Chapter 4 Methods B: Modification of Science Activities for Students with Disabilities

4.0

The following sections are dedicated to the science activities performed by students during each case study, and the methods developed to modify each activity for ID. These modifications also allowed for any physical disabilities that particular students had. As mentioned in the previous chapter, no such modified programs, aimed at using science learning as a vehicle for social and personal skills, are currently known to be implemented for students with ID.

There are many possible reasons for this. It is likely that the research-practice gap, highlighted in chapter five of the final findings of the Senate Inquiry, has not allowed Australian educators to benefit from recent research (Australian Senate Standing Committee, 2016b). To avoid falling into this research-practice gap, this chapter provides highly detailed descriptions of the science program and how it was modified for the student participants (see section 4.3 below). It is hoped that such a high focus on practical details will prevent my method of modifying science for ID being dismissed as purely theoretical.

4.01 Building on the work of recent scholars

I use the PAST model, as described in section 2.9.3, as the focal point of the intervention program of science activities. Specifically, I focus on Stocklmayer and Gilbert's idea that genuine interaction with science activities can produce more than science learning; it can also enhance how we make meaning of the world (Stocklmayer & Gilbert, 2010). I interpret this as a possibility to use science activities to enhance one's interactions with the world, by facilitating the improvement of one's personal and social skills. In the past there has been the assumption that students with disabilities gain greater benefit from more didactic instructions (Collins, 2012; Gallagher, 2004; Rowe, 2006). Consequently, teaching staff may not have the skills for modifying science activities according to the personal and open-ended focus of the PAST model.

As a result, I had to develop my own method of modifying science activities for students with ID. I had to ensure that this method of modification was systematic enough that it did not risk being dismissed as *ad hoc*. I therefore followed the example of Knight and others, who focused on a systematic 'preparedness' for dealing with whatever needs a student with disabilities may have (Knight et al., 2019a). Knight's work seems particularly relevant to science communicators working with students with ID, as she also takes into account behavioural and communication difficulties (Knight, Wright, & DeFreese, 2019b; Wright et al., 2020). Nevertheless, Knight and others (2019b) also acknowledge that the systematic delivery of science to students with ID still needs to be flexible enough to allow individual students to develop genuine personal understanding, beyond the explicit directives of staff. I therefore attempted to build on the research of Jimenez and others, who provide explicit instructions for students with ID, without restricting their personal input and free participation (Courtade et al., 2014; Jimenez, 2018). That is, Jimenez seeks to guide students with ID through habits of thoughts which would allow them to achieve academic skills for themselves (Jimenez et al., 2021). Drawing from these scholars, I have attempted to create a systematic method which provides students with ID with enough instructions to actively engage in science activities, while also directing them to use their skills to overcome any difficulties that their disability may cause. My methods seek to instil what Jimenez and others call 'Habits of Mind' (Jimenez et al., 2021). While Costa and Kallick (2008) first developed Habits of Mind for students and schools , Jimenez hones this method to focus specifically on students with ID. The Habits of Mind allows the student to overcome difficulties independently, without focusing on a fixed answer or outcome beyond the exercise of the student's own intellect (Costa & Kallick, 2008; Jimenez et al., 2021). To this extent, my methods also draw on the work of Faragher and Clarke, who focus on students with Down Syndrome (Faragher & Clarke, 2015). These researchers acknowledge the needs of students with Down Syndrome and incorporate these into their academic instructions. For example, they recognise the common difficulties of students with Down Syndrome with regard to numeracy. Therefore, when teaching mathematics, students are instructed on how to work through these difficulties, as well as whatever mathematical process is being taught (Faragher & Clarke, 2015). While being guided by, and building upon, all the research mentioned here, my own methods differ fundamentally in their aim. Specifically, while the scholars mentioned here seek to genuinely engage students with ID for academic progress, my thesis attempts to engage students with ID in science to further develop their personal and social skills. In my modification of science activities, science is a vehicle to develop the observational, rational and practical skills needed for fuller inclusion in society.

The benefits of a systematic method of modification is that it is replicable and therefore assessable and verifiable, as is desired of scientific procedures (Schrenk, 2017). The danger in disability studies and science communication alike, is that the method may replicate the limitations of the researcher, namely my own limitations. To avoid this, some level of reflexivity is required, and ideally this should be transparent throughout the communication of the method development (Rinaldi, 2013). I have attempted to do this through the use of subjective language and personal pronouns, so as to reveal my personal intentions and actions throughout the development of the method of modification. Moreover, such use of language indicates that this was only my personal experience of the students during the activities. Other science communicators may not have the same experience. Likewise, what is provided in this chapter is the students' intellectual and visceral response to the way I conducted the science program (Hoepner, 2017). It is an insight into the personal context of each student's experience (Falk & Dierking, 2018). This may not happen in other circumstances. The intention in detailing the procedures of the program in this manner is that it demonstrates a method that can be replicated when modifying science for students with ID in other circumstances. The method persists beyond the subjective experiences. The use of subjective language is merely an attempt at transparent "subjective ethnography" that has been long called for in disability research (Goodley, 1999, p. 25), and as I have explained previously (see section 3.1.1), it is a safeguard for those who may wish to build on this method, by revealing my personal effect upon it. A more objective point of view will be presented in the Results and Discussion chapters.

4.1 Developing a Systematic Method for Modifying Science Activities

To develop such a method, I was guided by the principles of the emancipatory paradigm and the PAST model, as detailed in Chapters 2 and 3. So far, science communicators in Australia have used methods similar to the PAST model mainly for neuro-typical students, so that they may experience more than just the science (Falk & Dierking, 2018; Staus & Falk, 2017). That is, participating in specially designed science activity stimulates and exercises the mind to make links with social and practical realities (Stocklmayer & Gilbert, 2010). However, there are no known methods which modify science with the specific aim of enhancing the personal and social skills of students with ID. This thesis seeks to fill this gap.

The emancipatory paradigm demands that participants with disabilities are empowered by the research and have some direct input in it (see section 3.2). I allowed for this input through conversations with participants while they were taking part in activities. I kept talking to them to see what they understood, how their understanding was growing, and if there was anything blocking their understanding. I also took observational notes of any noticeable difficulties, both in understanding or physical participation. I kept written field notes of what these difficulties were. There were also informal discussions with students at the end of each activity session (see section 3.5.6). These discussions gave another opportunity for students to express what they enjoyed and found difficult. In this way, the PAST focus on students' personal perceptions and interests were taken into account. All input from the students' informal discussions were written down and taken into consideration when developing subsequent activities and case studies, as suggested by the emancipatory paradigm.

Such a method for developing modifications is systematic in that it is based on participant input (Barnes & Mercer, 1997b; Oliver, 1997). These modifications were then implemented in further activities and ongoing iterations of case studies. The fact that all additional modifications were based on participant input means that they were flexible enough to account for those participants' needs. The logic behind how this method of modification was developed seems so intuitive that it is feasible that something similar may have been tried previously. For example, Stevenson (2014) presents a version of the emancipatory paradigm in which people with Down Syndrome are her co-researchers as well as participants. However, more recently, one of the founders of the emancipatory paradigm called for a recreation of this paradigm, so that it actually did empower the lives of participants with disabilities (Oliver, 2017).

4.2 General Modifications

The Australian national curriculum allows for reasonable adjustments for students with disabilities, and even provides guidelines for these adjustments (Australian Curriculum Assessment and Reporting Authority, 2018). Further suggestions for modifications specifically for students with ID are provided by Akpan and Beard (2016). Using these examples, I developed the following 'general modifications' for each case study, based on the precepts of universal design for science communication described by Reich and others (Reich et al., 2010) in section 2.9.5 of this thesis.

