Exploring the Effects of a Neglected Area

The United Nations Sustainable Development Goals in Science Education

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One of the major challenges of teaching science has been engaging students in discussions of concepts due to lack of perceived relevancy of topics to students’ individual goals and societal issues. Science has been viewed as a set of abstract topics disconnected from the real world. To increase student motivation, self-efficacy, and interest in pursuing a degree in STEM fields, educators highlight the role of science in explaining environmental issues and generating potential solutions. One of our previous studies investigated the effect of learning about phosphate sustainability on general chemistry students’ perceptions of science relevancy. The positive outcomes encouraged our group to develop several comprehensive Prezi modules to introduce the United Nations Sustainable Development Goals (SDGs) in science classes and reveal their connections to the topics taught in schools. The overall objectives of this project are to suggest an effective and meaningful method to make science relevant to students, enhance their sustainability awareness, and encourage them to take actions to help the global community achieve the SDGs. In this article, we explain the contents and structures of the presentations and discuss their potential uses in science classrooms to improve students’ curiosity and engagement.

In general, students seem to lack interest in the topics presented in science classrooms due to their inability to see the relevance of these topics to their everyday lives or future jobs (Osborne et al., 2003). In both chemistry education (De Jong & Talarquer, 2015; Ilhan et al., 2016) and physics education (Nair & Sawtelle, 2019), there is a distinct lack of interest from students due to the courses being disconnected from the reality and the knowledge gained appearing to have little use outside the classroom. In general, subjects are presented in an isolated realm of theories and principles. This disconnect has caused chemistry and physics teachers to reform their teaching practices and introduce abstract concepts in a context relevant to students’ everyday lives or in a way that provides them a multidisciplinary perspective about the topics they are learning (De Jong & Talarquer, 2015; Ilhan et al., 2016; Nair & Sawtelle, 2019). Even though biology is often considered more relevant to students than the physical sciences (Osborne et al., 2003), there are still several efforts aiming to improve students’ perception of biology relevance and help them see the connections between biology and society (Fowler, 2012). Students’ interest in science is vital due to the increased demand for workers in scientific and technological fields. A certain level of scientific literacy is also necessary to engage in the socio-scientific discussions occurring today that will affect the future (Fowler, 2012; Stuckey et al., 2013).

Relevance in the context of science teaching can be best summarized in three dimensions as presented by Stuckey and colleagues (2013): individual relevancy, vocational relevancy, and societal relevancy. The individual dimension relates to how science appears in students’ personal interests and their everyday lives. The vocational dimension involves preparing students for future careers and giving them the necessary background to pursue a science career. Finally, the societal dimension involves an understanding of science in society and prepares students to be responsible members of society (De Jong & Talarquer, 2015; Stuckey et al., 2013).

Sustainable development fits into these three dimensions of relevancy and has a strong connection to the sciences. Sustainable development can be defined as meeting the needs of the present generation while not compromising future generations’ ability to meet their needs. This involves preserving the environment, economy, and society for the future (Zwickle & Jones, 2018). The Sustainable Development Goals (SDGs) issued by the United Nations follow these same principles, working to protect the Earth from degradation, build societies of peace and equality, and end poverty and hunger around the globe. The environmental portion of these 17 goals is a response to environmental issues such as land degradation, loss.
of biodiversity, and ocean acidification that affect both societies and the biological sphere in general (United Nations, 2015).

