The Use of Drama in Socio-Scientific Inquiry-Based Learning

Roald P. Verhoeff

Introduction

Socio-scientific Inquiry-Based Learning

The educational framework socio-scientific inquiry-based learning (SSIBL) is a pedagogy, which connects the study of socio-scientific issues with inquiry-based learning and citizenship education (Levinson and The PARRISE Consortium 2014). Socially and ethically sensitive inquiry is at the core of this approach. This inquiry-based aspect of SSIBL means that it is question-driven and open-ended. It requires scaffolding and the generation of questions and/or issues, preferably by students themselves, which are authentic, that is, they emerge from pressing interests of the students. Issues should thus relate to real-world problems, engage the interest of young people and draw on scientific knowledge. As such, SSIBL is a way to bring the EU framework of Responsible Research and Innovation (RRI) to classroom practice. RRI stands for a comprehensive approach of research and innovation in ways that allow the engagement of stakeholders in the processes of research and innovation at an early stage. To address this approach in education presupposes the acknowledgement that non-scientists are, like scientists, concerned by changes influenced by technology in academic, professional and/or everyday life settings. Collaborative learning and reflecting on these socio-scientific issues related to emerging technologies is key. As outlined by Levinson et al. (2014), SSIBL can be assessed through four dimensions:

- Knowledge about an issue (both scientific and transdisciplinary)
- Skills in organizing a socio-scientific-based inquiry

R.P. Verhoeff (✉)
Utrecht University, Utrecht, The Netherlands
e-mail: r.p.verhoeff@uu.nl

K. Hahl et al. (eds.), *Cognitive and Affective Aspects in Science Education Research*, Contributions from Science Education Research 3,
DOI 10.1007/978-3-319-58685-4_9

- Values which reflect issues of social justice and well-being
- Dispositions in terms of recognition of inclusivity and democratic deliberation

These are scaffolded in such a way that criticality of students progressively increases via inquiry-based learning in which students contextualise knowledge to help answering their own questions.

In this study we focused on (future) issues around neuroscience, as it reflects an innovative field that has become a key topic for ethical deliberation (Savulescu et al. 2011). Over the last two decades or so, neuroscience has developed new treatments and technologies for therapeutic purposes but may in principle also be applied to healthy individuals to optimize cognitive functions, for example, in professions such as pilots, top athletes or the army. Enhancement technologies include genetic engineering, nootropic drugs (e.g. Modafinil), brain-computer interaction (BCI), neural implants and so on. These technologies may boost human performance in the near future and already raise various ethical dilemmas concerning autonomy (do these technologies empower 'us', or will we be forced to use them in an era of increased cognitive competitiveness?) and justice (will these technologies foster social mobility or rather enlarge the socio-economic division between those who will and those who will not have access to them?). On a more fundamental level, it raises the question whether and how it will affect human nature and human identity (Zwart 2014).

Drama in Science Education

To encourage young people to think about socio-scientific issues, various techniques can be used. For example, Knippels et al. (2009) show that storylines with a human theme, in this case using a clip from the movie Gattaca, are extremely effective at prompting opinion forming among young people. It has likewise been argued that well-considered use of drama fosters learning of cognitive, procedural and affective knowledge in an integrated way (Ødegaard 2003; Dorion 2009). Moreover, drama may allow students to engage in 'simulation' exercises, where the societal impact of science can be explored and enacted in various ways, providing a test-bed for probing alternative (perhaps conflicting) perspectives, inviting students to explicitly reflect on the tensions and differences that are made visible and tangible this way (Colucci-Gray et al. 2006).

Emerging technologies often involve uncertainties when it comes to their potential (medical, environmental or economic) benefits and risks, and drama seems especially apt to capture and articulate the ambivalence this entails. McSharry and Jones (2000) argue that, driven by the teacher, role play in science education can utilize learners' lifetime 'play practice' to both express themselves in a scientific context and develop an understanding of difficult concepts. They argue that engaging learners in creation and performance of science drama provides a physical and creative experience that may be more appropriate for personal learning styles,

offering them a sense of ownership of their education. They also underline its potential for effective learning about moral and ethical issues such as genetic modification in food production (McSharry and Jones 2000).

