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Learning Loss as Seen Through the Decline in Student Lab Skills Due to COVID-19

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Abstract: Learning loss due to COVID-19 in the science classroom extends beyond the academic measurements of standardized assessments. This loss limits students' ability to apply what they learn in the classroom to the real world. While schools were closed during the pandemic, students did not have the opportunity to enhance what they learned in the sciences with hands-on and inquiry-based experiences. This loss of experience left students unprepared to thoroughly learn science when they returned to an in-person classroom. The solutions to this loss of laboratory time, including virtual and at-home laboratory activities, did not bridge the gap needed to overcome the learning loss before the students returned to school. Though well-intentioned, the students did not develop the kinesthetic skills necessary to start the subsequent and more advanced laboratory course on their return. Some of these alternative solutions put the student and their family at risk to accidents while exposing the teacher and their districts to a broader range of liabilities. The focus of the science lab is to allow students to develop an understanding of the world around them in a safe and supervised environment. Pandemic-induced school closures hampered our ability to provide students with the experiences they needed to develop the understanding necessary to succeed.

Keywords: Lab Skills, Learning Loss, Science, Learning, Laboratory

1. Introduction

Our news feeds are inundated with headlines referencing the learning loss our students endured due to the pandemic. Learning loss, not to be confused with the learning loss that occurs over summer break, is when students do not learn content and skills on a level consistent with previous years' students [6, 13, 17]. Students suffered learning loss regardless of whether their schools were open or closed or operating on hybrid or virtual schedules. In the United States, over 60 million students were not allowed in their schools for some time during the pandemic [11]. These schools were not prepared to educate students remotely [16]. This is especially true with respect to hands-on learning experiences in the laboratory. Most studies on learning loss have focused on academic learning loss, especially in disadvantaged demographic groups, since this data is easily quantifiable through standardized testing. What gets measured gets reported. However, we need to recognize that other learning losses also occurred.

At the start of the 2021-2022 school year, school districts opened their doors to a regular full-time, face-to-face educational model. Schools were looking to bring student learning back to previous pre-pandemic levels. This was well-intentioned but lacked a focus on lab skills. Going back to hands-on inquiry-based learning was a more significant challenge than anticipated. The biggest challenge was reteaching our students the lab skills they “lost” during the pandemic. The next challenge was teaching advanced-level science courses to students who had never conducted authentic laboratory experiments during the pandemic due to school closures, virtual or hybrid learning, and social distancing. These students did not have the expected skill sets to conduct advanced laboratory activities in a rigorous setting. These skills are important to a student’s academic success [4, 14, 17]. A year later, during the 2022-2023 school year, students’ laboratory skills have not improved to the level they were before the pandemic. Through awareness, training, and resolve, educators must emphasize improving laboratory skills so that students may be more successful in their current

setting, post-secondary level, and future careers.

This article focuses on learning loss, as seen in the laboratory, through students' skills to collect data, perform experiments, and manipulate equipment. The purpose is to bring this issue to the attention of educators, both teachers and administrators, so that the correct actions can be taken to lessen the impact of laboratory learning loss.

2. Challenge

The pandemic challenged education as learning loss has been reported globally [2, 3, 7, 12, 13]. This learning loss can be seen across the entire education spectrum. Academic loss is easy to measure when one has years of standardized test data and can compare one cohort to others, and thus, the results are easy to report through the news [13]. Measuring lab skills takes work. There is no standardized test to report to the public that assesses how well a student measures with a graduated cylinder, manipulates tools used in an experiment, or how safely an experiment can be conducted. Therefore, since it is not measured, it is not reported. However, many science educators can tell that their students lacked laboratory skills when they returned to the classroom from the pandemic.

While many schools went to virtual, hybrid, or socially distanced learning models, laboratory activities and hands-on inquiry-based learning were difficult, if not impossible, to conduct [7]. However, laboratory activities are vital to a student's development in the discipline of science.[16] Students did not get to practice their lab skills, and educators could not assess them in an online learning environment [7]. Educators cannot expect students to progress as scientists without the ability to learn and practice their laboratory safety skills in a live laboratory setting. Even if educators tried to have students conduct activities at home, it was impossible to help them maintain and develop their skills. In the end, attending school in person and working in an environment set up for science laboratories is the best way for students to learn and improve their skills [1].

One of the first memories of returning to school after our pandemic-induced closing, followed by a hybrid learning environment, was the number of glassware students accidentally broke while conducting their first few "live" laboratories in almost 18 months. The students had lost their skills, and our responsibility was to help them re-develop their skills, as this was another learning loss that our students experienced.

3. Pandemic Era Solutions

There were many attempts to help students conduct inquiry-based learning activities during the pandemic. Many of them, including virtual labs and labs at home, were based on the best-case scenario and would not work today in a classroom where the students are completing the activities on campus.

3.1. The Argument for (or Against) Virtual Labs

Virtual laboratory activities were an excellent alternative to live-in-class laboratories. Virtual technologies may continue to be essential in developing students' inquiry skills [14]. In some cases, virtual investigations allow the students to explore concepts in an inquiry-based manner that they would not be able to do in the laboratory, such as using PhET to explore gravity. However, virtual labs are not an alternative that will allow students to improve their laboratory skills by physically manipulating science equipment and tools in the laboratory. The hands-on experiences allow students to develop the skills necessary to succeed in a real-world laboratory [6]. While students cannot develop these skills by manipulating virtual equipment, teachers cannot assess their lab performance and growth online [7].

When transitioning back to in-person schools in September 2021, teachers noticed a severe drop in the students' lab skills. Many students had not conducted an in-person laboratory activity in over 18 months. The virtual experiences did not compensate for the loss of in-lab experiences. Though the pandemic-era solutions were well-intentioned, they could not give the students the necessary experiences to grow as scientists as they need to experience the process of science. [2, 15] An international survey of school personnel revealed that loss of practical (lab) skills was a more significant concern than gaps in literacy or numeracy [2].

