Utilizing Case Studies to Increase Engagement and Better Learning Outcomes in Secondary Science Education

Nicholas Amos

Abstract: A significant portion of secondary school students lack engagement in science classrooms, and a possible solution could be to listen to how they prefer to learn. A popular answer students suggest for learning information is through real world applications. The use of case studies is a promising answer that implements real world applications in science education and accompanies important scientific explanations to life outside of the classroom. Case-based learning can positively affect important factors of engagement and is an effective approach when compared to traditional teaching methods. Due to an increase in engagement, students may also benefit from case studies by improving their learning outcomes. With the evidence provided, case studies are worthwhile to implement in secondary science classrooms.

Introduction

A problem with our current science education system is that, on average, the current science classroom is not a space that utilizes the most effective practices in engaging students. A 2013 Gallup poll of 500,000 students showed that only four in 10 high school students were attentive, inquisitive, and generally optimistic about school (Jason, 2017). A meta-analysis by Tze et al. (2015) also concluded that if students experience boredom in class, there are negative impacts on student academic outcomes. Students in a traditional science classroom are required to process and memorize a significant amount of information. This approach creates an environment where students are not motivated to learn past rote memorization and do not attempt to conceptualize the different processes and the larger picture of the content presented in class (Olgun & Adali, 2008). If students are experiencing boredom and are not engaged with material, they may not want to go out of their way to learn more about the topics being covered in the science classroom.

The AMGEN Foundation (2016) had students rank what they thought would make science classes most interesting. The results showed projects that relate to the use of science in real life, also known as real world applications, was one way that students prefer to learn information in a science classroom. A pedagogical strategy that can be used to incorporate real-world applications into the science classroom includes case studies (InTeGrate, 2021). Real world applications contribute to a fundamental goal in science education by pairing with scientific explanations to help explain the natural world. In its original form, case studies were used for law and business students to analyze realistic stories as examples of good and bad practice (Herreid, 2005). This strategy has now slowly expanded beyond the walls of the ivy-league schools that it originated in. Although case studies have a relatively long history in law and business colleges throughout the country, it is important to note that

case-based learning has rarely been used in secondary science teaching (Yalcinkaya, et al., 2012). Today, case studies in education can take many forms including lecture method, whole class discussion, small groups, individual case instruction, and mixed method. Of the different strategies, small group cases are the most popular in the classroom. Small groups allow for cooperative learning among the students and appear to be the easiest to teach for educators that are used to applying the lecture method in the classroom (Herreid, 2005).

Defining Case-Based Learning

Cased-based learning typically consists of two main parts: the case situation and the questions related to the case situation. The purpose of the questions is to gauge understanding of the material presented (Yalcinkaya et al., 2012). An example of a systematic approach for case studies according to Boston University (Boston University Centers for Teaching & Learning) include:

- What is the issue?
- What is the goal of the analysis?
- What is the context of the problem?
- What key facts should be considered?
- What alternatives are available to the decision-maker?
- What would you recommend - and why?

The calculated process of a case study allows students to engage in the curiosity of decision-making, problem solving, and discussions (Chammas, 2017). Since this method requires students to analyze, evaluate, and apply information, students also facilitate development of higher levels of Bloom's taxonomy of cognitive learning (Bonney, 2015).

Using Case Studies in the Science Classroom

How case studies can be implemented in the science classroom is nearly endless due to the limitless creativity and autonomy an educator has when introducing them in a lesson. For example, in a biology classroom that is learning about the central dogma of molecular biology, a case study that revolves around a relevant topic that has affected us all would be the Pfizer-BioNTech and Moderna mRNA vaccines. During a lecture, students would be taught that deoxyribonucleic acid (DNA) is transcribed into messenger ribonucleic acids (mRNA) within the nucleus of the cell. The mRNA is then translated outside of the nucleus, where ribosomes will help read the "message" and produce an amino acid chain that will fold into a protein. After the lecture, having students work together in small groups, a case study would be implemented to apply the information that was taught. In the case study scenario, the issue would be the COVID-19 pandemic that is currently devastating the United States and the rest of the world. The goal, through the use of vaccines,