So far, only a few empirical studies have been published concerning the effectiveness of drama in science education (Shepherd-Barr 2006; Wieringa et al. 2011). Moreover, in most papers describing the use of drama (or other 'genres of the imagination', such as novels or cinema), students are typically involved as spectators and do not actively perform themselves. In our case, we followed the tradition of research practitioners in 'drama in education' such as Heathcote, Bolton, O'Neill and others by involving students not only as an audience but also as authors and actors. Drama in education supports a collaborative learning process in which students explore ideas and feelings and take different perspectives within a fictional context (Bolton 1984, 1985; Heathcote and Bolton 1995). Reflection and analysis of the drama is key to extend and deepen students understanding of social problems and their (enacted) solutions (O'Neill 1995). As O'Neill (1985) has argued, linking the (enacted) world of fiction with the real world is key to the success of learning via drama. This asks of teachers to allow 'space for student reflection on the extent to which their enacted roles, movements or talk are realistic presentations of the science represented' (Braund 2015: 115). Teachers are required to cross pedagogical borders from the pedagogy of drama to the pedagogy of science and vice versa (Braund 2015; Fels and Meyer 1997). This is not self-evident for most science teachers, as they may perceive a loss of control when their students are improvising in an experiential setting. For teachers and learners more used to traditional educational activities or rational science teaching, for example, university (science) students, McSharry and Jones (2000) suggest the use of structured games, simulations like organized debates or court cases or plays scripted by the teacher or students in advance.

Following the suggestion of McSharry and Jones, we decided that the performance should be based on a script that had to be adhered to, albeit that the script was written by the students themselves (see also Toonders et al. 2016). We invited them to explore future societal impacts of emerging neuro-technologies with the help of drama, scripted and performed by the students themselves. This way, our approach was envisioned as a 'dramatic' form of SSIBL, with the performance being a kind of experiment, starting from an initial situation (the 'control condition') in which a novelty or unexpected element is introduced (the experimental condition), which then unleashes a series of consequences, building up the dramatic plot (outcome). The emphasis was on doing, acting and reflecting on science with and for society, in which plays were used to explore 'what if… ' scenarios as a means of socio-scientific inquiry. The teachers' role was to safeguard the realness of the play, i.e. the links between their imagined world and reality (cf. O'Neill 1985). Based on this drama experiment, we address in this paper the question: What aspects of SSIs related to neuroscience do students include in their plays?

Our Approach

The Drama Experiment

Neuro-enhancement is a rapidly growing research domain and a key issue in the ethical and moral debate on emerging technologies in the European Union. Within the context of an elective graduate course on human enhancement (3 ECTS), 22 students from various science disciplines were involved in a drama experiment, performing multiple roles as audience, reviewers, authors and actors (see also Toonders et al. 2016). The course started with two introductory lectures on new technologies to enhance neural processes and the ethical issues as described above in the introduction. The drama experiment itself featured three collaborative learning activities with different student roles. Students were invited to fulfil the role of an author writing a play, an actor performing it to their peers and an audience watching and assessing the performance of others. Following O'Neill (1995), in these different roles, we expected students to actively reframe and adapt their perceptions on science in society in general and neuro-enhancement in particular. Student groups (n = 5/6) were instructed to design an 8-min one-act play and to write out the whole screenplay, including short descriptions of the main characters and the words spoken by them, as well as nonverbal expressions of emotions. With respect to content, students were asked to develop a storyline that would provide insight in various options and dilemma's connected to an available, experimental or hypothetical neuro-enhancer, employable in a particular context sometime in the near future. The storyline should consist of at least three scenic elements: (1) an initial situation, (2) an occurring event and (3) an ending and focus on a particular neuro-enhancer, e.g. a technical device, pill software program and chip enhancing cognitive functions. In addition, students were asked to think about the presentational aspects of their play, e.g. how could the audience be involved? We expected that like a scientific investigation, drama would allow students to try out and enact possible 'what if…' scenarios and dilemmas in a relatively safe (intrusion-free) environment and explore the consequences of a certain innovation or technological novelty.

The teacher was asked to safeguard the realness of the play, to prevent symbolic overtones of meaning and to stimulate a reflective attitude, i.e. taking distance to negotiate the different enacted perspectives and views and their own relationship to them. This role implies the use of the 'reality principle' (O'Neill 1985), i.e. assessing the plausibility and authenticity of the plays.

