Grasping the Idea: Using Hand Dynamometry to Teach the Scientific Method to Elementary School Students

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Introduction

North Carolina Essential Learning Standards for grades 3-5 focus on Science as Inquiry. Science lessons must incorporate conducting simple investigations in small groups, developing predictions, utilizing advanced technology such as calculators and computers, keep accurate records, gather data in multiple trials, and express their findings through writing. In third grade, students are introduced to human body systems, specifically the functions of the skeletal and muscular system. Fourth grade expands upon this to include how exercise and physiological indicators play a role in maintaining health. Fifth graders expand upon the major systems of the human body, how exercise impacts those, and evaluating reliable sources of information. The “Which Hand is Stronger?” Lab meets those requirements by including background information on muscle and bone physiology as it relates to exercise and use, guiding students through hypothesis development, using charts and advanced technology including computers, hand dynamometer, pinch meter, myometer, and calculators, analyzing data collected over multiple trials, incorporating small group work, and prompting students to write about their findings and ask continuing questions.

Purpose & Aims

1. Develop a laboratory to teach the scientific method to elementary school students using hand dynamometry.
2. Present information on muscle and bone physiology as a supplement to North Carolina Elementary School Essential Learning Standards
3. Introduce rural elementary school students to a university research laboratory and equipment.
4. Provide a service-learning opportunity for undergraduate students in conjunction with PhUn week.

Methods

Subjects:
- 40 3rd, 4th, and 5th grade students from Mabel Elementary School, Watagua County, NC.

PhUn Week:
- 23 of the 4th and 5th grade elementary school students travelled to Appalachian State University for PhUn week activities. One of these activities included collecting baseline hand grip, lateral pinch, and forearm strength measurements.

Results

Dynamometry Data:

![Average Force Output for Hand Grip, Lateral Pinch, Arm Flexor](chart1)

![% Instances Hand Dominance Correlated to Force Output](chart2)

Text Analysis:
- In 94% of cases, students were able to correctly predict and/or provide an explanation as to why their hypothesis was or was not correct.
- Discussion topics included differences in activities performed by dominant and non-dominant hands and relating hand use to strength.
- 50% of students also included a question related to the activity.

Participant Feedback:
- Elementary school teachers involved with the study indicated that the lessons presented were developmentally appropriate and expanded upon the material that they had covered in science, health, mathematics, and writing lessons.
- The lesson length was appropriate - approximately 60 minutes.
- Teachers reported that students were enthusiastic about participating and engaged.

Conclusions

The “Which Hand is Stronger?” laboratory and worksheet were effective at presenting the scientific method to elementary students.

Hand dynamometry, pinch strength, and arm flexor strength were suitable measurements because students could relate hand dominance to hand, pinch, and forearm use in everyday activities (e.g. writing, throwing, drawing, lifting objects).

Elementary students were able to write a hypothesis, correctly analyze data, and evaluate in writing why their hypothesis was or was not correct. When prompted, they asked further questions relating to the experiment.

Despite current literature, our findings show that hand dominance does correlate to hand grip, lateral pinch, and arm flexor force output.

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GRAPSGING THE IDEA: USING HAND DYNAMOMETRY TO TEACH THE
SCIENTIFIC METHOD TO ELEMENTARY STUDENTS

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Abbreviated Title
USING HAND DYNAMOMETRY TO TEACH THE SCIENTIFIC METHOD

Keywords
Physiology, Exercise Science, PhUn Week, Hand Dominance, Grip Strength
ABSTRACT

North Carolina elementary school essential learning standards require students to understand both the scientific method and the functional interaction of muscles and bones. A technology-based laboratory was designed to help students grasp the concepts in an innovative way, while also introducing the students to a university research laboratory. The activities were lead by undergraduates in conjunction with the American Physiological Society’s Physiology Understanding (PhUn) Week. The “Which Hand is Stronger?” lab used hand dynamometry as a model to teach 3rd, 4th, and 5th grade students the scientific method since this methodology can be used to evaluate a simple, developmentally appropriate question; does hand dominance influence hand strength? The laboratory guided students through the scientific process: introducing background information on muscle and bone physiology, hypothesis development; performing functional tests and analyzing the data; and drawing a conclusion based on their results. A hand dynamometer (Biometrics Ltd. Newport, UK) was used to determine force of hand grip strength for both the left and right sides. With assistance, the students analyzed and recorded their force output data using software interfaced with the testing equipment. Most students concluded that their hypothesis that hand dominance was associated with grip strength was correct, however, this was not true for some individuals. This provided an opportunity to discuss proper interpretation of results and physiological differences related to the measures. Elementary teachers surveyed were enthusiastic about the lessons and determined that the laboratory was age-appropriate and met curriculum standards.
INTRODUCTION

