetische biologie uit het vignet werkt. Dat komt terug in een andere categorie  
*vb. Chantal: ‘but I don’t understand what they mean with that. Oh because their oil export decreases every year’*
- b. Vragen m.b.t. specifieke toepassing van vignet en regulatie van invoering van synthetische biologie uit vignet. van synthetische biologie anders dan: nadelen van SynBio, hoe werkt SynBio of hoe ver zijn we al met SynBio?  
het zijn specifieke vragen over de toepassing uit het vignet en hoe dat toegepast en gereguleerd wordt.  
*vb. Chantal: ‘Yes, questions like (...) which persons may buy it [synthetically made cure] ...’*

### 2. Kennis biologie algemeen – Algemene leemtes, niet specifiek over synthetische biologie, algemeen functioneren van biologie

*Vb. Chantal: ‘The last part? ...But yes, I do not have enough knowledge to really say something about that [effect from light on animals].’*

### 3. Kennis synthetische biologie

- a. Functioneren – hoe werkt zo’n kuur precies? Wanneer wordt het toegediend? Wat gebeurt er met je al je het toegediend krijgt?  
*vb. Chantal: ‘Yes, I would like to know that now, how it works etc.’*
- b. Staat – hoe staat het er nu voor? Waar staan we nu met die kuur? Zou zoiets later kunnen? Hoe staat het er nu voor met de ontwikkeling van zo’n kuur?  
*vb. Chantal: ‘I am very curious how, how fast these kinds of things actually, uh, how fast these things develop now.’*

### 4. Wenselijk

- a. Willen we dit wel? Is dit een goede ontwikkeling? Waarom zouden we dit willen? Is dit nuttig?  
*vb. Chantal: ‘...yes I do not know whether it gives more value to your life, a longer life.’*
- b. Hoe ver kan dit gaan? Waar leidt de ontwikkeling die naar voren komt in het vignet toe?  
*vb. Chantal: ‘...how far would this go, no with is already with the trees, but how far can this...’*

5. **Herhaling van (een van de onderstaande) vragen uit de opdracht/vragen die te maken hebben met de opdracht** – vragen die leerlingen konden gebruiken als leidraadsvragen tijdens de discussie. Deze vragen worden vaak letterlijk gesteld.
  - *Zijn jullie het met elkaar eens?*
  - *Waarom wel/niet?*
  - *Wat vinden jullie er van?*
  - *Zitten er veel verschillen tussen de emoties die bij jullie zijn opgeroepen?*
  - *Waarom wel/niet?*
  - *Hoe denk je dat dit komt?*
  - *Zitten er veel verschillen tussen de mening die je hebt over het probleem/dilemma?*
  - *Waarom wel/niet?*
  - *Hoe denk je dat dit komt?*
  - *Wat is de conclusie?*
6. **Effecten** – wat zou het invoeren van het vignet tot gevolg hebben? Waar kan het invoeren van de kuur toe leiden? Effecten op het functioneren van de maatschappij, wat zou er aangepast moeten worden?
7. **Verhelderende vragen** – vragen gesteld door leerlingen aan elkaar om iets te verduidelijken.
8. **Algemene vragen** – hoe staat het er in Nederland voor met bepaalde zaken? Dingen die leerlingen zich afvragen.

## Appendix 8 – Instructions used to categorize emotions by first instructor and second coder

Lees het vignet ‘Moederdag’.

In dit document zijn de verschillende emoties/gevoelens die genoemd zijn op het werkblad en tijdens de discussie bij elkaar gezet. Een scheiding is gemaakt tussen de emoties genoemd door leerlingen uit havo 4 (begint op pagina 2) en de emoties genoemd door leerlingen uit vwo 5 (begint op pagina 4). Er zijn verschillende categorieën waarin de verschillende emoties/gevoelens ingedeeld kunnen worden. Deze categorieën zijn hieronder aangegeven.

Basisemoties (Evans, 2001)

1. Vreugde (blijdschap= gevoel van vreugde, voldoening),
2. Verdriet (geestelijke pijn, leed, ongelukkig, somber),
3. Woede (boos),
4. Angst (bang; gevoel van beklemming, vrees, onveiligheid, onzekerheid, erg, schrikken, geschokt),
5. Verbazing (verrast; geestesgesteldheid bij het gewaarworden van iets onverwacht, verwondering),
6. Walging (afkeer, misselijkheid).

Andere gevoelens

7. Nieuwsgierig/geïnteresseerd
8. Vreemd/raar/vaag
9. Verward
10. Onrust
11. Eenzaamheid
12. Medelijden
13. Geen, maakt leerlingen niet uit.

De emoties van de leerlingen zijn verzameld in tabellen. De bedoeling is dat je aangeeft in welke categorie iedere emotie volgens jou valt. Dit kun je aangeven in de kolom ‘categorie emoties/gevoelens’ door het cijfer van de categorie te noteren.

## Appendix 9 – Instructions used to categorize dilemmas by first instructor and second coder

Lees het vignet ‘Moederdag’.

In dit document zijn de verschillende dilemma’s die genoemd zijn op het werkblad bij opgave 5 verzameld. De leerlingen hebben de opdracht gekregen om te noteren wat zij dachten dat het dilemma van het vignet is. Bij de opdracht is aangegeven dat een dilemma een lastige keuze tussen twee (on)aangename zaken is.

