

The use of plastics as a socio-scientific issue for developing critical thinking through argumentation with pre-service teachers

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Abstract

The treatment of socio-scientific issues in the classroom using role-playing is a teaching strategy of greater interest for the development of critical thinking in pre-service teachers by way of scientific argumentation. This paper shows a role-playing activity to reflect on the elimination of plastic use, which was put into practice with 66 Spanish pre-service teachers taking the Degree in Primary Education at the University of Malaga (Spain). The game involved several roles in favour (ecologist, fisherman, minister of industry, bioplastics producer) and against (lobby, packaging chain consultant, frozen fish company executive and others), and used a questionnaire, before and after the activity, to analyse the participants' understanding of plastics and their perceptions concerning the use of role-playing in the classroom.

Our findings show how pre-service teachers progress in their understanding of basic concepts related to the properties of plastics and, although there was no significant change in their decisions regarding the production and consumption of plastic, the reasons given were slightly modified before and after the role play. Similarly, after participating in the activity, they were more predisposed to use this technique as a teaching strategy in the classroom, and they also exhibited greater confidence in defending their role.

Introduction

Science education has utilised and studied the learning and use of scientific understanding to tackle complex social issues that can be explained by science – so-called socio-scientific issues (Sadler, 2009) – some of which are related to

energy, health, resources or the environment, amongst others. These socio-scientific issues are of particular interest to students, as they allow them to link scientific theory and understanding with issues that they encounter in their daily lives (Andrée, 2005) that may also be relevant to society and are often found in the mass media. Socio-scientific issues allow students to apply their scientific competences, thereby also allowing them to develop critical thinking by questioning different perspectives of the same issue, a fundamental aspect for the future educational professionals (Yang, 2012).

These issues may be studied through activities that allow argumentation from a student viewpoint, also known as decision-making in science education (Fang, Hsu & Lin, 2019), using a series of scientific evidence to support their arguments (Bravo & Jiménez-Aleixandre, 2018). Different teaching strategies can be used to approach these issues in the classroom. Role-playing, in which each student represents a relevant role related to

the issue and must defend their position in a reasoned manner, is one such strategy. This approach promotes argumentation in a socio-scientific issue (Simonneaux, 2008).

As such, this article concentrates on a relevant socio-scientific issue related to the decision concerning the production and use of plastics, and the discussion about how to act to minimise the environmental impact, given that current levels of contamination are unsustainable. Burmeister and Eilks (2013) have previously approached this issue with pre-service science teachers from a sustainable development viewpoint.

This study revisits this issue by providing a role-playing methodology concerned with promoting the search for evidence for argumentation in science and also attempts to provide a climate of argumentation and counter-argumentation in the classroom.

Study objectives

This study has two objectives:

1. To present a role-playing design based on the use of plastics, which has been implemented with Spanish pre-service science teachers to promote the development of critical thinking through scientific argumentation.
2. To analyse the understanding of plastics and the perceptions of the participants concerning the use of role play in the classroom.

The importance of argumentation in science

Argumentation with scientific understanding, using evidence, is recognised as one of the most important aspects of science learning (Driver, Newton & Osborne, 2000). According to the National Research Council (2012), argumentation is one of the scientific practices that must be promoted as part of the K-12 framework. Also, in students' daily lives, scientific argumentation will help them to construct arguments and defend ideas, and also provide them with a tool for analysing other arguments while developing their critical thinking. Consequently, students will be able to rely on tools that allow them to determine whether what they hear, see or read in the media is fake news. Despite its importance, in the majority of cases, argumentation is not a particularly widespread practice in primary or secondary classrooms, probably because teachers are unaware of its educational possibilities or have not received appropriate training in how to conduct this type of task, especially concerning current controversies.

Role-playing as an argumentation strategy Role-playing is already known to be a teaching strategy that allows the understanding, attitudes, beliefs and values of socio-scientific issues to be improved (Cronin-Jones, 2000; Howes & Cruz, 2009). This strategy requires a staging, in this case of the socio-scientific issue concerned, and a series of roles with different roles inherent to the issue, which will be used to show its complexity.

