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Evaluating Sustainability in Chemistry Teaching – Glyphosate & Orange Oil

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Background

In 2015, the UN (1) introduced the Agenda 2030. In the same year, a renewed version of the planetary boundary framework was published (2). For staying inside the boundaries and achieving the Agenda 2030 chemistry plays an important role (3). Despite its importance, chemistry is often perceived as unpopular and not interesting (4). Thus, an SSI-based approach is suggested e.g. by (5). One particular topic frequently arises in the daily media: pesticides. Some media excerpts claim that pesticides are responsible for decreasing numbers of pollinators or cancer. Others highlight their need for food security and stable food prizes.

"*A pesticide is any substance or mixture of substances intended for preventing, destroying, repelling or mitigating any pest[…]*" (6). Over time, more and more risks of pesticides were published (e.g 7). Today, crop protection has a range of options and pesticides were improved. But, avoiding synthetic pesticides is also a question of consumer behavior (8). Glyphosate is a widespread and effective, but also controversial. An alternative might be green pesticides, which are "*derived from organic sources that are considered environmentally friendly […]*" (9; 4). An example is orange oil with its main ingredient d-limonene which is a registered insecticide (USA).

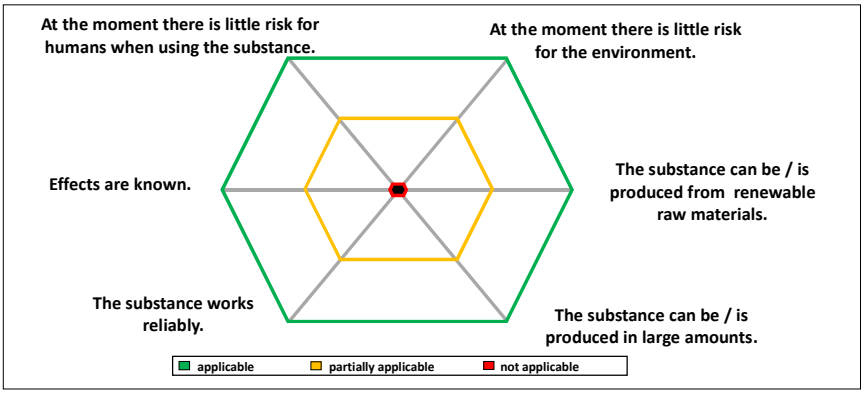

Fig. 1 Evaluating sustainability

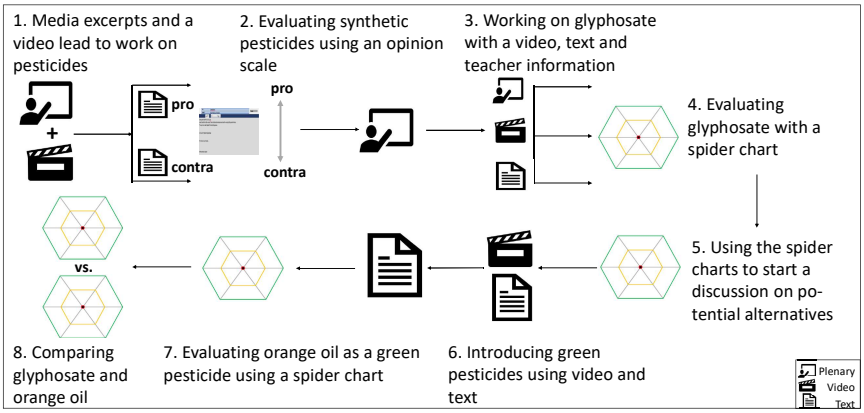

Fig. 2 Overview of the lesson plan

„I especially liked the use of those „spiderwebs", because it was very easy to see the opinion of all others and it was also fun." [1]

"I thought it is a great idea to involve someone who is professionally involved and is able to tell so much about it. It was always easy to understand her and she made you feel like she was sitting at the other end of the classroom." [2]

Rationale & Lesson Plan

Most ideas on integrating pesticides into chemistry teaching only focus on laboratory practices. Pesticides are a novel entity as highlighted by the planetary boundary framework (2). At the same time (10) emphasize the absence of sustainability in chemistry curricula. (11) name SSIs as a possible way to teach about and with sustainability. There is a demand for more holistic and interdisciplinary approaches (10). Assessing sustainability with students is difficult due to high complexity. Spider charts (12) are suggested to visualize sustainability aspects oriented on the 12 Green Chemistry Principles (fig. 1, 13). The lesson plan (135-150 min) starts with media excerpts highlighting the controversy (fig. 2). The learners are introducing to the agriculture in Brazil and pesticides. They work in groups to write e-mails evaluating pesticides which are placed on an opinion scale and lead to glyphosate. The students fill out a spider chart using information from another video. All spider charts on glyphosate are compared. Afterwards, green pesticides can be introduced through another video. In a next step the learners work with a text to fill out a second spider chart. Finally, synthetic and green pesticides can be compared in a classroom discussion. At this point it should be emphasized that a herbicide is compared to an insecticide.

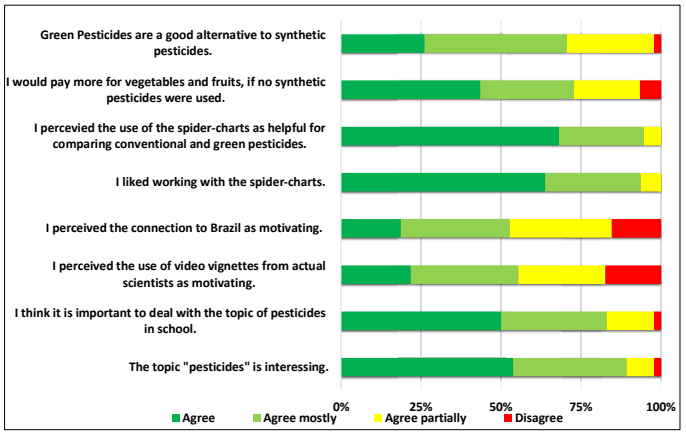

Fig. 3 Selected student feedback to Likert items (n=95)

Method & Experiences

The lesson plan was designed and developed by Participatory Action Research (14) with a group of teachers. After each implementation in school a questionnaire with 15 4-step Likert items and 5 open questions was used (selected results see fig. 3). The evaluation was conducted using descriptive statistics and qualitative content analysis (15; Cohens κ =.899). Overall, the students liked the lesson plan. Many students named the spider charts[1] and the methods itself as being very positive. E.g., for the open question "Describe how you perceived "working with" the Brazilian chemistry professor", most students answered in a positive way and mentioned e.g. the authenticity and expertise, the fact that their perspective has been changed towards a Brazilian view or a certain novelty to use videos in class[2]. Some students liked the video but said that it was hard to understand everything due to the English language. Any critical feedback was used to change the lesson plan for increasing feasibility. So, some students referred to a more content based approach regarding the chemical topic of pesticides. For that reason an additional work sheet was later designed.

Conclusion

First trials showed promising results on how the students perceived the spider charts in order to compare synthetic and green pesticides realizing that a panacea does not exist. Further research is necessary to improve and to test the spider charts for evaluating substances. Such tools might be introduced to learners even in lower secondary school to evaluate substances using ideas from the sustainability debate to include novel entities to chemistry teaching. Furthermore, the framework of filtered information introduced by (16) can be applied: science-based information can be perceived and passed on differently by different people, depending on factors such as own interest, prior knowledge etc. Here all students received the same information but perceived it differently. A broader discussion can be found in (17).

Literature

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