4.2.1 General modifications using visual aids

At the beginning of each case study, students were given a large clipboard, paper and writing materials of various colours. The clipboard contained a copy of the schedule for each activity session. That is, students would travel from school to the university at a given time on the same day every week. The lesson would begin with an explanation of the activity we were going to do. We would then do the activity, sometimes repeatedly. Finally, we would go to a café or eating area to socialise and have our informal discussions. This schedule was a memory aid for all of the students. For the sake of students who did not read, the schedule had pictures accompanying words. For visually impaired students, the schedule was larger or stored on a device that would read it to them.

In the room where the case studies took place, I made three large signs with basic tenets of science that we would use for every session. One sign read 'Look, Listen, Think' to remind students to use their senses to understand the activities for themselves. Another read 'Guess and Test' to encourage students to hypothesize during activities, and to use the activities as experimental tests of their hypotheses. The final sign read 'No "I Do not Knows"'. This was to reassure students that not knowing something was just the beginning of science. It should not stop them from trying the activities and having something to say. All three of these signs had pictures that matched the words.

For changing information, such as descriptions of the science activity from week to week, a whiteboard was used. Instructions for activities were written as a list. Those who could write would copy the list. Those who could not write engaged in a 'dotting' exercise that was in regular practice at this particular school. The staff assistant would make a pattern of dots as to what words the student needed to write, and the student would trace the dots. To ensure that students stayed empowered in this process, I asked the students to direct the staff regarding what to 'dot', and I asked the staff to only comply with the students' requests. This dotting process was known to all students from that school who could not write. This is because they were either learning to write, or they knew how to read but were training their hands to write due to physical dexterity impairments.

The whiteboard was also used for diagrams and pictorial instructions. The following (Figure 3) is an example of a pictorial instruction for pouring liquid into a container.

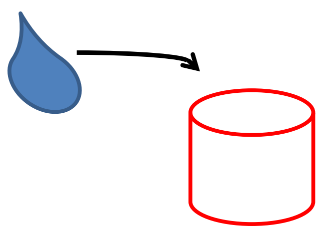


Figure 3: Diagram for pouring liquid into a container

4.2.2 Modified 'guided drawing'

Students would copy these diagrams into their notes. I would draw the whole diagram on one side of the whiteboard first. Then I would guide students with each step of the drawing process, as shown in Figure 4 below. The current practice of guided drawing for students with disabilities can be divided into two streams. First, it is used to describe a form of creative self-expression (Autism Live, 2013). Here guidance is given to assist students to express themselves positively through visual art forms. It also involves modifying equipment, such as bigger brushes that are easier to hold, and desks that are wheelchair accessible (Jordan Schnitzer Museum of Art, 2012). Second, a more instructive form of guided drawing is in use for young children without disabilities (Bentham, 2017). This involves giving students “step by step instructions to help them complete a picture”, especially those who “say they do not know how to draw and are reluctant to try” (Bentham, 2017, p. 1).

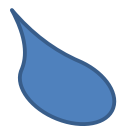
These two streams of guided drawing need not be disconnected. The step by step guide of how to make and connect particular shapes can give students the ability to express themselves through their own drawings. In this way, guided drawing differs from the standard prompts used in disability education in which students are more dependent on the assistants’ directives than their own ideas. The concept that guided drawing (sometimes called directed drawing) develops self-expression has been recognised to the point that it is sometimes used to develop communication in other primates (Matsuzawa, 1996). However, there is no known literature which indicates that it is used as an instructive guide for students with ID to create their own pictorial notes or diagrams. I therefore modified the existing steps of guided drawing to allow students to produce accurate enough diagrams to participate in activities without the constant directives of staff. Instead, students could use their own diagrammed notes as a guide.

As Figure 4 shows, the modified guided drawing developed for this thesis requires the provision of meticulous directions to account for a range of intellectual difficulties, as well as the possibility that students may be unfamiliar with diagrams. Those who did not feel they needed such detailed instructions were left free to copy the whole picture that was initially drawn, without waiting for each step to be shown. Some students attempted the diagrams on their own first, and then made corrections when I gave the guided drawing instructions.

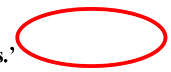
As recommended by the University of Massachusetts guide (Center for Access and Success, 2017), instructions and diagrams on the whiteboard where made in different colours. Different colours indicated different topics, instructions or items.

Throughout all of the Case Studies, no student had previously experienced making their own notes or diagrams as part of a learning experience. Some had notes and lists that other people had saved on electronic devices, as reminders of what to do at certain times. Others had electronic devices with pictures and words that would speak for the student when they selected a picture. The student participants were told that their notes were for their own sake, and I would not be correcting or scoring them. This was to be a way for them to make their own reminders. They were told they could check their notes at any time, and when they couldn’t remember instructions, their notes and diagrams would remind them.

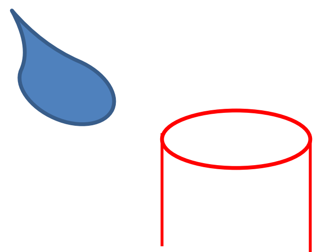
‘First make a tear shape like this. This is the liquid we will pour into the container.’



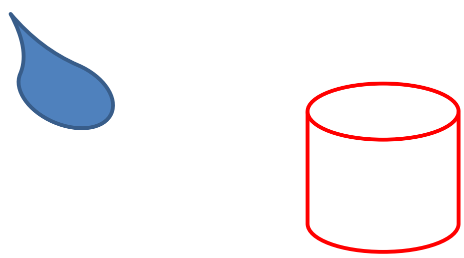
‘Now we draw the container. We start at the top with an oval like this.’



‘Now we add the sides like this.’



‘Join the two sides at the bottom.’



‘Now we draw an arrow from the liquid to the container to show that’s where it goes.’

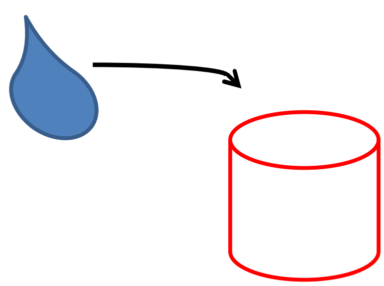


Figure 4: Example of modified guided drawing for diagrams and pictorial instructions

4.2.3 General modifications with auditory assistance

Modifications based on auditory input paralleled the general modifications for visual assistance. The three visual signs of ‘Look, Listen, Think’, ‘Guess and Test’, and ‘No “I Don’t Knows”’ became repeated catch-phrases. The first became “look, look, look; listen, listen, listen; think, think, think” and the remaining two were said as they appeared on their visual signs. These auditory prompts were introduced by me at the beginning of each case study, but were soon repeated by the students, especially when they became peer mentors. Some students even said it to themselves as a form of self-encouragement. Anything written on the whiteboard was read aloud. Instructions were also repeated while activities were being performed. Universal design for learning (UDL) further requires that students have the opportunity to communicate in free discussions with the educator about what they are learning (Hall, Meyer, & Rose, 2012). Therefore, during the activities, I spoke with the students about what was happening and what they felt they understood. Although I spoke to all students, I did not require all to reciprocate with constant conversation. It would be impractical for everyone to speak at once.

4.2.4 General modifications for all activities

All activities underwent the specific modifications detailed in section 4.3 and its subsections, so that all students could experience full participation in the informal science program.