Objectives and Overview

Background: North Carolina Essential Learning Standards for grades 3-5 focus on Science as Inquiry. Science lessons must incorporate conducting simple investigations in small groups, developing predictions, utilizing advanced technology such as calculators and computers, keep accurate records, gather data in multiple trials, and express their findings through writing. In third grade, students are introduced to human body systems, specifically the functions of the skeletal and muscular system. Fourth grade expands upon this to include how exercise and physiological indicators plays a role in maintaining health. Fifth graders expand upon the major systems of the human body, how exercise impacts those, and evaluating reliable sources of information. The “Which Hand is Stronger?” Lab meets those requirements by including background information on muscle and bone physiology as it relates to exercise and use, guiding students through hypothesis development, using charts and advanced technology including computers, hand dynamometer, and calculators, analyzing data collected over multiple trials, incorporating small group work, and prompting students to write about their findings and ask continuing questions.

Learning Objectives: After completing this activity, the student will be able to: describe the functional interaction between muscle and bone, understand how hand dominance relates to hand use, utilize presented information to develop a prediction, keep accurate data records, perform simple averages using a calculator, interpret their findings,
determine if their prediction was correct and provide an appropriate rationale, develop further research questions.

**Activity Level:** This activity is suitable for elementary school students in grades 3-5.

**Prerequisite Knowledge and Skills:** Before doing this activity, students should have a basic understanding of muscle and bone anatomy and physiology. Students should know how to: perform simple averages using a calculator, keep information in a data table, write 3-5 complete sentences on a topic.

**Time Required:** This activity had two components: 4th and 5th graders visited the university where the equipment had already been set up and took approximately 1 hour. A student volunteer and professor visited the 3rd grade classroom, so the entire lab took approximately 2 hours.

**METHODS**

**Equipment and Supplies:** hand dynamometer with DataLink System from Biometrics, Ltd., Newport, UK, laptop, “Which Hand is Stronger?” worksheet, basic calculators, writing supplies.

**Human or Animal Subjects:** This project was exempt from Appalachian State University’s Institutional Review Board. Adopters of this activity are responsible for obtaining permission for human or animal research from their home institution. For a summary of Guiding Principles for Research Involving Animals and Human Beings,
please see www.the-aps.org/mm/Publications/Ethical-Policies/Animal-andHuman-Research.

**Instructions:**

1. Gather all equipment, set up Datalink system, print enough worksheets for each student, and divide students into small groups of 4-6 children.

2. Pass out a worksheet to each student. Present background information on muscle and bone physiology relating to hand grip strength; explain the concept of hand dominance; define/explain hypothesis and scientific method.

3. Using the worksheet, ask students to identify their dominant and non-dominant hands. Indicate on worksheet.

4. Ask students to write a hypothesis based on the information presented- will their dominant or non-dominant hand be stronger? **Example:** My **dominant hand will be stronger than my non-dominant hand because I use my dominant hand to write with.**

5. In the small groups, help the students collect hand dynamometry data. Each student will perform 3 trials of force output data on both the dominant and non-dominant hands. The arm will be held straight out, perpendicular from the trunk at a 90 degree angle. Cue the student to relax their hand, then squeeze the dynamometer as hard as they can for a count of 3, then relax. Perform 3 times on each hand for a total of 6 trials (3 dominant, 3 non-dominant). Have the student record the force output values in the provided chart.
6. Using the calculators, the students will determine the average value of the three trials. Based on individual skill level, students may need help with the computation. Once the average values for dominant and non-dominant hand force output has been determined, have the student circle the higher value on the worksheet.

7. Using all of the information on the worksheet, ask the students to write if their hypothesis correct, provide reasons as to why or why not, and encourage them to ask further questions pertaining to hand dominance, the scientific method, and the experiment.