The sciences, specifically chemistry, are a key aspect in sustainable development because they are intricately involved in the creation of processes and products that can promote or hinder sustainability (Matlin et al., 2015). For example, science has created many byproducts that contribute to air and water pollution, but science also allows new technology such as solar power to be used efficiently. Science in general greatly affects the SDG topics of Zero Hunger (#2), Good Health and Well-Being (#3), Clean Water and Sanitation (#6), Affordable and Clean Energy (#7), Climate Action (#13), Life Below Water (#14), and Life on Land (#15). However, discussions around sustainability in the education of any discipline, especially chemistry, have been limited until recently. This lack of inclusion is primarily due to chemistry teachers seeing their goal as increasing student knowledge and preparing them to be successful on their tests instead of informing students of the impacts, both positive and negative, of chemistry on nature and society (Vilches & Gil-Pérez, 2013). Although these goals are important for evaluating students’ understanding and assessing the efficacy of institutions, there is a greater need to introduce a more meaningful purpose for the students to learn chemistry, help them comprehend the “big ideas” of chemistry in the context of global issues, and engage them in generating solutions while appreciating all three dimensions of relevancy (De Jong & Talanquer, 2015). This is needed for both future scientists as well as students pursuing other careers because students will encounter these societal issues in any career they choose.

Considering all the benefits of discussions around socio-scientific issues, our team decided to develop Prezi learning modules, like the one shown in Figure 1, focusing on the UN’s Sustainable Development Goals. The main goals in these efforts were to increase the relevancy of science for students and enhance their sustainability awareness. There is a great hope that they will be motivated to work toward achieving the SDGs by 2030. In this article, we will first discuss the effects on students’ motivation and self-efficacy as a result of integrating a socio-scientific issue, phosphate sustainability, into the general chemistry curriculum. Next, we will provide information on the current project that aims to produce seven more Prezi modules on sustainability topics. This project was driven by the positive results shared by Gulacar et al. (2020) and others (Juntunen & Aksela, 2014; Zowada, Frerichs et al., 2020; Zowada, Gulacar et al., 2018).

The past study

The socio-scientific issue of phosphate use and sustainability was introduced to 760 general chemistry students at a university in northern California using a Prezi learning module and related activities (Gulacar et al., 2020). The students received a link to the Prezi learning module via email and were expected to explore the module on their own. Their self-exploration was encouraged with a mini quiz that they needed to complete before the next discussion session. The learning module focused on phosphate recycling and its uses in society and tried not to present the information with bias toward any stakeholder. During the discussion session, each student assumed the role of one of these stakeholders (environmentalist, farmer, industrial representative, economist, or politician), and students were asked to discuss phosphate sustainability with their classmates from the viewpoint of their assumed role. For example, farmers would express their need for phosphate to grow their crops; their concern about the environmental impact of phosphate would be overshadowed by their desire to be economically stable. In contrast, an environmentalist would see phosphate mining as hazardous and would want to stop large corporations from using this chemical. The students were then asked a few
open-ended questions about their experience with the activity, such as if they saw learning about phosphate sustainability as important or related to their field of study. Two sets of pre- and post-activity surveys—a modified form of Jones’s MUSIC Model of Academic Motivation Inventory (Jones & Skaggs, 2016) and the College Chemistry Self-Efficacy Scale developed by Uzuntiryaki and Capa (2009)—were implemented; additional information can be found in the original paper for this study (Gulacar et al., 2020). Self-efficacy can be described as a part of motivation, and both perceived self-efficacy and perceived relevance can be associated with increases in motivation (Vanniarajan, 2010). Higher levels of both self-efficacy and motivation have been found to increase student performance as well (Kartal & Kutlu, 2017), giving instructors another reason to encourage these attributes in students.

The results of this study demonstrated the importance of discussing relevant topics. Three of the eight questions in the motivation survey had a statistically significant increase after the activity was implemented. These three questions were all related to students’ interest in the material. The questions related to the module’s usefulness did not show a statistically significant increase or decrease after the learning activity. A few students expressed not being able to see how the phosphate activity would be connected to the final in the class, which is most likely reflected in this perception of the activity’s usefulness. All the chemistry professors at the northern California university gave the same final exam for their courses, so the final could not be changed to reflect the extra learning occurring during the phosphate activity (Gulacar et al., 2020). For self-efficacy, 6 out of the 21 questions showed a significant increase in students’ confidence in their abilities, and the mean scores for all questions except three increased. Scores increased significantly for questions relating to everyday problem-solving and interpreting the news but decreased significantly for questions relating to lab reports and experiments, which was outside the scope of the research. Many students also had extensive arguments when role-playing during the discussion section, and some had positive comments regarding the learning activity (Gulacar et al., 2020). For example, one student commented that learning about phosphate sustainability “is more important than [their] grade as it impacts human survival” (Gulacar et al., 2020, p. 4).