4.3 Procedures for Activities

This section will list all activities used throughout the six case studies. The first session of activities for all case studies was an introduction. This consisted of giving students time to know me, the area we would be working in, and the scheduled routine of each session. It was at this early stage that I talked to the students about learning from failure, in order to reassure them that, even when things go wrong, there can be a positive outcome. Then students were given their clipboard, pens and pencils. Taking their own notes, making diagrams, and using these for themselves were explained along with the three large signs that said ‘look, listen, think’, ‘guess and test’ and ‘no “I don’t knows”’. In addition, each student was given their own safety goggles and gloves, and a bag for keeping these and their note-taking equipment in. Although every staff member who accompanied students in each case study attempted to collect these bags for safe keeping, they were told that each student had to look after their own equipment. The staff were permitted to advise and assist students with this, but not do it for them. At this point I would reiterate to the staff that the students would be learning for themselves, and from their own failures. However, this instruction needed repeating for most staff members. The first session also included an overview of some of the concepts we would be using throughout the case studies. These concepts were explained to the students as follows.

- IDEA: this is something that we think, even if we do not know it for sure.

- UNDERSTAND: when we know something for ourselves. It's an idea that we are more sure about. We might not know everything about it, but we know and can explain some things.

- INTEREST: something we like knowing or doing. Something we might like to know more about, or do more, or become better at.

- OBSERVE: look, listen, smell, feel – then think about what these mean. Your senses are telling you something.

- METHOD AND PROCESS: how we do things, what exactly we are doing, and the order we do it in.

- TRY: doing our best and having a go.

- GUESS/ESTIMATE: trying to think about what might be the answer. You could be right or wrong. We do not know yet, it's just a guess. It's just a try.

- TEST: after we guess, we do a test to see if our guess was right or not. If it was wrong, why? What happened during the test? If we were right, how were we right? What did the test show? The test always tells us something.

- SUCCESS/FAILURE, WORK/DID NOT WORK: since the tests always tell us something, there is no failure – we always find out something. Even if the activity or test does not work, we find out why it did not work. It's one more clue to finding success.

- FOCUS AND STAYING ON TASK: keep paying attention to what we are doing now. Keep observing and thinking from your observations. Keep looking back at our method and keep doing that process. And when we test, keep thinking about what we are testing and look for what the test is showing.

Finally, students were shown the various items of equipment we may be using. They were told what the items were, how we might use them, and were allowed to handle them. They were then taken to the areas where they would have their informal discussions after each session.

This first session was common to all case studies. The sessions that followed varied between case studies, according to the interests and input of the participating students. The following subsections comprise of all activities across the six case studies. The activities do not appear in any strict order. Rather, they are loosely listed according to the complexity of the activity and/or the level of modifications needed.

Each subsection has the following format. First the activity is described together with its aim and equipment. The 'Equipment' sections only list items that are generally used for each activity. Any added equipment necessary to cater for particular student needs is discussed in the section 'Specific Modifications for Unmet Needs'.

The process is then given, to describe what the students did and how they did it. This is similar to the way the procedures are described on the National Science and Technology Centre's website (Questacon, 2017) which inspired the activities. However, I also describe how I explained the process to the students, so that they had a greater understanding of what they were doing and why. I give these details here, rather than in the Appendices to show how much extra information was needed for the empowered, active participation of these students. This is not only important for researchers, but for all science communicators interacting with stakeholders with ID.

Next, any general modifications as described in section 4.2 are given. This is followed by the students' input, which I then used to develop specific modifications. Each subsection concludes with my specific modifications based on the students' hitherto unmet needs. In total, there are 21 activities (minus the introductory session described above) in their own subsections.

4.3.1 Mixing colours

This activity involved mixing coloured water to produce new colours. Its aim was to introduce the students to the 'guess and test' method of hypothesis and experimentation. It also showed them that they could use their observational skills to find answers.

Equipment:

- Test-tubes
- Test-tube rack
- Food dye
- Water

Process: Three test-tubes were filled with water and three were left empty. Food dye was added to each of the three water-filled tubes to make red, blue and yellow respectively. The students were told that these are the primary colours, which means all other colours come from mixing them. Students were then asked to guess what new colour would be made if two primary colours were mixed (for example, "guess what colour red and blue make"). After guessing, students poured the two colours into one of the empty test-tubes to test their guess. Later, the students repeated the process using the newly created colours (i.e. orange, green and purple).

General Modifications: There were no students with complete blindness. If there were, this activity would not be considered appropriate for their case study. There were some with various degrees of visual impairment. These students sat close to the activity, and were allowed to record it on an electronic device and play it back to themselves using a larger zoom. I paused during the activity from time to time, to allow these students to play back the recordings as needed.

All students made notes of the colours created. In these notes, the names of colours were written in their matching colour. For example, red and blue makes purple.

Student Input and Unmet Needs: Some students said that they could not guess what colours might be created because they did not know colours. They could recognise different colours and group them together, but they did not know their names. For example, these students could see that red differed from blue; and they could categorise different shades of red as belonging to the same group, while different shades of blue were a different group. It was just the case that they did not know the names of colours. They had heard the names before, but had never learned/been taught how to match the name to visual differentiation.

Specific Modifications for Unmet Needs: A large colour chart was made indicating possible colours that our activity may produce. The chart included a sample square of the colour with its name under it. Students who did not know the names of colours could point to the chart to make their guess. Some students chose to copy the entire chart into their notes so they could learn the colours by themselves.

4.3.2 Infra-red light

This activity involved using an infra-red toy gun to 'shoot' a moving toy bug. The aim was for students to understand that there were non-visible elements of the light spectrum. We do not see the infra-red light, yet we can see it work when we use it to shoot the toy.

Equipment:

- A large table

- An infra-red toy gun
- The gun's matching toy bug

Process: The students were told that light is made up of different colours. But we cannot see all colours. For example, there is a colour called infra-red that we cannot see. Students were then shown the infra-red gun and where the infra-red light comes out of the gun. They were shown the large toy bug and the part which was its 'target'. They were told that when they shoot the gun, an infra-red light comes out, and if it hits the target the bug will stop scuttling. So even though they cannot see the infra-red light, this is what the gun uses to hit the target on the bug.

The toy bug was placed in the centre of the table. The students took turns at trying to shoot it before it scuttled off the table. The students were encouraged to stand within the firing range of the infra-red gun, with a clear view of the target.

General Modification: One end of a piece of string was tied to the barrel of the gun while the other was stretched to the bug on the table. This was to give a visual representation of the general path the infra-red light would have to travel. The students made a diagram of this. The dotted line in Figure 5 indicates the invisible infra-red light

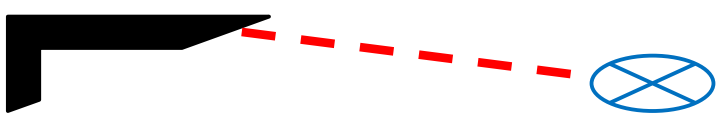


Figure 5: Diagram of how an infra-red toy works

This particular gun and bug had the option of sound effects. I activated the sound of shooting to assist auditory learners understand when the infra-red gun had been fired. However, I did not activate the bug noises as this seemed a superfluous distraction.

Students with lower vision were permitted to stand closer to the target.

Student Input and Unmet Needs: Despite the option of being able to stand closer, some students with lower hand-eye capabilities were disappointed that they couldn't hit the bug. Moreover, these students said things such as "it does not work…see nothing comes out".