**Troubleshooting:** This laboratory presented minimal issues for students and teachers. The third grade students had not had enough practice with performing averages and required help from the teachers. We wrote the instructions for entering the information into the calculator correctly on the blackboard, since many students were confused on which order to enter information into the calculator (trial 1 + trial 2 + trial 3) enter / 3 vs. (trial 1 + trial 2 + trial 3 / 3).

**Safety Considerations:** This laboratory does not pose safety risks to students above and beyond normal classroom activities.

**RESULTS**

**Expected Results:** While the literature has indicated that there is not a significant difference in force output of grip strength between dominant and non-dominant hands, our results indicated that hand dominance positively correlated to hand strength in 80%
of individual cases. Average left grip force output was 15.4 N and average right grip force output was 16.7 N. More students were right hand dominant than left hand dominant.

**Evaluation of Student Work:** A text analysis was performed on the discussion section of completed student worksheets. In 94% of cases, students were able to correctly predict and/or provide an explanation as to why or why not their hypothesis was correct. The author gave credit for demonstrating an understanding of the material if the student included a statement as to whether or not the hypothesis was correct and provided a rationale relating hand use to hand strength. In cases when the prediction was incorrect (data showed that the non-dominant hand was stronger than dominant hand), students provided a rationale such as “I write with my non-dominant hand, but use my dominant hand for chopping wood which requires more strength.” In 50% of cases, students also included a further question such as, “why was the non-dominant hand stronger even though the dominant hand gets more use” and “how do muscles grow after a workout?” In order to complete the worksheet, teachers and volunteers checked the student’s average calculations before proceeding to data analysis.
WHICH HAND IS STRONGER?

Most people have a hand that they prefer to write and throw with. In the Exercise Science world, we call this hand dominance. Many people are right-hand dominant, while some are left-hand dominant, and others have no preference, which is called ambidextrous. Your hands and arms have many small muscles that help you do everything from drawing, playing an instrument, driving a car, holding a glass, and typing on the computer. These muscles, just like all of the muscles in your body, get stronger the more you use them. We can test the strength of your hands and fingers by using a dynamometer. When it is connected to a computer, the dynamometer reads how much force your muscles are using to squeeze the handle. We can also look to see how hard your muscles are working through the EMG. When you make a muscle, your brain sends an electrical signal down your spinal cord to the muscle. This signal goes down your muscles and can be read by the sensors on your skin (don’t worry, you can’t even feel it happening). The harder you squeeze your muscles, the taller the lines get! Using this information, we’re going to do an experiment.

Instructions:

1. **Determine which hand is your dominant hand.** This is usually the hand you write with. Are you right handed or left handed? Are you ambidextrous?

   Dominant hand : _____________________
   Non-dominant hand: __________________

2. **Write a hypothesis.** A hypothesis is the question you’re studying. Will your dominant hand be stronger than your non-dominant hand?

   ______________________________________
   ______________________________________
   ______________________________________

3. **Perform the experiment.**
   a. Hold the dynamometer in your non-dominant hand.
   b. Squeeze it as hard as you can for 5 seconds.
   c. Relax for 10 seconds.
   d. Squeeze it as hard as you can for 5 seconds, then relax.
   e. Squeeze it as hard as you can one more time for 5 seconds.
   f. Relax.
   g. Repeat with your dominant hand.
4. A teacher will write down the numbers for you.

<table>
<thead>
<tr>
<th>Trial</th>
<th>Dominant Hand</th>
<th>Non-Dominant Hand</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

5. Analyze your results.
   a. First, we'll look at your non-dominant hand.
   b. Add all of the non-dominant hand values given to you by the teacher, and divide by 3.

   \[
   \frac{(\text{Session 1: } \text{_________} + \text{Session 2: } \text{_______} + \text{Session 3: } \text{_______})}{3} = \text{_________}
   \]

c. Do the same thing for your dominant hand.

   \[
   \frac{(\text{Session 1: } \text{_________} + \text{Session 2: } \text{_______} + \text{Session 3: } \text{_______})}{3} = \text{_________}
   \]

d. Was one number higher than the other? If so, for which hand?

   Dominant Hand | Non-dominant Hand

6. Write about it! Here are some questions to think about: Was one hand stronger than the other? Why do you think that is? What are some activities that you do with one hand, but not the other? Was your hypothesis correct? Write one question you have about muscle strength, hand-dominance, or the scientific method.

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