Experiential Learning and STEM Education

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EDCU 53900-003

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October 13, 2022

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When it comes to teaching Science, Technology, Engineering, and Mathematics (STEM) subjects, there are many different teaching styles and methods. For example, some teachers use lectures while some teachers use discussion questions or hands on experiments. Each one has benefits, but not all are as easy to do in a traditional classroom. Often the phrase "Experiential Learning" is tossed about. This research will investigate how experiential learning benefits students' learning in STEM.

STEM education goes beyond just the subjects themselves. "Besides providing science, technology, engineering and math skills, STEM education also provides students with the necessary skills to help students develop well into the 21st century such as problem solving skills, critical thinking, collaboration skills, communication skills…" (T. T. Nguyen & Ngo, 2021, p. 1). These skills are important to not just academics, or a pursuit of a STEM careers. These interpersonal skills are carried into multiple disciplines and careers. "If the United States is to remain competitive across global markets, we must be vigilant in developing problem-solving skills" (Euefueno, 2019, p. 12). Problem solving skills, communication skills, critical thinking skills are not something that can be taught through lectures, they need to be learned through experience, and experiential learning can provide that experience.

Literature Review

Wilson Gilmore (2013) explains that "Experiential Learning is the process of making meaning from direct experiences" (p. 1). According to Kolb (2015) many different people have contributed to forming experiential learning including John Dewey, Jean Piaget, and Kurt Lewin. In each case, students learn based on doing something. It is a teaching method that involves students actively building, researching, or thinking about the world around them.

Kolb and Yeganeh (2011) created a model for Experiential Learning Theory (ELT), describing different stages the learners go through as they learn through experiences. “The ELT model portrays two opposing modes of grasping experience – Concrete Experience (CE) and Abstract Conceptualization (AC) – and two opposing modes of transforming experience – Reflective Observation (RO) and Active Experimentation (AE)” (Kolb & Yeganeh, 2011, p. 3). Concrete Experience involves students involving themselves “fully, openly, and without bias in new experiences” (Kolb, 2015, p. 42) whereas in Abstract Conceptualization students are “manipulating concepts and images to go beyond present knowledge to invent and choose new actions” (Kolb, 2015, p. 90). Reflecting Observation is when students think about what they have just learned or experienced while Active Experimentation is students taking the theories learned and developing them to problem-solving solutions (Kolb, 2015). It’s important for the experiential learning process to include all these facets, moving in a cycle, reflecting on the experiences one has had based on the active experiments that come from abstract ideas. “…in the process of learning, one moves in varying degrees from actor to observer, and from specific involvement to general analytic detachment” (Kolb, 2015, p. 42).

How does ELT impact STEM education? “Direct experiences include hands-on projects in which students are able to apply science, technology, engineering, and mathematical skills to real live situations” (Wilson Gilmore, 2013, p. 1). Parno and Latifah (2021) found that STEM learning and experiential learning go together. “This is because experiential learning relies on experiences in a knowledge building process” (Parno & Latifah, 2021, p. 2). When children are young, play is often integrated in the curriculum. Children will practice fractions with LEGO pieces, play with blocks to build the tallest towers only to see them topple over, or drop Mentos inside a soda bottle to see an example of a chemical reaction. These experiences build knowledge blocks which form bases to more abstract concepts.

Euefueno (2019) describes experiential learning as Project-/Problem-Based Learning and explains how that approach is beneficial to STEM education. "Students learn team building through collaboration/brainstorming; learners create strategies a goal or objective and develop leadership and critical thinking skills. These are valuable attributes both for students in the classroom and the workforce of the future" (Euefueno, 2019, p. 9). This means that using Project-/Problem-Based Learning goes beyond just teaching math and science in the classroom but taking skills into everyday life and even future careers. The careers these skills are applicable to are universal, they are not limited to careers in science, technology, engineering, or math, but any career. This echoes the importance of building these skills.

Nguyen et al. (2020) designed an experiment where they combined Kolb's Experiential Learning Theory with the Engineering Design Process. They state that "STEM education emphasizes on Science, Technology, Engineering, and Mathematics with a major focus on engineering design process in which engineers require in solving challenges or problems" (Nguyen et al., 2020, p. 720). They created four different challenges to be completed by four different groups of middle school age students. After the engineering challenges were complete, they gave the students a questionnaire with closed and open-ended questions. Their results concluded that experiential learning was beneficial, that "the high scores… suggests that students agreed that experiential tasks in engineering design process were very effective activities to learn math and science concepts ("To Learn") and to make practical applications of math, science, and engineering context in order to solve real challenges ("To Make")" (Nguyen et al., 2020, p. 728).

Methods

Many studies have shown that experiential learning is effective, that students are able to demonstrate growth, but a control group is not included in this testing. To compare whether experiential learning has more of an impact on students, one approach would be to do a control lesson compared to one with experiential learning. Students from the same grade of varying abilities would be split into two groups. One group would sit through a traditional class period consisting of lectures and some discussion relating to a specific subject, i.e. Newton's laws of Motion. The other group would sit through an experiential learning lesson, where students would not only listen to the Laws of Motion, but they would also do activities that actively portray each law of motion. For example, students in the experiential learning class may roll a differently weighted cars down a ramp into a wall and measure how far they bounce back, indicating not only the amount of energy the car travelled with, but also Newton's 3^{rd} Law of Motion, equal but opposite reactions, by observing how the car responded to crashing into the wall. This would also tie in with the 2^{nd} Law, force = mass x acceleration, by observing which cars bounced the most, i.e. fast cars, heavy cars, etc. "The most important thing you can do to utilize experiential learning in STEM lessons is to include all four components [of experiential learning]" (Smith, 2018, p. 17). After both lessons, both sets of students would be given the same formal assessment to gather concrete data. While there are many different types of assessment, the one that would be applicable to both traditional learning and experiential learning would be a written assessment including multiple choice questions about the content and short answer open ended questions. This would collect both quantitative and qualitative data. The assessments would be analyzed and graded to see if there was any significant difference between the two groups.

Conclusions

Based on previous research, there should be a higher level of learning from the group who experienced hands-on activities. "Students who make research decisions may have a stronger engagement and commitment to the project as critical stakeholders who make important research decisions (Gentile, Brenner, & Stephens, 2017)" (Birney et al., 2021, p. 30). This research can then add value in validating experiential learning as more than just play or fun, but necessary to help students engage in STEM.

Wilson Gilmore believes that experiential learning will take STEM applications beyond the classroom. "Experiential learning will improve STEM education and better enhance and strengthen [our] nation, and raise the standards of solving, not only our nation's problems, but [the] world's problems." (Wilson Gilmore, 2013, p. 1). Often the goal of STEM education is to make a difference, for the concepts taught in class to be carried out into real-life applications. "…[It] is necessary to apply direct learning as a basis for constructive learning so that the students can solve problems." (Parno & Latifah, 2021, p. 2). And the problems that students face in STEM learning should be approached with hands-on learning to find solutions (Wilson Gilmore, 2013).

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