Evaluation: Year 3,4 & 6 Hughesdale Primary School
Energy and forces workshop

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Location: Hughesdale Primary School, VIC
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Overview

FLEET visited Hughesdale Primary School during National Science Week to conduct the workshop, 'Energy and forces' for all students in Years 3, 4 and 6. Each workshop ran for 50 minutes and there were up to two classes per workshop. The workshop consisted of an introduction to FLEET, an overview of the concept of energy and different forms of energy, and the hands-on activity where the students built and used catapults. There was a pre- and post-evaluation exercise also conducted to assess the impact of the workshop relative to the objective outlined below.

Highlights

- 280 Primary students engaged with FLEET members, their research and hands-on activities to learn about energy and forces
- Students showed they developed a deeper conceptualization of what energy is, how humans use and value energy, and the implications of its use.

Workshop objectives:

- For students to understand the basic types of energy and the concept of conservation of energy
- For students to understand the difference between kinetic and potential energy
- To increase awareness among students of FLEET research, to get them thinking critically about FLEET's research problem and how we value digital technology.
- To have students thinking critically about society's use of energy

Method

Following an introduction, the students were divided into two groups to conduct the catapult building and modification exercise. Because of the short time frame, the catapults were pre-built for the students. A FLEET member discussed with the students the different components of the catapult and got the students to indicate where the different forms of energy (potential elastic energy, kinetic energy) were in the catapult. Students then had to test the pre-built catapult out to see how high and far it would fling a projectile (weighted cotton wool ball). This was the observation phase. They were then asked to think about how they could modify the catapult and to make a prediction about what that modification would do. Students then made the modification and tested their prediction.

Students conducted pre-and post-evaluation activities and a short reflection. A detailed description of each component of the workshops follows.

Evaluation

Pre- and post-evaluation was conducted to assess the impact of the workshop. Before the introduction and the hands-on activities, students were asked to think about the following question: What comes to mind when you think of energy? We conducted this as a form of

brainstorm session where we asked students to yell out their answers and a FLEET member wrote responses on a whiteboard.

The process was repeated at the end of the workshop as part of the post-evaluation. We photographed the whiteboard after each Pre- and post-evaluation session and compared the responses using thematic analysis to determine the impact of the workshop.

Introduction

At the beginning of the workshop students were introduced to the difference between kinetic and potential energy, and the transfer of energy using the ball drop demonstration. The ball drop demonstration involves placing a tennis ball on top of a basketball and dropping the two from a height simultaneously.

After the ball drop demonstration, we introduced FLEET's research and the motivation for this research, which was framed around the problem of the increasing energy consumption of digital technologies. A FLEET member facilitated a short discussion in the context of FLEET's research problem to examine how students value digital technology. The students were encouraged to think critically about how they use digital technology, its value to them, the implications of energy consumption of such technologies and the acceptability of potential solutions.

Reflection

After the hands-on activities, students came together for a short reflection to examine what they learned. This was integrated into the post-evaluation discussion and was facilitated by FLEET. Again, the short time frame meant the discussion about what they learned about energy from their hands-on activities and its link to the energy consumption of digital technologies was brief.

Hands-on activities

Catapult

Students used and modified the catapult that is described in the FLEET home science experiment found here - https://www.fleet.org.au/blog/catapult/

Working in teams of 2-3, students had to apply the physics of potential elastic energy stored in the rubber bands and the icy pole stick, and the effect of different fulcrum points to do three tasks:

1. Students had to adjust the fulcrum point of their catapult and observe the height and distance their catapult flung their projectile.
2. Students modified their catapults to produce a desired effect (eg greater height or distance that the projectile could be flung). Student had to come up with a prediction/hypothesis for what their modification would do, test that idea and observe the effect.
3. Students used their modified catapults to play a game that involved flinging their projectile into bowls and cups that represented food and medical drops across a flooded river. Each bowl or cup was allocated a certain number of points. Some bowls/cups were called red cross volunteers and points were taken away for landing a projectile in these vessels.

Results

The exercise for all year levels was working in teams and starting to understand the scientific process of observation, prediction and testing. We did not evaluate how students tested their prediction or the outcomes of their predictions, but based on the post-evaluation a small number of students thought that their modification had an effect on projectile height and distance. FLEET supervision of students in this activity can also confirm that students made predictions, a modification (or a series of modifications) and then tested and observed the effect. What we evaluated is what students learned about energy, regardless of whether it was linked to the function of their catapult. The evaluation suggests that students did apply what they learned about potential and kinetic energy to modify their catapults. See Table 1. When we discussed students' modified designs with them, they showed they were trying to apply ideas such as increasing the elastic potential energy of either the lever or rubber bands. Their execution of the idea was often flawed, but following discussion, subsequent modifications were typically more successful.