Er is een scheiding gemaakt tussen de dilemma’s genoemd door leerlingen uit havo 4 (begint op pagina 3) en de dilemma’s genoemd door leerlingen uit vwo 5 (begint op pagina 4). De volgende categorieën zijn inductief ontstaan:

1. Duur leven
  - a. Langer leven (ongelukkig/eenzaamheid) – kort leven (gelukkig/weinig tijd/familie hebben),
  - b. Langer leven (doen wat je wilt) – kinderen (geen kinderen mogen als je langer leeft/wel kinderen mogen als je de kuur niet neemt),
  - c. Langer leven (+geen kinderen mogen) – (betere) zorg kunnen ontvangen,
  - d. Lang leven – snel sterven,
  - e. Langer leven levert problemen op – mensen willen niet dood,
  - f. Langer leven – niet tegen de natuur ingaan,
  - g. Langer leven – geen overbevolking.
2. Ontstaat overbevolking – wie krijgt het recht op zo’n kuur?
3. Niet in te delen als dilemma,
4. Geen dilemma genoemd/geformuleerd.

Vragen, argumenten voor keuzes en gevolgen van de keuzes die bedacht zijn worden ingedeeld in de categorie ‘niet in te delen’.

Het genoteerde dilemma moet een keuze zijn tussen twee dingen. Wanneer een leerling bijvoorbeeld twee dingen aangeeft waarbij het ene een gevolg is van het ander dan wordt het ingedeeld in de categorie ‘niet in te delen’ (bijv.: kort leven <-> kinderen, gelukkig; op de plek van <-> kan leidt tot worden ingevuld).

De bedoeling is dat je in de tabellen waarin alle genoteerde dilemma’s van de studenten verzameld zijn aangeeft bij welke categorie dilemma jij denkt dat het dilemma ingedeeld kan worden.

## Appendix 10 – Instructions used to categorize values and beliefs by first instructor and second coder

Lees het vignet ‘Moederdag’.

In dit document zijn verschillende fragmenten uit de groepsdiscussies in de klas opgenomen. Deze fragmenten kunnen in verschillende categorieën normen en waarden ingedeeld worden. Bij iedere categorie staat aangegeven wat er onder verstaan kan worden.

De bedoeling is dat je bij ieder statement aangeeft in welke categorie jij vindt dat het valt. Noteer het cijfer van de categorie achter het fragment. De categorieën zijn gebaseerd op: Beauchamp & Childress (2013), Ross (1930), vd Zande.

1. **Autonomie:** Respect voor vrije wil. Twee condities zijn essentieel voor autonomie: *vrijheid* (onafhankelijk van controlerende invloeden) en *agency* (capaciteit voor intentioneel handelen).  
De keuze is aan jezelf. Je moet de kans krijgen voor iets te kunnen kiezen. Anderen mogen deze keuze niet voor je maken. Het komt op meerdere vlakken voor, belangrijkste is dat jij zelf je keuze kan maken. De verantwoordelijkheid voor die keuze en de gevolgen van die keuze vallen hier niet onder. Die komen terug bij andere norm/waarde.
2. **Weldadigheid = Goed doen:** een daad die iemand iets goed doet, het welbevinden van anderen bevorderen. Het bevorderen van het leven van andere/voorkomen dat anderen ergens last van krijgen. Wereld verbeteren door de keuzes die je maakt. Kansen die ontstaan door de keuzes die gemaakt zijn verbeteren de wereld.
3. **Geen kwaad doen:** Kwaad vermijden, andere geen schade berokkenen. Dingen die je fysiek/psychologisch zouden beïnvloeden. Proberen spijt te vermijden. Als de gevolgen van een keuze er voor zorgen dat fysieke of psychologische schade opgelopen wordt valt het in deze categorie (bijv. fysiek niet meer functioneren, geen ruimte meer hebben om te leven, etc.).
4. **Rechtvaardigheid:** Gerechtigheid, eerlijk verdelen van lusten en lasten. Iedereen heeft recht op hetzelfde. Bijv. of iedereen of niemand. Vragen als: ‘waarom zou iemand iets niet mogen terwijl ander dat wel mag?’ ‘Moet iedereen alles wel mogen?’ vallen hieronder
5. **Beschermwaardigheid van het leven.** ‘Normaal’ leven kunnen leiden. We moeten het leven beschermen, niet te veel aan sleutelen (tegen natuur in gaan). Wat is leven nog waard als we er zo aan sleutelen? Bepaalde levensprocessen gaan nu eenmaal zoals ze gaan. Hoe ver mag je gaan met knutselen? Je leven beschermen zodat je niet te veel aftakelt.
6. **Verantwoordelijkheid,** voor het nemen van keuzes omtrent je leven. Je bent verantwoordelijk voor je eigen keuzes en de gevolgen die daar aan verbonden zijn. Dat betekent dat je moet nadenken voordat je keuzes maakt. Een ander is niet verantwoordelijk voor de keuzes die jij gemaakt hebt.

7. **Zorg om elkaar/familie.** Je moet elkaar verzorgen. Er voor zorgen dat iedereen gelukkig is.
8. **Vermogen liefde te geven en te ontvangen.** Het kunnen hebben van een familie/gezin. Zonder familie ben je minder gelukkig.
9. **Recht op (niet) weten.** Alle informatie die jij wilt moet voorhanden zijn. Je hebt het recht om alles te weten rondom/over bepaalde ontwikkelingen. Voordat mensen een keuze maken moeten ze op de hoogte zijn van alles (de gevolgen van hun keuzes).
10. **Recht op (niet) behandelen**  
Je moet behandeld kunnen worden voor ziektes (beter om oplossing te vinden voor de ziekte dan een 'onnuttige' kuur te ontwikkelen). Gebruik de kuur als medicijn. Keuzes die te maken hebben met de mogelijkheid dat een ziekte behandeld moet kunnen worden