Introduction

The incorporation of hands-on investigations in science is a significant factor in student engagement (Satterthwait, 2010). Such activities have numerous other benefits for the students as well, including improved retention and understanding of the material, providing all students with a sense of accomplishment (not only those who excel at academic tasks) and improved language skills (both reading and oral communication) (Haury & Rillero, 1994). Satterthwait identified three significant factors that contribute to the success of student learning through hands-on activities: cooperative learning, object-mediated learning, and embodiment (Satterthwait, 2010). It is with all of these findings in mind that I strive to incorporate as much hands-on learning as possible in my science lessons.

Hands-on investigations in Action

During one of my professional year placements I taught pulley systems within the Grade 8 mechanical systems unit. When we began the section that discussed pulley systems and mechanical advantage, I decided to incorporate hands-on investigations into my lesson in order to teach the students the relevant concepts rather than lecturing them on the topic. I compiled a lab activity designed to allow the students to investigate the mechanical advantage of various pulley systems and to discuss the concepts in order to enhance their understanding of why that scientific concept is important in real life.

Learning Goal

To explore the concepts of theoretical and observed mechanical advantage (MA) using different pulley systems (i.e., single fixed, single movable, single fixed with single movable, double fixed with single movable, and an original design).

Expectations

- Overall: Investigate a working system and the ways in which components of the system contribute to its desired function.
- Specific: Use technological problem-solving skills to investigate a system that performs a function or meets a need. Use appropriate science and technology vocabulary in oral and written communication.
Materials
- Retort stand or other pulley support structure
- Pulleys
- String or rope
- Newton spring scale
- A weight (1000 g)

Procedure
1. Students should be put into groups to perform this activity. A group size of 3 or 4 students would be ideal.
2. Attach a weight to the bottom of the spring gauge. Record the weight of your weight on the observation page. You will use this same weight throughout the entire lab.
3. Suspend one pulley as shown in Figure 1 by using string to tie it tightly to the clamp on the retort stand.
4. Pass a length of string over the pulley.
5. Tie the weight to one length of the string and hook the spring scale to the other end of the string.
6. Lift the weight off the desk by pulling on the spring scale and record the reading on the spring scale in the observation chart.
7. With your group construct the pulley systems shown in Figures 3 - 4.
8. For each system, lift the weight off the desk and record the reading on the spring scale in the observation chart.
9. Design a pulley system of your own to try. Draw a diagram of your design in the space in the observation chart.
10. For your system, lift the weight off the desk and record the reading on the spring scale in the observation chart.

Each of the students was also required to answer follow-up questions to expand on their observations and make connections to other concepts.

Follow-up Questions
1. For each pulley configuration you studied (#1 to #5 on the observation chart), explain why someone would want to use that particular configuration. Your explanation should include information about the effort force, mechanical advantage, and any other reasons you can think of.

2. For each pulley configuration, is the theoretical MA and observed MA the same or different? If they are different, give a reason for the difference.

3. According to your textbook, the theoretical MA of a pulley system is equal to the number of ropes pulling up on the object being lifted. In Figure 1, MA = 1 but in Figure 2 MA = 2. Explain why these configurations have different MA in terms of how the effort force is applied to the system.
4. How could you determine the amount of friction that a pulley experiences? For Figure 2, estimate (calculate) the amount of friction, in Newtons, that the pulley experiences.

5. What is the general trend that you have observed for the MA of the pulley systems?

**Discussion**
Throughout the activity, the students participated in cooperative learning by working with the other members of their group. They were able to share and discuss their ideas with their peers, reflect on their ideas, and then draw conclusions. I believe that enabling this to happen in class was much more beneficial to student learning than delivering a one-sided, lecture-style lesson. The entirety of this activity had the students manipulating various objects in order to facilitate learning. I expect that this exposed the students to several experiences that they would not have gone through had I given them a lecture: they gained knowledge about how to construct a working pulley system, they were able to physically measure the force required to lift the weight and then calculate the mechanical advantage of each of the systems, and they were able to feel the difference while lifting the weight using each of the systems and then relate those feelings to the value they calculated for mechanical advantage. The physicality of hands-on activities such as this one helps the students to better understand the underlying science concepts. In addition, ways of applying mechanical advantage to the world outside the classroom were explored by the end of the activity through discussions about situations in the students’ lives where an effective pulley systems could help make a job easier (e.g., lifting a couch to the second story of a house).

**Conclusion**
I believe that Science teachers everywhere should be aware of the benefits of hands-on activities to student learning and try to modify their teaching to incorporate these activities whenever possible.

**References**