Specific Modification for Unmet Needs: The response above suggested that some students were still trying to see the infra-red light. I put these students in front of a television with an infra-red remote control. Once they understood how to use it, I placed a whiteboard between them and the television. They experienced the remote control no longer working when its invisible beam was blocked by the whiteboard. They repeated this several times, sometimes with the whiteboard blocking the infra-red signal, and sometimes without. In both instances, the infra-red beam was not visible. But when the beam was not blocked, they experienced the infra-red remote control switching the television on and off. The use of a familiar item, in this case the television remote control, helped most students understand the presence of the infra-red beam. This was especially helpful for students who could not hit the bug.

4.3.3 Invisible ink

This activity involved making an ink that was invisible in normal light, but could be seen under ultra violet light. Its aim was to show students that there are different types of light, and some things are only visible under different lights.

Equipment:

- 6 non-toxic yellow highlighters
- Pliers
- A 2 litre glass jar
- A paintable surface (semi-porous so that it would hold the ink)
- Two litres of hot (not boiling) water in a separate jar
- Paint brushes for each student
- Gloves for each person in the activity

- Access to a dark room
- An ultra-violet torch

Process: Students were told that there are different kinds of light, and that there are some things that we cannot see under regular light. For example, there are some parts of plants and animals that we can only see under ultra-violet light. They were then shown the ultra-violet torch and instructed never to flash it in their own eyes or anyone else's. They were told that we can make an invisible ink that can only be seen under ultra-violet light.

Everyone taking part was instructed to wear gloves to avoid getting their hands stained. First the pliers were used to pull the nibs out of the top of the highlighters. The ink could then be drained into the 2 litre glass jar. This was done for all six highlighters. The hot water was gradually added to the jar and stirred into the highlighter ink with a brush. This continued until the colour of the ink was barely visible. All students could then use their brushes to paint with the ink, which would be invisible when dry. Students were given sufficient time to be sure that their painting was invisible.

The students then took their paintings to a room that could be darkened. Once they were ready, the lights were turned off and the ultra-violet torch was shone on the paintings. The students could see their invisible paintings glow under the ultra-violet light.

General Modifications: Students made a numbered list in their notes of the equipment that was used. They then made a second list of the process. For example:
1) Put on gloves
2) Pull out the nibs with pliers
and so forth.

I gave the example of how to remove the nib of the first highlighter and drain its ink, by way of modelling. The students then all had a turn of copying this. While the students were taking their turns I would talk to them, asking what they were doing and why. This was a way of engaging auditory learners without constantly imposing direct instructions.

When it came to mixing the hot water, only I handled the kettle and the jar, and I used heat-resistant gloves. This was in keeping with the ethics protocol. However, I did ask the students how much water I should add at each stage, and if they thought the ink was clear yet.

Student Input and Unmet Needs: Some students did not have the physical dexterity or strength to remove the nibs from the highlighters. Others were scared of the dark and refused to be in a dark room. Some did not understand the difference between an ultra-violet torch and a regular torch. Thus, they could not understand that it was the ultra-violet light that made their invisible ink visible.

Specific Modifications for Unmet Needs: If students did not have enough physical dexterity or strength themselves, I asked a peer mentor or another student to help them. I would not let a staff member help. This was so the student who needed help could practice co-operation with their peers rather than being (unnecessarily) dependent on staff. It also allowed the helper to experience empowerment and comradery with their peers.

For students who were scared of the dark, small torches were used so that they could see enough to be comfortable, but not enough to completely dispel the darkness of the room. The staff assistant would stand close to these students with a torch the whole time.

These small torches also assisted students who did not understand the difference between an ultra-violet torch and a standard torch. The small torches used regular bulbs, so when they were shone on the invisible paintings, nothing could be seen. But when the ultra-violet torches were shone on the paintings, they became visible. This helped confirm the difference between ultra-violet light and 'regular' light for the students.

4.3.4 Making and launching circular paper planes

This activity involved making and launching a paper plane, which was circular in design. The aim was to encourage experimentation, by showing students that things do not have to be done the same way. For example, we could make a plane that flies well, even though it does not have the usual shape of a paper plane.

Equipment:

- Scissors
- Sticking tape in a dispenser
- A4 stencils of the planes we were to build (see figure 6)
- A drinking glass
- A book of paper plane designs

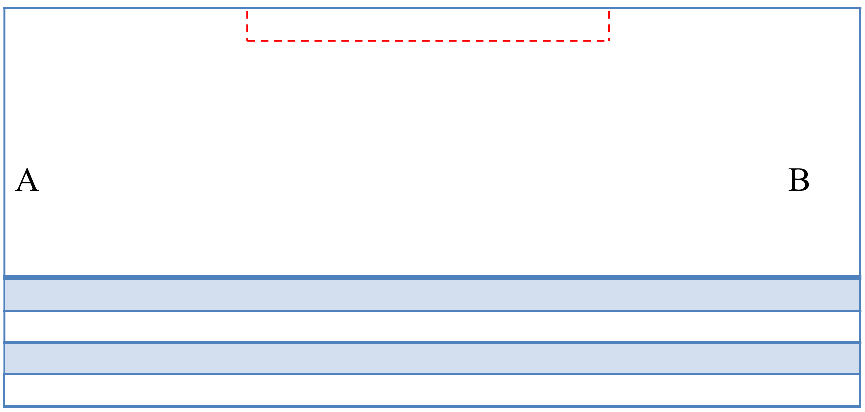


Figure 6: Stencil of a circular plane

Process: The students were told that this was the stencil for making a round plane. They were told that this was a very easy plane to build and fly, because it had a different design. They were told that trying a different way of making and doing things was what 'guess and test' experiments were all about. Doing things differently could produce different results, like a plane that was easier to build and fly.

Students were told to fold along the horizontal solid lines, so that the folds pile up on each other. Then they cut out the red dotted line. Finally, they curved the sheet vertically to make side A meet side B, thereby making a cylindrical shape. Placing the drinking glass in the middle of the stencil helped to make it a smooth curve. Then they used the sticking tape to join the two ends together so that the cylinder held firm. This was a circular paper plane.

Once all of the students had made a plane, they took it outside to throw. They were told that, because of the design of the plane, it was easy to throw and would fly over long distances.

General Modifications: Students were shown examples of other paper planes from the book. This assured them that the current design was both unusual and simpler. I also showed them what I meant by the horizontal lines, and the vertical edges on the stencil.

I modelled each step of the folding, cutting, rolling and sticking process both before the students began, and while they were making their own planes.

Student Input and Unmet Needs: Some students did not have the dexterity to cut along the dotted line or to use the tape dispenser.

More significant were student protests that they could not make paper planes and therefore, could not make this one. The same students said they could not fold or cut, even though these were students who were dexterous enough to do both. These students also complained of elbow pain when throwing the plane.

Special Modification for Unmet Needs: As in the section 4.3.3, students with less dexterity were given assistance from other students.

The students who vocalised complaints about not being capable of doing this activity displayed aggression by raising their voice, throwing objects and arguing that it was other students' fault that they were incapable of making the plane. I interpreted this as an expression of anxiety at having to do something unfamiliar.

My priority was to calm these students and keep everyone safe. I moved them away from the activity and gave them time to sit with the school staff assistant to make sure they did no harm to themselves, others or property. Some students agreed to try again when they were calm. Some students demanded that the staff assistant make and fly the planes for them. For those that refused to join in, I told them they did not have to participate but that the staff assistant would not be making or flying their plane. When these students saw the other students with their own planes, they joined in too. In the end, all students in all case studies who were offered this activity eventually participated in it.

4.3.5 Learning how to use tools

This activity involved learning how to use common hardware tools such as hammers, spanners, pliers, etc. The aim was for students to become familiar with these tools and be able to use them appropriately. A further aim was for students to practice following instructions.