For example, students wanted to add more potential elastic energy to the lever and examples of their first modifications were like those in Figures 1 (a) and (b). Observation, refining and further modification produced more effective catapults such as those in Figure 2.

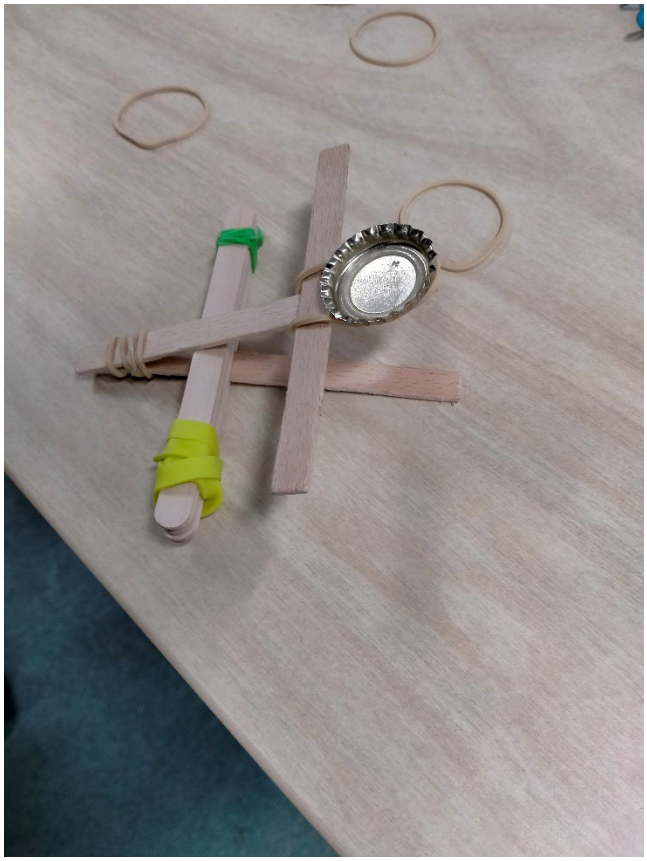

Figure 1(a) An early modification to increase potential elastic energy to the lever – the cross-stick modification