Moreover, according to Harwood, MaKinster, Cruz & Gabel (2002), the role-playing activity 'extends the traditional notion of debate and discussion in the classroom to one that is more complex, dynamic, and authentic' (p. 444). The advantages of role play in science education include the fact that it allows different points of view to be visualised, in order to attempt to approach the complex reality of a social issue in which science is implicated using different roles, and it also facilitates an activity that requires the

construction of scientific arguments to defend the different roles, as well as counter-arguments to refute opposing ideas.

Role-playing with the use of plastics

The role play presented here is based around the current issue of plastic production and consumption. Specifically, it is based on an agreement reached recently by the European Union to eliminate single-use plastics as of 2021.

This activity proposes two educational purposes: (1) to develop critical thinking using this problem, and (2) to provide role-playing training strategies to pre-service elementary teachers (PSETs) in order to make them reflect on this type of practice in the classroom.

This experience has been introduced to 66 PSETs, aged between 19 and 43 years, all of whom were third-year students from the Primary Education Teaching Degree at the University of Malaga (Spain). This activity was carried out as part of a broader training programme to improve the critical thinking of PSETs by way of scientific argumentation. The activity was carried out over two sessions, separated by a period of one week (Figure 1).

[Figure 1]

Session 1

- Part A: A questionnaire exploring prior knowledge about plastics and perceptions of role-playing before the activity.

- Part B: Presentation of the role-playing and assignment of roles. In this session, the scenario in which the PSETs are to carry out the role play, which is framed in the context of a televised debate known as Science and Society covering a real-life and current issue, namely an agreement that the European Union wishes to establish in 2021 a ban on the use of plastics in its member states, is presented to them. Once the context has been explained, the roles that will feature in the role play are assigned, with the PSETs being allowed to choose the role and team of advisers so that they can represent the character with which they feel most comfortable. As can be seen from Figure 2, to ensure a balance of opinion, eight roles in favour of this ban and eight against it were designed. Each participant was provided with a description of their character so that they could seek further information (Table 1).

[Figure 2]

[Figure 3]

[Table 1]

Before staging, the PSETs completed a form for the role assigned (Figure 3), in which they were expected to include the different arguments that they would use to defend their position during the debate and arguments, along with possible strengths and weaknesses, in order for the other roles to be able to counter-argue. This second part of the form is intended to be completed by the role advisers during the role play to allow the PSETs to counter-argue and refute against other roles. PSETs were given one week to prepare their role. They were informed that the evidence they provided could be from any source,

including photos, figures, scientific publications and news items, and that they could bring these with them to the debate to defend their viewpoint.

Session II:

■ Part A: Staging of the role play, which was proposed with the following structure, was carried out in this session:

- o A three-minute introduction by the presenters to present the issue;
- o One minute for each role to present their arguments for or against the issue. No interruptions or counter-arguments were allowed at this time;
- o A five-minute break for the roles to prepare the debate for the counter-argumentation round, together with their advisers;
- o A 25-minute debate in which the various roles can defend or counter-argue against the various positions; and
- o A final period in which the presenters respond to the issue proposed for debate.

[Figure 4]

In this type of activity, it should be noted that the main role of the teacher is to create a context, based on real-life and current issues, which promotes a positive attitude towards student participation by way of situations or issues appropriate for their age and closest reality. During the role-playing session itself, the teacher should step back and leave the responsibility for guiding the debate and controlling each speech to the presenters. Throughout the staging of this role-playing game, a social-cognitive process of self-regulated academic learning is put into practice.

So, the person can self-regulate his or her learning, taking into account the behaviour and the environment (Zimmerman, 2000).

■ Part B: Test of knowledge about plastics and perceptions of role-playing (after the activity). In the final session, the initial questionnaire is administered again to detect improvements in the PSETs in terms of their ability to argue, their learning of the knowledge required and their perception of the role-playing strategy.

Data collection and analysis

The study design is mixed-method and experimental, including both qualitative and quantitative data collection methods, analysis and interpretation (Creswell, 2014). A survey before and after the activity was used as an instrument, including various questions covering participants' knowledge of plastics, as well as others related to their perception of the use of role play as a strategy in the classroom. The questions analysed in this article, concerning the decision-making regarding the socio-scientific issue (item 1), the knowledge required to understand it (items 2 and 3), and the perceptions and emotions of the participants regarding applying it in the classroom (items 4, 5, 6 and 7), can be found in Table 2.