**Present learning modules**

The phosphate activity had overall positive results, but this past project was limited in the scope of information that can be given to students because the module discussion was designed to fit into one class period. The current project aims to create a set of seven learning modules based on the UN’s SDGs for the purpose of providing material for a discussion-based seminar class or a class that includes extended discussions as part of their lectures. This current project eliminates the problem of not being able to include as much information as desired as well as providing material unrelated to a final exam. Due to some of the SDGs having a less scientific focus, this project involves 7 out of the 17 SDGs, which can be seen at the following links: Zero Hunger (#2), Good Health and Well-Being (#3), Clean Water and Sanitation (#6), Affordable and Clean Energy (#7), Climate Action (#13), Life Below Water (#14), and Life on Land (#15). These SDG topics are then tied to science curricula in the learning modules to show the relevancy of the curricula while also increasing awareness of global issues.

For example, the SDG Life Below Water (#14) has strong connections to chemistry topics related to aqueous solutions, such as solubility, molarity, and acid-base chemistry. Figure 2(a) demonstrates the inclusion of pH as a topic in this learning module when talking about ocean acidification as an environmental issue. Other slides in this module include concepts that connect to physics, such as ultrasonic irradiation as a solution for eutrophication. Figure 2(b), a slide from the learning module of Zero Hunger (SDG #2), also addresses acidification, showing how soil acidification involves biology concepts like the nitrogen cycle and chemistry concepts like neutralization reactions. Clean Water and Sanitation (SDG #6) has sections describing how reagents like chlorine and ozone can be used to treat water, giving it a chemistry focus. This module also has connections to microbiology because of its discussions of various forms of water pollution; one primary example is a discussion of antibiotic resistance in relation to bacteria in water. Further examples in other modules include photosynthesis and osmosis in the Life on Land (SDG #15) module, anaerobic digestion and biopesticides in the Good Health and Well-Being (SDG #3) module, greenhouse gas molecules in the Climate Action (SDG #13) module, and nuclear fission and hydrogen cell reactions in the Affordable and Clean Energy (SDG #7) module.

**The structure of the Prezi learning modules**

As previously mentioned, Prezi was used to create these learning modules for both the current project and the previous project. Prezi allows for a more dynamic showcasing of information than other presentation types, such as PowerPoint slides or a website, due to Prezi giving the user some freedom in exploring the content in any direction and to any depth, instead of presenting one idea after another (Krause & Eilks, 2014).
The Prezi format can facilitate what Krause and Eilks (2014) call “three-dimensional structuring of information” (p. 19), in which the author can provide deeper levels of information about a certain topic and the user can choose what information they want to learn based on their interest in the topic. The abundance of topics addressed through the seven modules should also provide many chances for students to relate to the topics introduced at a personal level or see how their future careers may be impacted by sustainability issues, tying to the dimensions of relevancy presented by Stuckey et al. (2013).

Due to the complex nature of sustainability issues and the issues’ interconnectivity with each other (such as the greenhouse effect’s relationship to population growth), an interdisciplinary approach must be used to address the SDGs. There are many issues and concerns outside the authors’ field of chemistry (Vilches & Gil-Pérez, 2013), so this project incorporates the opinions and ideas of faculty from a range of disciplines, including political science, nutrition, plant science, environmental policy, community and regional development, among others.