Doing science in the laboratory is vital to the development of the scientist [1, 15]. The experiences gained and the skills practiced are necessary for their success at the post-secondary level [17]. Virtual laboratories cannot compensate for the loss of in-lab experiences Because students are not doing real labs [6]. However, they were a solid alternative when school closures and social distancing required educators to look for other options [12, 15].

3.2. The Case Against Labs at Home

We do not recommend assigning laboratory activities outside of the school laboratory. If an educator assigns such an activity, they must provide the "Duty or Standard of Care" to keep their students safe from the risk that a reasonable or prudent person would foresee [9]. The teacher is the content expert, and most parents did not receive training to become content experts for laboratory procedures. Therefore, educators should not expect parents to act as such since any untrained parents will struggle to provide the level of guidance needed to develop student skills in the science laboratory. Not every parent is a content expert in the sciences or how to teach the sciences. Therefore, asking parents to provide the level of supervision that a certified teacher can provide when they have never been trained to provide adequate supervision is not acceptable [10].

Suppose an accident were to happen and someone in the vicinity of the accident is injured due to the accident. In that case, the teacher who assigned the activity and their school district can be found liable [5, 9-11]. If an administrator

approves the experiment being off school grounds, the administrator can share the liability.

It is only possible to provide the adequate supervision that a reasonable and prudent person would provide if the educator is in the same room or setting as the student(s) experimenting.

Conducting laboratory activities at home is not a prudent strategy to help students overcome the learning loss in the science lab they experienced as part of the pandemic.

4. Other Considerations

In addition to the broken glassware, educators must include other considerations when addressing the loss of lab skills due to the pandemic. Educators must address these losses and make temporary changes to the curriculum to provide students and staff with the time and practice needed to overcome the loss.

4.1. Advanced Preparation

Because of the pandemic, students were enrolled in AP-level classes who had not completed a physical laboratory activity at their school's pre-AP Program (not to be confused with the College Board's pre-AP Program). Educators are tasking students to perform University-level lab experiments using skills they have not sufficiently practiced in the introductory courses. Gizmos, PhET, and other virtual tools did not allow students to develop kinesthetic skills or the insights needed to complete the lab activities successfully [17]. This lack of experience is a hindrance that can have long-term effects that follow students into their post-secondary studies and careers [6]. Educators must decide whether to complete the "suggested" AP laboratory activities in preparation for the AP assessment or adequately prepare the students for the AP assessment while they develop their laboratory skills. It is a near-impossible task to complete both in a single school year.

Educators use prelab activities in various forms, and for this discussion, we will assume a focus on classwork. Requiring students to demonstrate skill competency (e.g., lighting a match or correctly filling up a buret with a solution) can be a way for teachers to determine the skill level of individuals or a class as a whole. The educator may supplement these prelab checks with an introduction (at the beginning of the period or in a previous class) where the teacher models the appropriate usage of lab equipment. Using student volunteers enhances engagement, or if a "cold calling" method is used, will force students to pay closer attention. Attaching a formative assessment mark may also be implemented to hold students accountable.

Now may be a good time to reevaluate the desired goals of the laboratory experiments performed in class. That is, one could argue that the "cookbook" style lab experiments, while helpful when the design is to gather an experimental value from lab data and compare it to a known result, do not enhance the development of a kinesthetic lab skill. For example, in an experiment to determine the percentage of water in a hydrate, students must essentially heat a mass of a compound (the aqua blue copper (II) sulfate is the most well-known) and compare the mass obtained before and after heating to determine a percentage composition or mole ratio. The execution of this experiment can be carried out in numerous ways. Students could be presented with a variety of equipment and be asked to use their group to build a setup that could heat the hydrate. Wire gauze-supported beakers/porcelain dishes, clay triangles with crucibles, and clamps holding test tubes are all viable solutions to the problem. After approving their design as described earlier, teachers should allow lab groups to test their setup. Multiple trials should be encouraged if time permits, with lab groups encouraged to try different designs.

4.2. Developing and Understanding of the World Around Them

Laboratory activities are a strategy to allow students in a hands-on environment to develop their lab skills and improve their understanding of the physical universe [8]. Without the proper laboratory experience, this is impossible. Virtual lab activities did a good job of bridging the gap when students could not perform in the laboratory.

To challenge intuitions and make connections, students need good lab data. Students need this data to develop an understanding of the world around them. The better the lab skills, the better the data collected, and the better the connections between the observed phenomena and the accepted theory.

The purpose of a quantitative lab, especially in the physical sciences, is often to use data to calculate a value and compare it to some known result. In the hydrate activity noted earlier, the different procedural methods provide a basis for evaluating their efficacy based on a percentage error determination. Furthermore, students can use qualitative observation (the hydrate turns white as it is heated) to decide for themselves how long the hydrate should be heated rather than give instructions to heat it for a predetermined time. Again, students can use the ease with which the end color can be determined (methods that allow for even heating, such as a porcelain dish, allow for better results than a test tube where the interior color cannot be seen) to evaluate the procedural method.

5. Conclusions

Educators are challenged to help students overcome the learning loss experienced due to the pandemic. This learning loss includes the students' laboratory skills. The challenge forces educators to decide how to address the laboratory learning loss in their current class offerings and how to get students to the level they need to be. Educators and administrators must make decisions focusing on the students' needs, the curriculum's demands, and the skills required to be a successful scientist. These are crucial to overcoming the challenges.

Future research must address this issue by developing

measures to determine student lab skills and determine if the learning loss as seen in student lab skills due to the pandemic still exists and what is being done to counteract it.

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