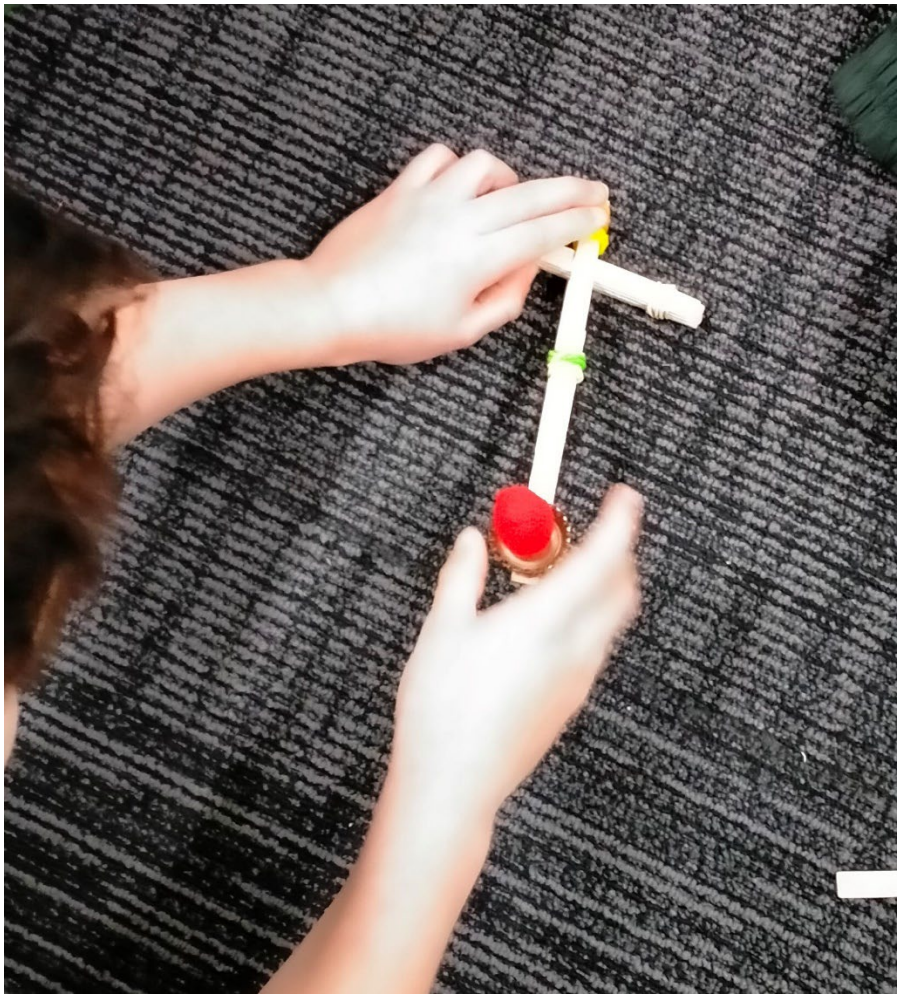

Figure 1 (b) An early modification to increase potential elastic energy to the lever – extended lever modification

Figure 2. Students' later modifications were more successful. Two layer of icy pole sticks increased the strength and potential elastic energy of the lever.

Pre- and post-evaluation and reflection

Students were asked what comes to mind at the beginning of the workshop and then again at the end. I compared the responses to understand if there was any impact relative to our objective of student understanding of energy and critical thought about FLEET's research problem, how we value digital technology and the implications of how we use digital technology.

The short time frame meant we only recorded single responses on the whiteboard. For example, different students might repeat the word lightning, but we would only record it once. Therefore, analysis of the pre- and post-responses is qualitative only. Reflection was integrated into the post-evaluation discussion.

The students' pre-evaluation responses to the question, What comes to mind when you think of energy were similar across the three year levels. They were grouped under the following themes:

- Human energy: Students used words to describe their perceived relationship between energy and the human body, for example, running, crazy and stamina.
- Energy forms: Student listed different forms of energy such as kinetic, potential and electrical.
- Providing energy: Students responded with things that provide energy such as the sun, lightning, or fuel.
- Tech using energy: Students listed the names of devices/technologies that use energy such as iPads, TVs or transport.
- Scientific – base level: Student responded with words that indicated a base level of scientific understanding about the nature of energy, for example, E=mc2, friction, atoms and watts.

The post-evaluation responses across all year levels suggest learning occurred and the students thought critically about how we value and use energy. See Table 1 below for the breakdown of pre- and post-responses for each year level. The post-responses were grouped under the following themes:

- What is energy: Students considered where energy comes from, or that devices produce heat energy when used.
- Applying understanding of energy: Students applied what they had learned and experienced with the catapults to understand the relationships between force and the forms of energy and how we can use that to do work.
- Implications: Students thought about the implications of our use of energy providing descriptions such as, make devices that use less energy, or Lots of energy use is bad for the environment.
- Energy forms – higher level: This is similar to the pre-responses but using words that suggest a deeper understanding such as elastic energy, transferring energy, and still objects still have energy.
- Tech using energy: As with pre-responses, but a lot fewer responses in comparison.

Table 1. Pre- and post-evaluation responses from Hughesdale Primary students to the question, What comes to mind when you think of energy?

Grade 3 pre-evaluation responses [themes]	**Grade 3 post-evaluation responses [themes]**
Energetic (human) / strong / play – lots of energy / psycho / Getting a boost / crazy / powerful **[Human energy]**	Cannot be destroyed / comes from Big bang / using (electrical) energy in devices makes them hot **[What is energy – deeper thinking]**
Sun / Oil / Fire / Lightning bolt / Big blue sparks / electricity **[Energy forms]**	Energy needed to make technology work / Lots of energy use is bad for the environment **[Implications]**
Ipad / Air pods / Phones / laptops /TV / Technology / Apple watch / light / airplane / charge up / transport **[Tech using energy]**	Changing the angle (of the catapult) will change the trajectory (of projectile) / Change pressure (on lever) = more elastic energy / Changing angle (affects the projectile) **[Applying understanding of energy]**
*Protons and electrons / friction / atoms **[Science words – base level]**	Transportation **[Tech Using energy]**
Grade 4 pre-evaluation responses [themes]	**Grade 4 post-evaluation responses [themes]**
Light / solar panels / Technology **[Tech using energy]**	Kinetic energy / Potential energy / transferring energy / Elastic energy / Food = more energy, which is transfer of energy / electrical **[Energy forms– higher level]**
Force / Lightning / Sun / space / Fuel / power **[Providing energy]**	Burning coal / solar / **[Tech Using energy]**
Kinetic energy / transfer of energy / potential energy / Electricity **[Energy forms]**	Supersonic – Chaos emeralds
Exercise / Stamina / fitness / running / play sport / energy (human) / running around / Sport / Renegade / Speed / Sugar / Powerade / Glucose **[Human energy]**	Make devices that use less energy / use fire more efficiently **[Implications]**
	Sim cards in phones / LEDs / electronics **[Tech using energy]**
	Catapults / Force (pushing) gives elastic (potential) energy / Pushing (force) provides elastic energy / More force = more energy **[Applying understanding of energy]**
Grade 6 pre-evaluation responses [themes]	**Grade 6 post-evaluation responses [themes]**
Volts / Watts / Electricity / Power / Science / E=mc2 / **[Scientific – base level]**	Two types of energy – kinetic and potential / transfer of energy / Still objects still have energy **[Energy forms– higher level]**