Data Collection and Analysis

Qualitative methods were used to collect data from participating students as we wanted to gain insight into the kind of ideas they had about SSIs in a particular personal or social (theatrical) setting. Data collection and analysis are built on the

analytical framework developed by Dorion (2009). We distinguished three themes: (1) prior knowledge, drama experience and motivation to enrol in the course; (2) learning activities and performances; and (3) students' self-perceived learning. Inspired by the SSIBL framework (Levinson and The PARRISE Consortium (2014), the analytical focus of this paper is on students' reflexivity, i.e. linking scientific knowledge with personal assessments and finding out which of the following attributes of SSIs they included in their plays:

- Openness (i.e. no preset answer)
- Authenticity (reality principle)
- Comprise different and conflicting perspectives
- Links between personal and social relevance
- Epistemologically appropriate (i.e. it should draw on science knowledge which students have acquired or can be taught)

We handed out three questionnaires to all participants before, during and after the course. The first questionnaire mainly focused on students' awareness of socio-scientific issues and prior knowledge on neuro-enhancement. The second questionnaire asked students to reflect on the plays that had been performed. The final questionnaire included questions about their self-perceived learning, their attitude towards the enacted SSIs and their appreciation of drama experiment including their own performance. Initial findings (student evaluations) were cross-checked via interviews with the teacher after each session in which he was asked about his opinion on the attitudes, skills and insights acquired by the students. In addition, all class discussions and performances were videotaped, while audio recordings were made of group discussions.

Results

Most of the students enrolled in the course indicated that they took this course because they were interested in neuro-technologies and wanted to gain more insight in the ethical aspects around this emerging technology. Only two out of 22 students had prior experience with performing a play before an audience, and consequently, the prospect of a live performance raised some general concern among the students initially. On the other hand, when asked what students expected of this module in a questionnaire at the start of the module, they valued it as an innovative learning strategy that would allow them to express their views and opinions in a creative manner (n = 7). Other students expected that it would allow for more creativity in developing their own perspective on future innovations (n = 2) or they were mainly looking forward to seeing and hearing the views of their fellow students (n = 3).

In the scripting phase, students were prompted to answer the question 'What would happen if…?' with a social inquiry around a specific neuro-enhancer with the three scenic elements: initial situation, event and (open) ending.

Table 1 Overview of the plays enacted by the five student groups

Neuro-enhancer	Short description of the play/SSI
Memory chip	An enhanced (flawless, arrogant) and a non-enhanced (experienced, friendly) surgeon apply for the same job. The enhanced doctor gets it. Should chip implantation be seen as a moral professional obligation?
Enhancement pills	Two families are portrayed in their everyday lives to illustrate different views on life quality: a competitive family using smart pills to excel at many areas and a cooperative family cherishing their talents.
Robotics	In a café a robot bartender symbolizes technological advancement and loss of autonomy. Without empathy, it monitors the physical state of the visitors and knows exactly when they have had enough to drink.
Brain-computer intervention	A talk show is enacted on memory alteration: What would you do when mistakes could be erased and your mental health improved? No 100% safety guaranteed!
Smart pills	A heated parental discussion is staged about raising their child with or without smart pills. There is mutual distrust among the parents about the child's excellent piano play. Does she still take her performance drug?

Concrete examples of neuro-enhancement were discussed in all the student groups including possible social implications (see Table 1), such as the idea of a 'memory chip'. Would it lead to an enhanced elite? What would be the impact on human nature if important capacities such as memory no longer need to be trained? Would it be desirable to remember everything, or does forgetfulness serve a purpose? Also, issues of autonomy were addressed: would it be objectionable to implant memory chips in children? Who is to decide? Comparisons with already available types of implants were made such as cochlear implants.

In designing their play, all students decided to present concrete applications in particular settings. All plays featured contrasting views, albeit in various ways, e.g. by staging an accurate and fast-acting physician with a memory chip implant and a traditional (non-enhanced) physician struggling to keep up with the new generation of medical doctors (group 1); by comparing an enhanced family 'with individuals aiming to achieve as many goals as possible' with a non-enhanced family, supporting each other to utilize their talents (group 2); by presenting the story of a traditional bartender, outcompeted by a robot bartender (group 3); by staging a discussion between experts who supported and experts who criticized a new technology on 'memory alteration' (group 4); or, finally, with a discussion between a mother and father of a juvenile candidate for enhancement therapy because he has lost his love for playing the piano (group 5). As one of the participants phrased it: 'presenting multiple viewpoints on stage allowed us to shed more light on the topic from different angles'.