[Table 2]

Results

Figure 5 shows the results obtained from the PSETs regarding the decision of the European agreement, before and after participating in the role play (item 1, Table 2).

[Figure 5]

As can be seen, the PSETs have not significantly changed their position on whether to eliminate or conserve plastics in their production and consumption. However, among the PSETs who wanted to keep plastics in production and consumption, some moved from thinking that disposal should be immediate to a more moderate position where more progressive and regulated disposal was preferred. For instance, one PSET reasoned at the beginning:

'I firmly believe that we should all fight and work to make our planet a better place and to do so we should change many bad habits as, in this case, eliminate the use of plastic. Although we are on the right track with actions such as paying for plastic bags in shops, it is very difficult that, in 2021, Europe will stop consuming this material. We must make society aware of the harmful effects that plastic has on everyone and in this way we could eradicate the problem and make a large part of plastic disappear'.

After the role play, this PSET indicated:

'I believe that by 2021 we should have become aware of the use we make of plastics and have eliminated a large part of them from our daily lives, for example, the bags in supermarkets, the packaging of the food we eat...but we must also be aware that we cannot completely eliminate this material from our lives, as many life-saving sanitary materials are made from plastics as well as some safety features in vehicles. In the longer term, we should regulate the use of plastics by law worldwide'.

Some PSETs who did not consider the elimination of plastics alluded to the need for continued production and consumption of certain plastic materials that could not be replaced by others. As an example, one PSET said: 'The mass use of plastics should be stopped in almost all areas, but not in all. Sometimes plastics are necessary to meet new developments in health and sanitation or technology, for example. People would not be able to wear contact lenses if they stopped using plastics'.

Concerning decomposition time for plastic (item 2, Table 2), the most popular response both before and after participating was one hundred years, with this being the correct response (Figure 6).

[Figure 6]

Although the improvement found after the activity (4.0%) is small, it nevertheless demonstrates a change in the concept of the time taken by plastic to decompose, which is an aspect that the general public often has difficulty in understanding.

As regards to the property responsible for the floatability of plastics (item 3, Table 2), density was the main answer at both points in the intervention (69.6% before the activity and 76.9% after) (Figure 7). The improvement seen in this result added to the decrease in the percentage of the mass property after the activity and this appears to indicate that staging allowed the PSETs to assimilate this concept.

[Figure 7]

With respect to their perceptions about the strategy (item 4, Table 2), both before and after carrying out the activity, all PSETs indicated that role play was an interesting strategy for the primary classroom, as it ‘means that children have to put themselves in someone else’s position’, ‘helps to respect other people’s decisions’, ‘creates empathy, ‘develops critical thinking’ or ‘promotes the ability to argue’. Concerning the potential of role-playing to promote this ability to argue in primary school children (item 5, Table 2), although this was given a high score on both occasions, it was higher after carrying out the experiment (8.3/10 before the activity and 8.6/10 after). Similarly, concerning staging, 54.1% of the PSETs showed interest and 20.3% uncertainty when they were preparing the roles (item 6, Table 2), with these values changing to 64.9% and 1.8% respectively when defending their roles (item 7, Table 2).

Final considerations

Generally speaking, the role-playing experience with plastics was considered to be very positive, as the participation of the PSETs was satisfactory and they showed a willingness to use role play as an activity to encourage arguing about science in the primary classroom.

Similarly, the activity showed an improvement in the PSETs in terms of some aspects of their understanding of the properties of plastics, as well as in their reasoning about an awareness that was not changed before and after the role-playing, but was reinforced by ideas that happened during the staging. This improvement should be considered to be the starting point to continue to make progress towards more significant learning by PSETs using this type of strategy, and which could lead to their transition into future teachers.

In a forthcoming study, we intend to analyse the quality of the arguments given by PSETs in their interventions to determine whether role-playing is a good strategy for developing scientific argumentation.

In conclusion, we encourage primary school teachers and teacher educators to carry out role-playing activities, in order to promote and improve the capacity of children and undergraduates to work in a collaborative and argumentative manner, as the experiment presented herein highlights the need to train PSETs in this type of strategy so that they can carry such activities out in the classroom successfully.

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