This interdisciplinary approach will also involve faculty from outside of the United States gaining a more global perspective on sustainability issues. At the time this article was written (2020), the SARS-CoV-2 virus affected almost all countries around the world. Some countries were more successful than others in fighting this virus, and some efforts in these countries made the situation worse rather than improving it. All these observations demonstrated the necessity of a global perspective for finding solutions to global issues such as sustainability. Not only do we need ideas and opinions from experts globally to bring about good solutions to sustainability issues, but we also need a global effort to combat these issues. Including a range of local and global input on the Prezi learning modules is a first step in providing a global perspective.

In addition, the inclusion of global perspectives as well as the growing body of information on problems and solutions in sustainability mean that these Prezi learning modules will continue to evolve and be modified even after they are released to the public. The feedback received from the faculty with different expertise has already led to the inclusion of new topics and ideas in the learning modules. It is our hope that the learning modules will continue to be relevant outside of the environmental and societal realities that specifically define the current era with their ability to be changed and modified.

**Ideas for future implementation**

At the northern California university where the previous phosphate module was introduced (Gulacar et al., 2020), first-year seminars are available for freshmen and other students to take. These seminar classes have a cap of 19 students and focus on conversation and curiosity, exploring topics and thinking critically about them (University of California, Davis, 2019). Using this type of class to present the Prezi learning modules would allow students to be active contributors to the classroom. Students would also be exposed to the opinions of their classmates, allowing them to see multiple perspectives on sustainability topics. The structure of this seminar would work best as an extension and expansion of the procedure described in the previous phos-

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**FIGURE 2**

Sample Prezi learning module slides.

*a* Change in pH Levels

*Note.* (a) A slide from the Life Below Water (#14) Prezi learning module detailing how and why ocean pH is changing and its negative effects on ocean life. (b) A slide from the Zero Hunger (#2) Prezi learning module detailing how nitrate leaching and the nitrogen cycle are involved in soil acidification.
phate study (Gulacar et al., 2020). Each week, students could be sent a learning module focusing on an SDG and asked to explore the module before the class period. During class, students could be assigned roles corresponding to stakeholders in the topic at hand. These roles would change slightly depending on the SDG being addressed, but some roles, such as environmentalist or politician, would be consistent across topics. Students would then discuss the information presented in the module for that week with each other from the perspective of the role they are assigned. Later in the semester, students would take what they have learned in class and contribute to local sustainability efforts, either by designing a project of their own or contributing to a project already occurring in the community. This project should contribute to their learning on personal and societal levels, as they would see how sustainability issues affect their specific community.

In addition, a specific section in each Prezi module is dedicated to learning outcomes, highlighting connections between slides with certain topics and commonly targeted learning objectives in chemistry and biology science curricula. The learning outcomes are included in the modules so that integration of these modules into science curricula can be done easily and successfully. Many instructors, even at the college level, are more concerned with covering the suggested content than with helping their students connect abstract scientific principles to real-world issues (Harris, 2001; Herreid & Schiller, 2013; Johnson et al., 2016). The presence of the learning outcomes is expected to encourage instructors to use the Prezi modules to any extent they want, make science learning more meaningful, and still cover the content dictated by the curriculum followed.

**Conclusion**

Relevancy holds importance in the sciences due to its ability to increase student interest, which can lead to scientifically literate and engaged citizens (Stuckey et al., 2013). Sustainability has the potential to be of interest to students, fitting into the three dimensions of relevancy (individual, vocational, and societal) defined by Stuckey and colleagues (2013). An earlier study (Gulacar et al., 2020) showed that using a Prezi learning module to address a sustainability topic such as phosphate usage increased motivation and self-efficacy. The current Prezi modules, inspired by the earlier study, aim to introduce students to the UN’s Sustainable Development Goals, increasing student interest in the subject matter. The seven Prezi learning modules in development could be used in a seminar setting so that student discussions could occur and students could see sustainability issues from multiple perspectives. These Prezi modules and their uses in a seminar-like class or otherwise should contribute to the goal of producing informed citizens who are interested in generating solutions to the socio-scientific issues we face today (Stuckey et al., 2013).

**REFERENCES**

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