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Enhancing Middle School Science Education with Virtual Labs and the Think – Pair and Share Technique

Abstract: This white paper explores the potential of virtual labs and the Think-Pair-Share Techniques to improve science education among middle school students. It discusses the challenges faced by students in traditional science classrooms and how science education is perceived by students. It presents a case for the integration of virtual labs with classroom instruction and combining them with an active learning technique like Think-Pair-Share. This paper also provides insights into the benefits of these strategies, practical implementation tips, some names of websites that conduct virtual labs and the potential impact of these on students and their learning.

Introduction: Science is everywhere. Teaching science to students offers them an opportunity to understand the world around them, understand how and why things work. It prepares them to think, learn, solve problems, make informed decisions, and pursue new interests. Middle school science education important in a students' life as it inculcates in them problem-solving and critical thinking skills which are two very important skills a student learns in school. It lays the foundation for a more advanced scientific thinking, logical and analytical skills.

Problem: Traditional science classrooms also face issues like the availability of textbooks, equipment, resources for hands-on experiments, training and professional development of science teachers, the need to meet standards and to prepare students for standardized examinations (Anderman & Sinatra, 2012). There are limited opportunities for students to develop critical thinking skills and to connect theoretical knowledge to real world applications. Many students are wary of learning science, they think that it is tough and that they are incapable of learning complex and complicated concepts, theories, and vocabulary, they also think that learning science is boring and useless (Shafer,2015). Science teaching is

more hands-on than other subjects and the science curriculum is driven by taking tests and exams, and the coverage of a lot of topics. Lab work is critical and often lab exams are a big part of the evaluation (Coppens, 2020). Other critical problems faced by science teachers in terms of doing hands-on experiments are:

1. Safety issues: conducting an experiment can be impacted by inappropriate behaviors of students, their handling of equipment or chemicals and not following directions.
2. Amount of time required for preparation to conduct an experiment: conducting a lab takes lot of advance planning and set up. Teachers also have limited time to conduct and clean up after the lab. Hence, they are limited in what they can do and achieve.
3. Budgetary constraints: basic lab equipment is expensive and not all schools can buy equipment or supplies needed to conduct experiments. Very often, science teachers are forced to make do with what is available and must plan around limited resources.
4. Teaching aids: It is hard to find prepared science materials and teaching aids. Most times is the science teacher who will create or find and buy the resources needed to do the job.

Solution: To overcome these challenges, educators need innovative approaches that foster active learning, critical thinking, and collaboration among students. It is extremely important to understand and build upon the abilities of the learners and engage them in their learning. Teachers need to nurture in their students a curiosity about the natural world and focus on the scientific process of discovery. In doing so, students will be more involved and actively engaged in the subject matter (Shafer, 2015). Active learning encourages a student to take an active role in their learning, it engages students through activities and/or discussion in class rather than passively listening to a teacher. It fosters critical thinking, problem solving, collaboration and emphasizes higher order thinking (Freeman, et. al., 2014).

Using “Virtual Labs” is a great way to actively engage students, develop mastery over a subject, developing scientific reasoning ability and cultivating interest in science (Assem, 2023). Virtual Labs

are an e-learning tool where a student can conduct many experiments in a virtual environment without the constraints of safety, time and other problems faced by real labs. It covers a wide range of science disciplines that helps them make connections between science and real world. The 3D animations, simulations, quizzes, and theory that are part of the labs make them all the more engaging to students. The labs can be accessed from any device with an internet connection, offer flexibility in performing experiments and can be repeated as many times as it takes to fully understand the material. They help students and teachers save time and effort and protect them from risks like dealing with hazardous or dangerous materials, chemicals, electricity or fire (Assem, 2023). Virtual labs are also cost effective as they do not need physical resources or and do not need constant maintenance that a physical lab needs. Virtual labs can also be paired with many active learning techniques, Think-Pair-Share is one of the classic strategies to engage students (Testa, 2020). The Think-Pair-Share technique is a collaborative learning strategy that encourages active participation and discussion in class. This is a 3-step technique in which the teacher asks an open-ended question about a topic and students THINK about it for a few minutes. Then they PAIR up with a partner and discuss the question for a few more minutes. Finally, the whole class engages in a discussion where all the students SHARE their thoughts and ideas (Robertson, 2006). Usage of this technique in classroom encourages active participation, peer-to-peer teaching and learning, fosters critical thinking and problem-solving skills and enhances communication skills (Robertson, 2006).

Implementation: Combining the Think-Pair-Share technique with virtual labs can enhance the learning experience for all students as it actively engages them, provides hands- on experiences as well as peer interaction. Students can think about their virtual lab experiments independently through quizzes and simulations, then pair up to discuss about what they learned and what they still need to figure out. Lastly, they share their insights with the class (Testa, 2020). This collaborative process promotes a deeper understanding of the material and creates a dynamic learning environment. To implement a

virtual lab, the classroom needs to have access to computers, internet connectivity and the required software for virtual lab simulations. Teachers would need training and professional development to become proficient in using the software and to effectively integrate the virtual lab as well as the Think-Pair-Share into their lessons.

Some virtual labs websites that can be used with middle school students are:

1. Explore Learning Gizmos
2. PHET Virtual labs
3. Nova Labs
4. The Concord Consortium
5. Inq-ITS Virtual Lab

Conclusion: When combined together Virtual labs and the Think-Pair-Share technique can enhance middle school science education as they connect classroom learning to real-world-applications in a collaborative and dynamic environment. When students think about a problem before, during and after their virtual lab, it enhances their critical thinking skills as they analyze data, make inferences, and consider alternative explanations. Pairing with a peer promotes problem solving, exchange of ideas, teamwork, and collaboration. By sharing the results of the virtual lab, students develop effective communication skills and are better prepared to apply scientific concepts to practical situations.

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Appendix:

1. This article is intended to be submitted for publication in the CSL “Connected Science Learning” journal published by the National Science Teachers Association NSTA.
2. This paper is a precursor to a study that is intended to be presented at the New Jersey Science Convention 2024.