# Elective 5: Modifying for Levels of Inquiry (LoI)

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<tr><td>Resource:</td><td>Push Harder - Newton's Second Law</td></tr>
<tr><td>Resource Description:</td><td>This lesson is a hands-on project that allows students to build their own cars using craft materials as a way to explore the relationships between force, mass, and acceleration. The students get to graph data and make observations in real-time by using either the Google's Science Journal app or with a meter stick and stopwatch.</td></tr>
<tr><td>NGSS Alignment:</td><td>
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<tr><td>MS-PS2-2.</td><td>Plan an investigation to provide evidence that the change in an object's motion depends on the sum of the forces on the object and the mass of the object.</td></tr>
<tr><td>Science & Engineering Practices</td><td>Planning and Carrying Out Investigations. Plan an investigation individually and collaboratively, and in the design: identify independent and dependent variables and controls, what tools are needed to do the gathering, how measurements will be recorded, and how many data are needed to support a claim.</td></tr>
<tr><td>Disciplinary Core Ideas</td><td>PS2.A: Forces and Motion. The motion of an object is determined by the sum of the forces acting on it; if the total force on the object is not zero, its motion will change. The greater the mass of the object, the greater the force needed to achieve the same change in motion. For any given object, a larger force causes a larger change in motion.</td></tr>
<tr><td>Crosscutting Concepts</td><td>Patterns. Graphs, charts, and images can be used to identify patterns in data.</td></tr>
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<tr><td>Physics Content Connections:</td><td>The students design and build their own vehicle to house an accelerometer (cell phone with app) to execute an experimental plan to explore the relationship between force and acceleration by collecting and graphing appropriate data. Specifically, the students explore how the size of a force (push strength) exerted on an object (vehicle) affects its acceleration. The students explore the relationship between force and acceleration with the help of a student worksheet asking them to record and average the maximum acceleration acquired from three trials at each push strength level (light, medium, and hard). They are also asked to make a graph of the maximum acceleration versus the strength of the push. The lesson culminates with reflection and discussion about the trends that were found in the data, the relationship between force and acceleration, and determining if other variables such as mass impact acceleration as suggested by Newton's 2nd Law of motion.</td></tr>
<tr><td>Pros and Cons:</td><td>Pros:
<ul>
<li>Students design and build their own vehicle to explore the relationship between force and acceleration.</li>
<li>Students collect and graph appropriate data needed to identify acceleration patterns based on different size forces.</li>
<li>Students provide evidence (graphs) that the change in an object's motion depends on the forces acting on the object.</li>
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Cons:
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<li>Student's follow a teacher-guided inquiry protocol instead of devising their own experimental plan.</li>
<li>Students aren't encouraged to explore other variables such as mass and</li>
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| | friction that also impact acceleration. .<br>● Difficult to keep the push forces constant.<br>● Student's are not encouraged to calculate the net force being exerted on the cars while the mass remains constant. |
| **Modifications for low LoI:** | During the "engage" portion of this lesson the instructor demonstrates how to use the accelerometer in the Google Science Journal app. He or she would open the accelerometer and put the phone on a table (with the screen facing up), press record, push the phone forward slightly, and then press the stop recording button. A graph would appear and the instructor would ask the class what they see in the graph, ask if they could explain what was happening, and then explain how positive and negative acceleration are reflected in the graph. According to Wenning (2005), this teaching practice exemplifies an intermediate level of inquiry known as "Interactive Demonstration" which generally consists of a teacher demonstrating a scientific apparatus, such as an accelerometer, and then asking probing questions about how something might have happened. As an alternative to using an interactive demonstration (intermediate LoI) a teacher might also try using a more basic form of inquiry-oriented learning known as "Discovery Learning" (Wenning, 2005). The teacher could instruct the students to use the provided materials to design and build a car (without the use of the accelerometer) to be used as a mechanism to explore the concept of acceleration. The teacher could use a sequence of questions (Does your car move? What forces are causing your car to move? Can your car move slowly? fast? very fast? How does force affect motion?, etc.) during and/or after the experience to guide the students to a conclusion about how acceleration (changes in motion) is impacted by force. |
| **Modifications for high LoI:** | This lesson might be classified as an "Inquiry Lesson" (Wenning, 2005) because the teacher makes certain that proper experimental protocols are observed such as the control of variables (e.g., one independent variable (push force) and one dependent variable (acceleration) tested at one time). This lesson requires that the experiments be conducted in a proper order. In order to take this inquiry lesson to a higher level of inquiry practice, the students would have to develop (independently) an experimental plan and collect appropriate data reminiscent of an "Inquiry Lab" (Wenning, 2005). Transforming this lesson into an inquiry lab approach, allows the students to analyze the data from their experimental plan to find a precise relationship among the variables (force and acceleration) with minimal guidance from the instructor. |
| **References:** | Wenning, C.J. (2005). Levels of inquiry: Hierarchies of pedagogical practices and inquiry processes. *Journal of Physics Teacher Education Online,* 2(3), 3-12. |