In staging the controversies on neuro-enhancement, various contexts were chosen, varying from professional settings up to private and educational environments. For instance, two groups (1 and 3) demonstrated how untreated humans may be outcompeted by robots or enhanced humans at work. Other students showed how enhancement could make life easier for humans (groups 2 and 5), by making people

more creative, but less social (group 2), or enhancing their effectiveness in doing their profession (groups 1, 2, 3 and 5), although the question was also raised whether enhanced professionals could really be trusted in complex situations (group 1) and whether unforeseen collateral damage might be involved (group 4). These proved to be questions for which a 'dramatic experimental' laboratory seemed especially suitable.

When reporting on their performances in classroom setting, students remarked that they considered it important for their performance to reflect an authentic 'realistic' controversy. They discovered that 'theatrical' exaggerations and the absence of ambivalence and doubt in the characters' viewpoints could easily distract the audience as well as the actors themselves from the socio-scientific inquiry that was to be staged and discussed afterwards. Two groups tried to 'personalize' the arguments by placing themselves in the characters' positions, after having thoroughly discussed the controversy and the discussion they wanted to raise among the audience. Subsequently, they started to improvise to see what worked best (groups 3 and 5). One of the lessons learned during this 'trying out' was that 'the devil is in the details'. In the case of group 5, for instance, this involved the exact age of the child, the relation between the parents and the qualitative aspects of the enhancement pill with respect to its effectiveness and potential side effects. Also, students experienced that a logical and coherent sequence of events helped them in communicating their message in a clear and convincing way.

Although 'effectiveness' and 'side effects' refer to the science behind neuro-enhancement, little reference was made in the plays to science knowledge which students had acquired during the course or previous education. The exact 'workings' of the neuro-enhancers remained a black box in each play and didn't seem to be considered relevant for the short storylines to be more 'realistic'.

After the course, we asked students to fill in a questionnaire on their self-reported learning (n = 17 students). A majority of students (12 students) indicated that our module helped them to gain insight in complex ethical issues related to neuro-enhancement. Fifteen (15) students answered positively to the question whether it had improved their understanding of other people's opinions and arguments, while only half of the students indicated they had further explored people's interests or stakes. Almost all students (16) reported that the module had given them more insight in how emerging technologies could influence daily life. Moreover, it helped them to develop their own opinion about the dilemmas at hand (12), although the drama experiment had not per se stimulated them to formulate and substantiate their own opinion (9).

Three students explicitly evaluated the drama module in negative terms. They stated that they had experienced the drama module to be rather time-consuming and that they were not comfortable in performing before an audience.

Discussion and Conclusions

SSIBL proposes a model of concepts and practices central to inquiry, which supports teachers in integrating citizenship education and the EU framework of Responsible Research and Innovation in science classes. This paper underlines the potential for using drama as an educational tool to stimulate students to take a reflexive position on the socio-scientific particularities of science and technology. In our study drama engaged students in a socio-scientific investigation in which the various techniques of enacting and expressing emotions and dilemmas are the equivalent elements compared to the scientific equipment (Kottler 1994: 273). By allowing students themselves to play a more active role, processes of imagination, exploration and identification enabled them to 'try out' and experience their envisioned scenarios in a relatively 'safe' environment, before the new technology enters the real world.

Contextualising a controversy and placing oneself in a real-life situation, e.g. by enactment in a play, seems essential in linking scientific knowledge with personal assessments and views on societal issues. Our drama experiment seemed to activate students in opening up a future lifeworld which they could relate to. It allowed them to acquire additional insights in social and ethical implications of neuro-technologies and created awareness of different viewpoints that people can have, primarily in everyday life settings. Moreover, students tended to take a reflexive position on the personal and social implications of neuro-enhancement so as to present a 'realistic' dilemma to the audience. In doing so, as also illustrated by the plays (see Table 1), students tended to frame SSIs more as personal and ethical (values and norms) as opposed to technical and economical (risks and stakes). The latter implications were hardly considered.

In addition, the focus on everyday life contexts did not prompt students to consider the science aspects of SSIs or draw on science knowledge they had acquired earlier in their academic science education. In terms of our SSIBL attributes, the SSIs portrayed in the plays could not be considered epistemologically appropriate. This illustrates the difficulty for both teachers and students to cross pedagogical or educational borders from 'drama education' to 'science education' as Fels and Meyer (1997) and Braund (2015) already noted. In this respect, the 'reality principle' (O'Neill 1985) should not only address the enacted scenes but also the science represented, based on science knowledge that students have acquired or can be taught.