Equipment:

- A hammer
- Various sized nails
- Various sizes of spanners
- Various sizes of screw-drivers, both phillips-head and flat-head
- Flat pliers of various sizes
- Needle nose pliers
- Wire cutting pliers
- A variety of old electrical and mechanical equipment

Process: Students were told that they were going to learn how to use various tools. To make sure they practised using the tools correctly, they were going to use them to take apart old electrical and mechanical equipment to see how they worked inside, and if they used the tools correctly, they would be able to take the items apart without completely smashing them.

The students were then taken to a salvage shed that sells discarded items, in order to find their own pieces of electronic or mechanical equipment. The students were asked to find items that fit the following descriptions:

- You should be able to see that it has screws, bolts or nuts that we can remove.
- You might see or guess that it has wires inside so that we can look at the wiring.

- You should not spend more than $10.

Once all students purchased their items, the group could return to the university.

Upon return, students were shown the various tools, and how they were used for dismantling the items. Nails were also provided so that the students could practise using the hammer for nailing. When students removed screws, they were also able to practise putting them back in.

General Modifications: Students made a list of the criteria for the items they had to buy from the salvage shed and took this with them. This helped remind them of what they were looking for as they searched by themselves. The school staff assistant and I verbally reminded them of the sort of items they were looking for.

Student Input and Unmet Needs: Most students had only seen tools being used but had never been allowed to use them. Therefore, they did not have rudimentary knowledge of how to hold and manipulate tools.

Some students needed significantly more time to choose their items from the salvage shed, or to learn the coordination needed to use a tool.

Students expressed high excitement at being allowed to use tools for the first time. Sometimes this excitement was heightened to the point that they would smash the item they were working on. Sometimes when they removed a part successfully, they would throw it in the air or on the ground. Some students, in their excitement, threw the tools.

Specific Modifications for Unmet Needs: Students who had not used tools before required step by step instructions on how to hold and use them. For example, I had to model how to hold and twist a screw driver, but I also had to instruct students that they needed to apply downward pressure while twisting. When students used wire-cutting pliers I had to show and instruct them as to where the cutting edge was. When using hammers with nails, I had to model and instruct how to hold the nail and give gentle initial taps to stabilise it before moving their hand away for harder taps.

With regard to students who needed more time, it was often necessary for me to stop the school staff assistant from doing the task for them. My intention was to let these students have as much time as they needed, with appropriate prompts from the staff assistant. However, if staff repeatedly attempted to complete the task for the student, or were too intrusive with their prompts, I had to remove the staff member from the student. Instead, I would assist the student needing more time, while the staff member supervised the rest of the participants in their dismantling.

To prevent excitement from becoming so heightened that students were not careful in their actions, I kept talking to them about the work at hand. I praised success, but in a measured tone, and with comments about the rest of the task. For example, I might say, “Well done, you removed that without damaging anything at all. What do we take out next?” Students who did become emotionally heightened could take a break to calm down. They could either take the break in the same room as the rest of the group, or they could choose to move away with the staff assistant accompanying them. If they had thrown anything, I waited until they were calm to explain that this was unacceptable, and they were asked to pick it up and restore it to its proper place.

4.3.6 Categorising parts

This task extended the preceding activity. It involved taking parts that were dismantled from old objects and categorising them into groups of type and size. The aim was to show students how to categorise things into useful groups.

Equipment:

- The parts that students had disassembled in a previous activity
- Labelled containers of various sizes

Process: Students were shown all the parts that were to be categorised. They were told that the parts were to be put into groups, so that if people want to use them, they could find them easily. Students were shown the containers. Each container had a label indicating what should go into it. The students were told that the labels showed them what group of things should go into them.

General Modifications: The labels on the containers were in writing and had a picture of the item. Staff assistants were told that they could read the labels to the students as needed.

Student Input and Unmet Needs: Some students would not attempt to match items with the labels on containers. Instead, for each item they picked up, they asked the staff assistant where it went. When I asked why they kept asking instead of looking at the label, many replied that they wanted to be sure, since they had never done this before.

Specific Modifications for Unmet Needs: To fulfil the students' needs for an additional check, I placed A4 sheets in front of each container with coloured, actual sized pictures of the items that went into them. Students could then compare each item to its life-sized colour picture, as well as the label on the container. In this way, it was the students themselves who provided the second check. This empowered them beyond reliance on the staff to check every item. It did not mean that students always chose the correct container. But when a mistake was made, I could ask them to compare the incorrect item to the life-size picture and the label on the container, and explain to me what their mistake was.

4.3.7 Cloud in a bottle

This activity involved making a vapour cloud in a sealable bottle. The aim was for students to understand high and low air pressure, and to see what happens when an area of high pressure suddenly drops to low pressure.

Equipment:

- An empty 2 litre plastic bottle (This must be a bottle that previously had a carbonated soft drink inside, as these bottles are made to tolerate high pressure.)
- A cork with a diameter that could seal the bottle

- A hand-held air pump with a thin nozzle attachment for inflating sports balls
- Rubbing alcohol

Process: Before presenting this activity to the students, it was necessary to use a power drill to create a narrow hole through the cork. The hole was such that when the cork sealed the bottle, the hole extended from the face of the cork that remained outside of the bottle, through to the inside face of the cork. The diameter of the hole was just wide enough to squeeze the nozzle of the air pump through.

The students were told that we were going to make a cloud in a bottle using air pressure. They were shown the empty bottle. A little rubbing alcohol was added and swirled around the inside of the bottle, and the excess was drained out. It was explained to students that the coating would evaporate quickly, making it easier to make a cloud. A student sealed the bottle with the cork, making sure it was tight, but leaving enough cork on the outside for someone to pull out. Students were then shown how the nozzle fit tightly through the cork. Another student then slowly pumped air into the bottle with the hand-pump, while I (or any assistant/supervisor) made sure the cork held tight. Students were told that, because they were pumping more and more air into the bottle, the air pressure inside was getting higher and higher.

Once the pressure in the bottle was so high that it was difficult to hold the cork in or the student could not pump any more air in, students were told to carefully squeeze the bottle, while I/an assistant held the cork in place (the air-pump remained attached, but was rested on a table or similar surface). When the students were satisfied that there was so much air in the bottle that it was hard to squeeze, they were reminded that this is high air-pressure made by pumping in all the air.

Students were asked to look at how clear the air in the bottle was. They were told that as soon as I released the cork, all the air would rush out. As soon as the cork was released, there would be no more high air-pressure, since all the air would escape. This meant that the high air-pressure in the bottle would drop to low pressure. They were told that they would see this immediate drop because it would form a thick vapour cloud inside the bottle.

Students were told that I would pull the cork out at the count of three. They were to keep watching the bottle to see the air inside instantly go from clear to a thick cloud. On the count of three the cork was released and an instant cloud was formed.

General Modifications: Students drew two bottles in their notes to remember the process. The diagrams were similar to Figure 7 below to show their observations of an instant transition from high air-pressure to low air-pressure.

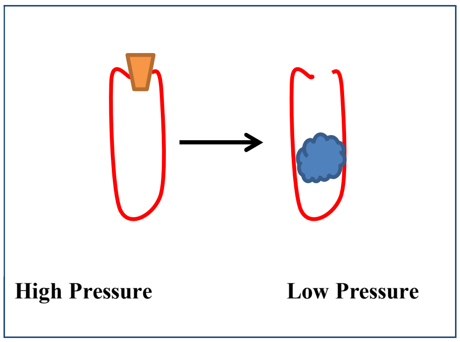


Figure 7: High air pressure instantly dropping to low air pressure

The scientific component of this activity was for students to gain an understanding of what high and low pressure is. I gave them a simplified catch phrase, 'High pressure is a lot of stuff in a small space. Low pressure is a little stuff in a lot of space.' This catch phrase was written on the whiteboard and in their notes. It was also repeated throughout the lesson.