Running / Speed / Excited / Food / Brain / Being hyper / Jumping / Psychic / energy in body **[Human energy]**	Catapults / bouncing ball = energy / steadiness = accuracy (catapults) / Greater tension (on lever or rubber bands) has more energy / more stick = projectile going further **[Applying understanding of energy]**
Light / Cars / Electronics / solar panels **[Tech using energy]**	The more you use it (devices) the hotter it gets = heat energy / wasted energy / how often we use it (devices) **[Implications]**
Lightning /Ultrasonic /Kinetic **[Energy forms]**	

The majority of the student pre-evaluation responses to the concept of energy were associated with two themes: tech using energy and human energy. Responses reflecting the human energy themes did not emerge in the post-evaluation responses and responses under the theme, tech using energy were minimal. There was a complete shift in student thinking about energy following the workshop with new themes emerging in the post-evaluation responses. Responses also shifted from one or two words to short descriptions. Responses shifted from what energy does (makes you run or be crazy) and what uses it (devices), to what energy is (kinetic, elastic, potential, conservation of energy), how can we use it (to change the effect of their catapults) and consideration for the implications of how society uses energy (The more you use it [devices] the hotter it gets = heat energy, and make devices that use less energy).

*A caveat for the year 3 pre-evaluation responses is that at least two of these examples under the theme [Science words – base level] came from my son, who I used as the test pilot for parts of this workshop. Therefore, the responses to this theme in the pre-evaluation for grade 3 students suffer from sample bias.

Impact

Pre- post-evaluation data

Students were able to conceptualize and understand energy with greater depth, and a small number of students across all year levels thought critically about FLEET's research problem and FLEET's aim to develop energy efficient electronics. In the short time available to engage the students it was always going to be difficult to cover in-depth the purpose of hands-on activity and conversations around FLEET research. The focus in this instance was on the concepts of energy and applying that to the catapult activity.

Regardless, the shift in themes between the pre- and post-evaluation questions suggests that students learned about the types of energy and how to apply that knowledge to improving their catapult (eg, Change pressure (on lever) = more elastic energy). They began to understand the concept of conservation of energy (eg, Cannot be destroyed; and Food = more energy, which is transfer of energy). And they began to think at a deeper level about what energy is and the implications of that to the world they live in (eg, the more you use it (devices) the hotter it gets = heat energy/wasted energy).

Limitations

There is a degree of priming in the student responses in that they are likely to be repeating things they have just heard or that we emphasize. But in the reflection and post-evaluation

session, we deliberately tried to get students to provide their thoughts without any prompting other than the question, What comes to mind when you think of energy? We did get them to elaborate on what they meant with certain responses. For some classes where it had not been raised, we did ask the student to tell us about their use of electronic devices. This prompted them to remember about heat as wasted energy, or that devices use lots of energy and we need to develop more efficient devices. While there may have been some degree of priming influencing these responses, it the fact they recalled it and good articulate its significance (to varying extents) suggests there was a degree of learning and critical thinking.

FLEET Reflection

With short engagements such as this it would be good to find a short interactive to engage students (or adults) with FLEET's research and research problem. The jumping rings apparatus is an effective and engaging way to explain resistance and heat, but that is often not accessible for FLEET outreach. The solution will need to be simple and portable, but something that students remember. For example, the jumping rings is something that resonates and has good recall with those who interact with it.