Learning about plastic pollution and reduction using a serious game

Annika Hoffmann, Kaezuko Kamakuere and **Tim Hartelt** offer a view from Germany and Namibia on how to present and evaluate a fun and engaging way to learn about an environmental issue

Increasing global plastics production and consumption is causing plastics and microplastics to accumulate in our ecosystems, posing threats to all living organisms, including humans. Therefore, it is important to teach students about the risks of plastics pollution and to develop a more sustainable way of living, with reduced consumption of plastics (Jensen *et al.*, 2023). While there are several possible instructional approaches to address the issue, we suggest that a 'serious game' is a motivational and effective approach.

Serious games can be defined as '*playful acts that do not have entertainment, enjoyment or fun as their primary purpose*' (Spil *et al.*, 2021: 3) but have educational outcomes. The field of serious games is growing (Laamarti, Eid and Saddik, 2014) for good reason. Research has shown that playing serious games can positively affect knowledge acquisition and content understanding as well as affective and motivational variables (Connolly *et al.*, 2012). For example, serious games not only result in significant learning gains in primary school students but also in high levels of motivation because of the generated interest and fun when playing the games (Arosquipa Lopez *et al.*, 2023).

Because of the relevance of learning about plastics pollution and reduction, as well as the potential of game-based learning, we designed and evaluated a serious game about plastics pollution and reduction for upper primary and lower secondary school students. The aim of the game is to promote students' knowledge about plastics and actions to reduce the use of plastics, promote critical attitudes about plastic consumption, and reduce the behavioural intention to use plastics.

The serious game 'Plastic Town'

The game can be played in groups of two to six students; however, our experience shows that groups of three to four students are best as the game is played faster with fewer students, and they do not get bored waiting for the other players to make their moves. Before implementing the game in class, teachers need to prepare the materials for the game (see *Useful links* – Supplemental Materials), depending on the number of students in their class as well as the preferred group size (for details on the preparation of the game, see Box 1).

Once all the materials are ready, teachers can introduce the issue of plastics pollution by sharing a few photos and initiating a class discussion about plastic items that students use in their everyday lives, what the students think about plastics, and what they already know about the impacts of plastics on the environment. Then teachers can introduce the game. Depending on the class level, it may be helpful to go through the rules together with the students.

Box 1 Preparing for the game (for 6 students)

Printing (see Supplemental Materials):

- **Print the two game boards (30×30 cm or similar)**
- **Print the game cards (A4) and cut out the individual cards**
- **Print the rules (A4)**

Supplies needed (students may bring these in):

- **1 large plastic pot as a communal plastics container (e.g. yoghurt pot)**
- **6 small plastic pots as individual plastics bins (e.g. yoghurt pots)**
- **approx. 30 small plastic items**
- **6 different game player pieces**
- **1 dice**

Groups of students then play the game independently (Figure 1). The students' goal in the game is to reach the finish line on the game board with their game pieces first. When moving their game pieces over the game board, students 'move' through 'Plastic Town', a place where plastics are produced and used in abundance. Students' goal as residents of that town is to reduce plastics consumption and fight against the overwhelming presence of plastics in the town.

This is best done by answering questions correctly that are related to knowledge about plastics and ideas about how to reduce plastics consumption. For incorrectly answered questions, students accumulate plastic items in their individual plastic bins. Students may also accumulate plastic items in their bins when being on an action field, for example when they must use a taxi that brings them a few fields forward but that also produces microplastics through tyre abrasion. Too many plastic items in an individual's bin will result in penalties during the game. With fewer plastic pieces in their bins, students are likely to move forward faster and win the game. It takes 30 to 45 minutes to play the game.

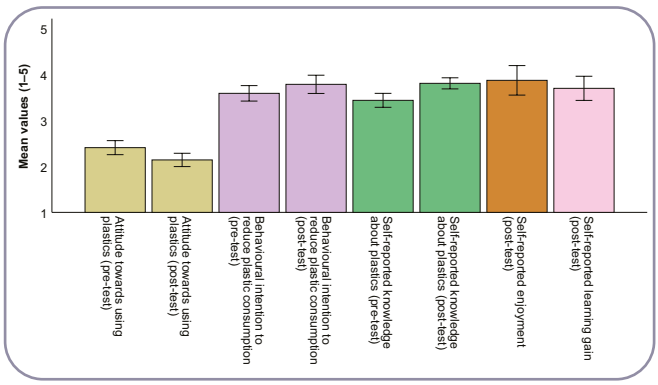
▲ **Figure 1** Playing the game 'Plastic Town'

Evaluation of the game

We tested the game with 83 students in Germany and Namibia. While a subset of 19 students played a prior version of the game which provided feedback for some minor revisions, another subset of 64 students played the final version of the game. The students playing the final version of the game were, on average, 11.2 years old, attended classes three to seven, and were of various genders (45.2% female, 54.8% male).