While students in their role as script writers and actors actively used their imagination, as audience (and to a lesser degree also as actors looking back at their performance) they represented the 'reality principle' by assessing and discussing the plausibility and credibility of the enacted scenes (cf. O'Neill 1985). As others have argued, drama enables the exploration of different perspectives and conflicts in socio-scientific issues, including students' own relationships with the conflict (Colucci-Gray et al. 2006; Wieringa et al. 2011).

It must be noted here that a significant amount of students reported that they had not gained insight into how to formulate and substantiate their own opinion, which is considered an important aspect of SSIBL. This could be explained by the fact that students are used to a 'rational science context' in which inquiry is based on planned observation (cf. Yoon 2006) and deserves further attention: How could this type of active involvement of science students contribute effectively to their learning on the social implications of their domain? This also refers to the challenge that in our module, learners perceived the design and performance of a play to be time-consuming and thus less effective as opposed to more traditional ways of learning.

We are aware that many variables affected students' views on the social and scientific issues surrounding neuro-enhancement, due to the complex nature of teaching and learning. Nonetheless, the results of our study underline the potential benefits of using drama as a tool for socio-scientific inquiry-based learning. When asked whether students would recommend the course to fellow students, an overwhelming majority gave a positive answer. Socio-scientific drama clearly stimulated our students to consider in depth the impacts of new technologies in everyday life and to develop arguments that would be relevant in an authentic personal or democratic deliberation.

References

Bolton, G. M. (1984). *Drama as education: An argument for placing drama at the centre of the curriculum*. London: Addison-Wesley Longman Ltd.

Bolton, G. M. (1985). Changes in thinking about drama in education. *Theory into Practice, 24*(3), 151–157.

Braund, M. (2015). Drama and learning science: An empty space? *British Educational Research Journal, 41*(1), 102–121.

Colucci-Gray, L., Camino, E., Barbiero, G., & Gray, D. (2006). From scientific literacy to sustainability literacy: An ecological framework for education. *Science Education, 90*(2), 227–252.

Dorion, K. R. (2009). Science through drama: A multiple case exploration of the characteristics of drama activities used in secondary science lessons. *International Journal of Science Education, 31*(16), 2247–2270.

Fels, L., & Meyer, K. (1997). On the edge of chaos: Co-evolving worlds of drama and science. *Teaching Education, 9*(1), 75–81.

Heathcote, D., & Bolton, G. (1995). *Drama for learning. Dorothy Heathcote's mantle of the expert approach to education*. Portsmouth: Heinemann.

Kottler, J. A. (1994). *Advanced group leadership*. Pacific Grove: Brooks/Cole.

Knippels, M. C. P., 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.

Levinson, R., and The PARRISE Consortium (2014). *The SSIBL framework,* D1.2 PARRISE, co-funded by the European Commission under the 7th Framework Programme, Utrecht/Institute of Education, London.

McSharry, G., & Jones, S. (2000). Role-play in science teaching and learning. *School Science Review, 82*(298), 73–82.

Ødegaard, M. (2003). Dramatic science. A critical review of drama in science education. *Studies in Science Education, 39*, 75–102.

O'Neill, C. (1985). Imagined worlds in theatre and drama. *Theory into Practice, 24*(3), 158–165.
O'Neill, C. (1995). *Drama worlds: A framework for process drama*. Portsmouth: Heinemann Drama.
Savulescu, J., ter Meulen, R., & Kahane, G. (Eds.). (2011). *Enhancing human capacities*. Oxford: Wiley.
Shepherd-Barr, K. (2006). *Science on stage: From Doctor Faustus to Copenhagen*. Princeton: Princeton University Press.
Toonders, W., Verhoeff, R. P., & Zwart, H. (2016). Performing the future. On the use of drama in philosophy courses for science students. *Science & Education*. doi:10.1007/s11191-016-9853-3.
Wieringa, N. F., Swart, J. A., Maples, T., Witmondt, L., Tobi, H., & van der Windt, H. J. (2011). Science Theatre at School: Providing a context to learn about socio-scientific issues. *International Journal of Science Education, Part B, 1*(1), 71–96.
Zwart, H. (2014). Limitless as a neuro-pharmaceutical experiment and as a Daseinsanalyse: On the use of fiction in preparatory debates on cognitive enhancement. *Medicine, Health Care & Philosophy: A European Journal, 17*(1), 29–38.