Student input and Unmet Needs: Some students expressed great distress at the idea of pumping air into the bottle. This was expressed by attempting to run out of the room, screaming, covering ears or any combination of these behaviours.

Students who were not distressed were the ones chosen to use the hand-pump. However, some of them were so enthusiastic that they moved the hand-pump too vigorously, thereby bending the nozzle.

Specific Modifications for Unmet Needs: To prevent student distress, I began by saying the activity would be very safe as long as everyone stayed calm and in their seats. I explained that I did not want to get hurt myself, so I would not be doing anything that was too dangerous.

The students who did get distressed needed time to calm down. To assist this, I put the equipment out of sight (in a foam box) at the first sign of alarm. I would then wait and talk about what we might do to make sure we were safe. Many students asked to wear their goggles, which I allowed. Others expressed a fear of noise. Since sound was not part of their observation for this activity, I procured some noise-cancelling headsets from the school for these students.

To prevent students from damaging the nozzles, I first showed them the nozzle. We talked about how thin it was. I asked them if it would be easy or difficult to break it. All students who were asked this question realised it would be easy to break and so agreed to use the pump slowly and carefully. In case students still damaged the equipment, I kept spare nozzles and corks with me whenever doing this activity.

4.3.8 Fire

This activity involved some basic concepts about fire and how to deal with it. The aim was to show that fire produces heat and light which is useful, but it can also destroy and burn. It was also to show that not all liquids extinguish fire.

Equipment:

- Fire tray (Deep fire-proof tray that is filled with sand. Small fires can be safely lit in such trays, and extinguished using more sand)
- Fire trolley (the structure that holds the fire tray)
- Fire-resistant gloves
- Extra-long tongs
- Extra-long matches

- Bucket of water
- 5kg bag of sand
- 50ml of methylated spirits

Process: Students were told that today we were talking about fire and that we were going to do it in the safest possible way. They were introduced to a guest from the disability industry who assisted with fire safety. The students were told the safety features of the fire trolley and shown the other equipment.

The activity was conducted in an open outdoor area, away from anything flammable, and without the danger of wind. All students were made to stand at a safe distance from the trolley, and the guest assistant lit a large candle in the sand in the fire tray. The students were asked what they observed from the fire burning the candle. Once they acknowledged that it indeed produced light and heat, they were asked what light and heat are good for. After they mentioned a few benefits, such as cooking and keeping warm, we moved on to the next part of the activity.

I told the students that the way fire gives light and heat is by burning something. In this case, it was burning the candle. But fire can burn almost anything. The guest assistant then created a small fire in the fire tray and burned a few items such as paper and leaves. This caused smoke, which the students were told is just as dangerous as the burning. The students were then asked what we could do to put out the burning. Water was then used to extinguish the fire.

Following this, it was explained to students that water cannot put out all fires. Also, there are some liquids that look like water, but they make fire worse. To demonstrate this, the methylated spirits was poured on top of the area that was just drenched in water. A lit match was then dropped onto this area, using the extra-long tongs. The methylated spirits caught fire, even though it was on sand that had been previously soaked in water. The students' attention was drawn to two points here. First, the water beneath could not put out this fire. Second, the methylated spirits looked like water, but made the fire worse.

To conclude, the guest assistant spoke to the students about how confusing a fire can be when it is out of control. The best thing is not to throw random liquids at it, but to get away and get help as soon as possible.

General Modifications: Before beginning, to avoid distress and to ensure safety, students took notes of the good properties of fire (light and heat), and its dangers (burning and fumes/smoke). They listed the safety measures in place. This included the presence of a guest assistant, the features of the safety trolley, me and the assistant wearing fire-resistant gloves, students standing at a safe distance, and the whole activity being conducted in a safe open location.

Student Input and Unmet Needs: Despite the general modifications, some students still showed alarm at the idea of an activity involving fire. These students displayed the same behaviours as the students who showed distress about pumping air into a bottle in section 4.3.7. However, in this circumstance it was crucial to the safety of all that these students remain calm during the activity.

To ensure this, these students were allowed to remain indoors with the school assistant. The guest assistant and I conducted the activity with the remaining students. We also shared an electronic device from the school, which we used to film each other during our respective roles in the activity. This electronic recording was then played back to the students who remained inside, while the students who did the activity helped explain what was happening in the recording.

4.3.9 Non-Newtonian matter

This activity involved making a non-Newtonian substance. During this activity, the substance was called ‘oobleck’, as it is popularly known (Harmon, 2011). This activity was done after the students had participated in activities showing the difference between liquids and solids. The aim of this activity was to create a substance that sometimes has the features of a liquid, and sometimes the features of a solid.

Equipment:

- One mixing bowl per person
- 2 measuring cups per person
- 1-2 cups of water in one measuring cup for each person
- 2 cups of corn flour in the second measuring cup for each person

Procedure: Each student initially added all the corn starch but only some of the water into their mixing bowl. They slowly mixed the water into the flour with their fingers. They had to move slowly otherwise the mixture would become too hard to mix properly. If the mixture was too dry or lumpy, they gradually added more water, mixing slowly the whole time. For this amount of corn flour, no more than two cups of water were needed.

Once the substance was mixed thoroughly through, each student had a bowl of oobleck. Students were told that force makes the oobleck 'act like a solid'. That is, it holds its shape. If they tapped it quickly and forcefully, it kept its shape. It seemed to have a solid surface that did not let their hands go through it. But if they slowly and gently dipped their hand into it, the oobleck flowed around their fingers.

Similarly, students were told that if they quickly picked up a handful of oobleck and rolled it around in their hands, it would maintain the shape of a ball the whole time that they kept moving their hands. But the moment they stopped applying movement and pressure, the oobleck poured through their hands like a liquid.

General Modifications: The students wrote a list of the equipment used in their notes, including the amounts of water and corn flour. They wrote a list of the procedure they followed to make the oobleck.

Student Input and Unmet Needs: Some students did not want to mix the water and the corn flour as they had a hypersensitivity to certain textures. This same sensitivity made students unwilling to touch the oobleck at all.

Other students enjoyed the activity so much that they would throw the oobleck around the room, or pour/spill it onto the furniture and floor. Some also wanted to eat or drink it.

Specific Modifications for Unmet Needs: Some who expressed a reluctance to touch the oobleck were happy to wear disposable gloves. Others who found the gloves unsatisfactory were given a spoon. This was used for mixing the oobleck, and even for tapping it when it was ready. However, the spoon did not let them roll the oobleck into a ball. Neither did it allow them to feel it pour through their fingers when it was not under impact or force. To make up for this inability to experience the feel of oobleck, these students were told they had to be extra observant with their eyes. They would have to observe how the oobleck reacted when others rolled it up. They had to see what happened when others stopped moving it. These students were encouraged to practise using another form of observation in place of tactile observation. I then asked them questions about what they observed in the other students' oobleck, to make sure they understood what it was they were meant to be observing.

The fact that some students made a mess during this activity was acceptable, as long as they continued to observe the reaction of the oobleck to different amounts of force. I kept asking them questions about this throughout the activity, to make sure they were indeed making these observations. I also kept reminding them that whoever made a mess would be helping to clean it up.