To evaluate the game, 24 students filled out a pre- and a post-test. At both measuring points, students reported their attitude towards using plastics, their behavioural intention to reduce their use of plastics and their knowledge about plastics. All aspects were measured using a 5-point Likert-type scale, with low numbers indicating low or negative values, and high numbers indicating high or positive values (item development based on Francis *et al.*, 2004). Similarly, students rated their enjoyment and learning gain during the game in the post-test. We also asked open questions about what they had learned (post-test) and how they could reduce their plastic consumption (pre- and post-test). Two coders assigned the open answers to various categories (percentage agreement: 97.4%).

We found that students' attitude towards using plastics, behavioural intention to minimise use of plastics, and self-reported knowledge about plastics changed in the intended way from the pre- to the post-test, even though changes were small. Furthermore, students reported relatively high levels of both fun and learning while playing the game (Figure 2). In the pre- and post-test, the students reported several actions they could perform to reduce plastics (Table 1). The most striking result here is that the responses more than doubled from pre- (29.2%) to post-test (66.6%) in the category '*Avoiding plastic use with naming specific alternatives*'. Some other aspects were not mentioned often, for example '*activism, actionism and education*'. The students also reported several learning outcomes



▲ **Figure 2** Pre- and post-test results (mean values and standard errors)

(Table 2): they had learned about the harmfulness, ubiquity and longevity of plastics as well as about measures against plastics production and usage.

Reflection

The results are promising: the serious game 'Plastic Town' can potentially reach the predefined goals. However, the evaluation also points to some aspects that need to be reflected upon. While we found descriptive differences between pre- and post-test results, these differences were fairly small. This may be because students already had a critical attitude towards using plastics, a high behavioural intention to minimise plastics use, and a high knowledge about plastics before playing the game, resulting in a ceiling effect.

So why is consumption of plastics still a problem? Jensen *et al.* (2023) reported that students perceive several challenges and difficulties in reducing their plastics consumption:

- there is a lack of alternatives in the supermarket because many companies use plastic packaging;

Table 1 Reported actions to reduce plastics use

Category	Example comments	Percentage of mentions	
		Pre-test	Post-test
Avoiding plastic use with naming specific alternatives	You could perhaps use glass bottles instead of plastic bottles	29.2%	66.6%
Avoiding plastic use without naming specific alternatives	Don't buy plastic bottles	37.5%	29.2%
Reuse	Reuse things made of plastic	4.2%	12.5%
Correct disposal	Do not throw on the floor	8.3%	4.2%
Change dietary behaviour	Become a vegetarian	4.2%	4.2%
Activism, actionism and education	Organise a strike that everything belongs in the bin	8.3%	0%
Reduction of plastic production	One could produce less plastic	0%	8.3%

Table 2 Self-reported learning outcomes

Category	Example comments	Percentage of mentions (post-test)
Harmfulness (for environment and health)	Plastic is harmful and can cause diseases	37.5%
Ubiquity	Plastic is used almost everywhere	29.2%
Measures against plastics	Use fruit nets rather than plastic bags	16.7%
Longevity	Plastic takes 450 years to break down into microplastics	8.3%
Unspecific learning gain	A lot	8.3%
No learning gain	Nothing and nothing	4.2%

- not buying and using some of their favourite products is hard;
- they cannot decide (alone) what will be bought when shopping for groceries as their parents pay and do the shopping.

Thus, students' perceived behavioural control is often low and can influence their intention and actions to reduce their plastics consumption negatively.

Discussing with the students after the game what actions are within their own power could enhance students' perceived behavioural control. For this discussion, the specific actions the students reported regarding reducing plastics (Table 2) may serve as an inspiration. Teachers may ask students for ideas of specific actions for various categories, especially for categories that have not been named very often by the students, such as '*activism, actionism and education*'.

Conclusion

With the suggested additions above, I and my project team believe that the serious game 'Plastic Town' can be implemented in upper primary and lower secondary education as a fun and engaging activity to change students' attitudes towards using plastics, promote the behavioural intention to use minimal plastics, and promote knowledge about plastics and specific alternatives to plastics.

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USEFUL LINKS

Supplemental Materials: https://uni-kassel.de/go/plastictown

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