is to control the spread of COVID-19 and prevent deaths due to the virus. The context is that a newly implemented vaccine, with the help of mRNA biotechnology, has shown success during clinical trials in preventing the spread of the virus. After implemented, the vaccine will create protein spikes identical to that of the virus. If the Pfizer-BioNTech and Moderna vaccines use this type of mRNA biotechnology, what is the process a cell goes through to initiate an immune response and create antibodies with the mRNA the vaccine provides? This process requires each group to follow the central dogma of molecular biology to find the answer and can create a discussion about the efficacy of the vaccine. A common misunderstanding with mRNA vaccines is that it can influence or alter DNA. Could this be true? After students work to find the answer, they will understand the mRNA is translated outside of the nucleus, thus not interfering with DNA at all. Although extremely simplified, a case study like this can apply biological concepts, as well as learn new information that directly relates to them in the real world.

Case Studies, Engagement, and Learning Outcomes

Engagement in education includes how involved students are within their learning environment and can positively influence motivation and achievement (Fredricks et. al, 2004). Motivation is defined as the "process whereby goal-directed activity is instigated and sustained" (Pintrich & Schunk, 2002, p. 5.). Understanding motivation in education is why it is vital to consider students' perspectives about how they want to learn. How a student engages in material results from intrinsic interest or enjoyment and task value or utility. If students are intrinsically motivated when presented with material, they will work harder to overcome possible difficulties of the work presented (Yalçinkaya et al., 2012). The purpose, through increasing engagement, is not only to help motivate students in the classroom, but also to help increase learning outcomes. Learning outcomes include the knowledge, skills, and abilities that a student can apply after a learning experience about specific concepts (Stanford, 2017). Since case-based instructional strategies can increase students' understanding of how relevant science is in their lives, applying this approach also shows promising results for increasing learning outcomes (Fisher et al., 2019).

Case Studies and Engagement

To understand the effectiveness of implementing different case studies into the science curriculum, how does it compare to traditional teaching methods when it comes to engagement? A study by Bonney (2015) looked at the effectiveness of case studies for topics most often covered in a general biology course: chemical bonds, osmosis and diffusion, mitosis and meiosis, and DNA structure and replication. The control variable, or traditional teaching methods, included instruction delivered using minimal slide-based lectures, textbook reading assignments, and group discussions. The experimental group was taught using case studies from the National Center for Case Study Teaching in Science (NCCSTS) along with original case studies created specifically for the class. After the general biology course was finished, an evaluation tool was used to compare student perception of learning gains. Nearly 60% of students answered that case studies helped perception of learning gains a

"great" amount, compared to class participation and textbook reading within the 20-30% range. The results represent a statistically significant difference in learning perception gains for students taught through case-based learning.

A study presented by Olgun and Adali (2008) involved comparing the attitudes of fifth grade science students learning about viruses, bacteria, fungi, and protista. The students were divided into two separate groups: one involved with learning through case studies and the other relying on a reading and lecture method approach. Before arriving for class, students in the case study group were asked to read the material revolving around the case they would go over. Once in class, students read out loud their specific case for the day. After the case was read, students worked in small groups to discuss the questions for the first part of class. Each group worked to find answers and combined their conclusions into a report for each of the case studies provided. The classroom climate was significantly more positive when involving a case study approach in the classroom. The case-based group learned by doing, analyzing, and researching whereas the comparison group passively worked to find answers within the textbook. Students reflected that case-based learning was "fun." They also felt that they were "very active in the classroom" and they "learned a lot" in the process. The frustrations with working only with a textbook and through lectures were notable as well. Students stated that "listening to the teacher without doing anything was very boring" and that the "lessons were monotonous." This evidence suggests that the improved attitudes toward science when utilizing case-based instruction were motivational factors that increased engagement.