Students who wanted to eat or drink the oobleck were firmly told that this was a science activity. Safety comes first and our observations come next, so we would not be eating oobleck. 'Safety first and observation next' became a catch-phrase that these students repeated.

4.3.10 Liquids

In this activity, students interacted with various liquids and observed them in different containers. The aim of this activity was to give students a basic concept of what is meant by 'liquid' as opposed to solid. Therefore, I did not go into the greater technicality of all fluids (liquids and gases), but only mentioned the term ‘liquid’. No students in any case study asked about fluids, so I did not have to pursue this further.

Equipment:

- A cylindrical glass
- A triangular cocktail glass
- A square transparent tub
- A transparent latex glove
- 500ml of water
- 500ml of vegetable oil
- 500ml of undiluted cordial syrup
- Food dye
- A pencil
- A piece of paper
- A facial tissue

Process: Students were given a simplified rule for identifying liquids. Specifically, all liquids can be poured and they take the shape of their container.

I placed the cylindrical glass, the triangular glass and the square tub in a row. I coloured the water with food dye to make it easy to see. I asked a student to pour the water into each glass and the tub. I then asked, “Did the water pour?” I asked what shape the liquid took when it was poured into each object. I repeated this pouring and questioning process with the oil, followed by the syrup. A different student was asked to pour each time.

I asked, from what students observed, were the water, oil and cordial syrup all liquids and why? Did the thickness or the stickiness matter? Did the colour matter? Did all three substances fit the basic rule that ‘liquids can be poured and they take the shape of their container’?

Next, I told students that solids do not generally change their structure to fit the shape of a container. Solids can be hard, soft, thick or thin, like my examples of the pencil, paper and facial tissue. But we do not pour them, and they do not change shape of their own accord to take the shape of a container. Solids generally hold their own shape. I demonstrated by showing that the pencil kept its shape in the different shaped glasses and in the tub. It could be broken to fit in the triangular glass, but it did not break itself to fit into the glass; and even then, its parts did not change shape to fill empty spaces. I then demonstrated that the piece of paper could be crumpled to fit into the containers, but it did not change its shape to fill empty spaces. Neither did it crumple of its own accord. Furthermore, it could be removed from the containers and flattened out again to show that it had not changed its original shape. I demonstrated that the same was true for the facial tissue.

Finally, I asked students to name some things that were liquid, and to say why they think they were liquid. I then showed them the latex glove and asked what shape the liquid might take if I poured some into it (any response that indicated a hand shape or a glove shape was satisfactory).

General Modifications: As mentioned above, food dye was added to the water so it was easier to see. I made sure this dye was not the same colour as the cordial syrup so that students could see that colour difference did not matter.

Students wrote the simplified rule 'liquids can be poured and they take the shape of their containers' in their notes. Then they made the diagrams in Figure 8. The green outline indicates the container and the blue indicates the liquid. The difference in the containers in this diagram allowed the students to see different ideas. In the diagram of the cylindrical glass, although the liquid takes the shape of the container, there might not be enough to fill the whole container. The liquid will fill as much as it can while staying one whole body of liquid (it has 'no gaps'). The diagram of the triangular glass is a side view. The square diagram is a top view.

Figure 8: Liquids take the shape of their containers

Student Input and Unmet Needs: Many students complained that they did not know the names of shapes and so they felt they couldn't answer questions about the shapes liquids took. The only answer these students could give was to say which shape the liquid would take when poured into the glove.

Other students found it difficult to give examples of liquids on their own, because they confused liquids with very small solids, like grains of sand or flour. That is, sand can be poured and it seems to take the shape of a container without leaving gaps.

Specific Modifications for Unmet Needs: In response to the first problem, I constructed a large chart as seen in Figure 9.

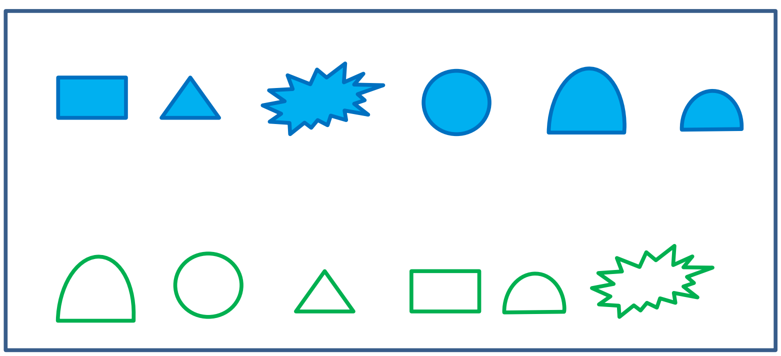


Figure 9: Shape chart for matching liquids and their containers

Students were told that the bottom green shapes were diagrams of containers, as seen from the top only. The top blue shapes were the shapes that liquid would take if it was poured into one of the containers. I then pointed to a green shape and asked them to point to the shape the liquid would take if poured into that container. This seemed to work as all students in all case studies who were offered this activity were able to successfully match the liquid shape to the container shape. However, it is possible that these students were simply matching like shapes.

The second unmet need required a different type of response. I showed the students a high magnitude magnifying glass and told them what it did. I then asked them to look at coloured water under the magnifying glass. Was it all one body of water, or lots of little separate parts? Then they were told to look at a pile of sand. Was this the same as the water, or lots of little separate parts? Did each part look like a liquid or a solid part that keeps its shape? I confirmed that each grain of sand was actually a solid. We do not pour a single grain. And each grain does not change shape to fit the shape of a container. This was a difficult concept and not all students understood it. This lack of understanding was inferred from those students who continued to say they *could* pour sand or that sand *could* change shape. Some students demonstrate this by pouring handfuls of sand or pushing around the pile of sand to change its shape.

4.3.11 Boats

In this activity, model boats were made out of corrugated plastic and a rubber band. The aim was for students to learn what models are, by making their own working model.

Equipment:

- An A4 sized sheet of corrugated plastic (corflute) for each person
- Large heavy duty scissors
- Size 33 rubber bands
- Electrical tape
- B2 pencils
- Pre-made boat stencils

Process: Students were told that they would make their own working model of a boat. They were told that a model is *like* a real thing, but different from the real thing. The model might be smaller or simpler, so that we can use the model to learn about the real thing. Their model was going to be smaller and simpler than a real boat, but we were going to use it to see how boats use propellers to move through water.

Each student was given an A4 sheet of corflute, a B2 pencil and two stencils that I previously made.

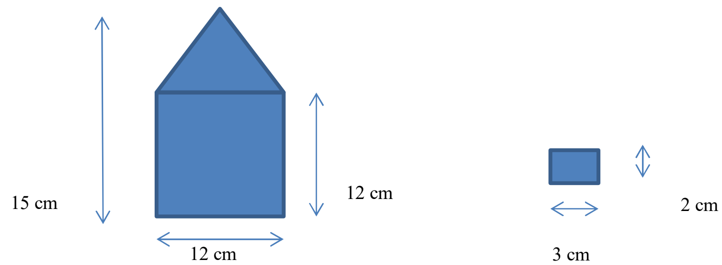


Figure 10: Boat and propeller stencils (not to scale)

The measurements of the stencils were based on my previous tests of what dimensions were necessary for this material to move under propulsion from a rubber band. The measurements were explained to the students. The students traced around the large boat stencil on the corflute, using the pencil. They then traced around the smaller propeller stencil with the pencil. Students then cut out the boat and propeller that they had traced.

Students then cut a space at the bottom of the boat for the propeller to fit into as shown in Figure 11.