Lastly, Yalçinkaya et al. (2012) investigated how effective incorporating case studies were on 10th grade students' perceived motivation about chemistry. For a period of 12 weeks, students were presented with cases in a small group format. The role of the groups was to work toward finding the answers to 15 separate case studies. After the 12 weeks, implementing case studies positively affected students' extrinsic goal orientation, task value, control of learning beliefs, and self-efficacy for learning and performance. In addition, students taught through case studies experienced an increase in self-efficacy due to this strategy's ability to increase motivation.

Case Studies and Learning Outcomes

The study previously mentioned by Bonney (2015) also compared assessment scores between case study and control groups. By comparing the results of each assessment, there was a significant difference in examination scores between each group. For example, students taught with case studies averaged an 18% higher score among each of the four assessments given compared to the control group. The most impressive difference recorded between each group was a 25% higher average assessment score experienced by the experimental group under the osmosis and diffusion section. It is also important to note that the average increase in examination scores was nearly two letter grades higher across the board. This is enough to boost student course grades from an unsatisfactory or failing range to a grade that would be considered passing. This is positive evidence to indicate that case-based teaching methods may be more effective for students to learn concepts than more commonly used methods in the classroom.

The Olgun and Adali (2008) study that compared attitudes of fifth grade science students also reviewed pre and post assessment results of case study groups compared to traditional teaching methods. To compare the difference in learning between the experimental and comparison group, a performance-based assessment listed as a Science Achievement Test (SAT) used strictly multiple-choice questions. The 25-question SAT resulted in a score that was roughly 16% higher in the group that was taught through case studies.

Review of the Data

Among the research provided, each study reached similar conclusions. Through increases in important factors such as self-efficacy, motivation, and improved attitudes there is convincing evidence that implementing case studies into science education curriculum could increase engagement within the classroom. Olgun and Adali (2008) imply that the success is in how the case study strategy is designed. Since students are engaged with the material, they are convinced that doing research and thinking critically is more effective than simply remembering facts. Yalçinkaya et al. (2012) even recommends that teachers implement case-based instruction in the classroom due to the influence of motivational beliefs on students' achievement.

Based on the comparison between case-based learning and traditional teaching methods, the evidence is clear that approaching education through traditional methods is not the most effective approach to better learning outcomes. This is where a case-based approach would be effective due to its ability to have students discuss, analyze, and find solutions for problems presented in each case. Bonney (2015) even goes out of his way to suggest that case study teaching should be used to promote learning and performance on class assessments.

There is also a positive correlation between student engagement and learning outcomes. The research reviewed by Bonney (2015) showed an average of 18% higher examination scores using cased based instruction when compared to a lecture method approach. Not only did students do well on their exams, but they also felt that they were learning effectively in the process. The results provide that learning gains are a strong motivating factor for engagement in the classroom which then led to better assessment scores. Olgun and Adali's (2008) research also show that an increase in engagement through case-based instructional strategies resulted in assessment scores roughly 16% higher than a traditional approach.

Conclusion

There is clear evidence as presented here that an increase in engagement will result in better learning outcomes for students in secondary science education. The proof of positive evidence presented through the implementation of case studies is certainly promising and deserves to be investigated more for United Stated secondary science education classrooms.

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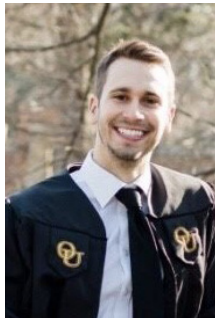

About the Author

Nicholas Amos is a 7-12th grade life science educator with a B.S. degree in Health Science from Oakland University and a M.Ed. degree from the University of Toledo. One of Nicholas' passions as an educator is to create an equitable classroom environment that promotes real world applications to curriculum.