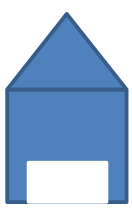


Figure 11: Boat stencil with gap made for the propeller

This was done by placing the propeller at the bottom of the boat, tracing it, and then cutting out what was traced. Five millimetres were then cut from the bottom and side of the propeller to give it room to spin in the gap that was just cut.

Electrical tape was used to stick the rubber band onto the propeller, and the ends of the rubber band were looped onto the boat.

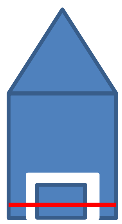


Figure 12: Boat with propeller attached

Once the boats were constructed, students were taken to a pond (or similar body of water) to use them. They were instructed to let the boats float in the water to see what happens. Then they were told to wind the propellers until the rubber bands were tight, and then let them go in the water. To conclude, I asked about the difference in the boats' speed and movement when we used a propeller.

General Modifications: This activity was unfamiliar to the students and contained many steps. For students with ID, it is recommended that such a task be presented with step by step demonstrations (Weis, 2014). I gave these instructions, as the students were building their model boats, so that they could go through the steps with me. Students were also allowed to stick the stencils they used into their notes.

Student Input and unmet needs: Many students were unsatisfied with step by step instructions. They also felt that simply having the stencil for their notes was not enough. Many of these students asked for diagrams of the steps.

Some students found it difficult to wind the boats and then put them on the water. Some would let go of the wound propeller before putting it on the water. Others would try to push the boat under water without winding the propeller.

Specific Modification for Unmet Needs: I interpreted the students request for their own diagrams as a desire for more understanding or control over the activity. I advised them that

I could show them how to make diagrams of every step of the process, but that this would take a lot of time. These diagrams required much guided drawing, with explanations of where every line must go, and an approximation of how long that line should be. This was such a detailed process that it extended the boat making activity over two sessions. However, most students chose to persist with making their own pictorial instructions. In the end, the diagrams requested by the students were as shown in Figure 13.

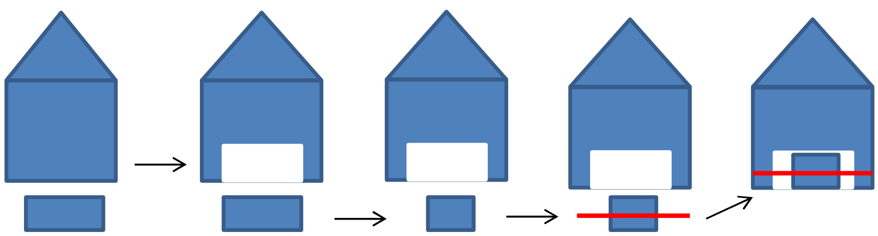


Figure 13: Pictorial instructions for making model boats

The students who found it difficult to wind the propeller were shown how to hold the body of the boat in one hand, and wind the propeller with the thumb and forefinger of the other hand. All students were told to hold onto the propeller while placing the boat on the water, so it did not unwind. They were reminded to float the boat on top of the water and then let go of the propeller.

4.3.12 Propellers

In this activity, students manually launched a model propeller. The aim was for them to understand how propellers work. In this case, the model propeller together with the inspiration for the activity was from Questacon - The National Science and Technology Centre (Questacon, 2017).

Equipment:

- A Questacon model propeller

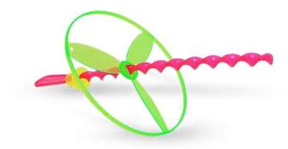


Figure 14: The Questacon propellers used by students

Process: Students were asked if they knew what a propeller was, or if they could give examples of propellers. They were told that there are many types of propellers, but we were going to look at ones that make things fly up. We began with a diagram of a propeller (see General Modifications below). We then talked about how a propeller works. In simplified terms, a propeller works like a screw, twisting its way through the air. It pulls air from above itself and pushes it down below itself. Pushing the air down is what lets the propeller lift a helicopter up. This is why the blades of a propeller are curved/slanted to direct the air from above it, to go down through to below it. Students were reminded that this was just a simple explanation. They were also given a simple propeller (the green part of the model above) to see and feel its blades. Students then launched the propellers and observed their flight.

General Modifications: I provided guided drawing, so that students could make diagrams of propellers in their notes. I guided them to draw the simplest two-blade propeller.

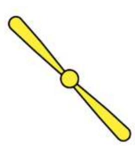


Figure 15: Two-blade propeller

We then completed our diagram with notes.

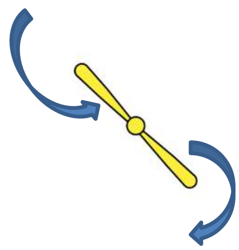


Figure 16: Air moving through a propeller

Immediately before launching the models, students were given step by step instructions with demonstrations. They were to point the launching stick up (the pink part in Figure 14); then push the launcher (the yellow part in Figure 14) up the stick as fast as they could. This would start the propeller spinning and push it up into the air. Then it could fly on its own.

Student Input and Unmet Needs: Even with step by step instructions and demonstrations, many students were unable to launch the propeller. Some could launch it, but could not fly it well.

Specific Modifications for Unmet Needs: I watched the students who expressed disappointment at not being able to fly the propeller well. For many, the difficulty seemed to be coordinating both hands to do different things. To assist with this, I gave them more exact instructions, while modelling the actions with them. These instructions and modelling had to be as detailed as follows:

- Take the pink launching stick in one hand and point it to the ceiling.
- Only hold the pink launching stick by its flat handle.
- With your other hand, make a fist.
- With the hand that is a fist, stick out only your thumb and pointing finger.
- With only your thumb and pointing finger, hold the yellow launcher.
- Do NOT let your two hands touch each other or hold on to each other (this stops you from pushing the launcher quickly).

- Make sure the launching stick is still pointing up.
- Make sure the green propeller is sitting on the yellow launcher.
- Using only your thumb and pointing finger, push the yellow launcher up as fast as you can.
- Push it all the way up the stick.

While these instructions with modelling helped most students, some still needed full physical hand-on-hand prompting (as explained in section 3.8.1) to push the launcher with one hand while holding the stick upright in the other.

4.3.13 Home-made batteries

In this activity, students made a model of a battery which lit up an L.E.D. bulb. The aim was to show students that electricity has to come from somewhere. In this model of a battery, they experienced electricity as generated by a chemical reaction. This further involved them being introduced to the idea of chemicals.

Equipment:

- An empty 12 hole ice cube tray
- Uncoated copper wire
- Galvanized nails
- Wire cutting pliers
- White vinegar
- L.E.D. bulb

Process: Students were asked to name something that uses electricity. Then they were asked if they know something that made electricity. They were told that batteries make and store electricity through chemical reactions. They were going to see a chemical reaction by making a model battery.

Vinegar was poured into each of the 12 compartments of the ice tray until each compartment was half full. The students were shown the copper wire and told what it was.

They were told that copper is one of the chemicals for their battery. They were then shown the nails and were told these were covered in zinc, and that zinc was another chemical for our battery. I cut a piece of copper wire approximately 7cm long. This was to demonstrate the length that students were to cut their wires. They had to cut 11 pieces in total.

The students and I wrapped each of these pieces of wire tightly around 11 nails, just under the head of the nail. The first nail was placed in the first compartment of the ice tray and its wire was bent to lean into the second compartment. The second compartment was the one adjacent to the first, running along the length of the ice tray (see Figure 17). The second nail was placed in the second compartment, with its wire bent to lean into the third compartment. This was repeated for all nails and wires. Students were told to be careful not to let the wires attached to one nail touch the nail in the following compartment. There should be vinegar between the wire and the next nail. This vinegar acted as an acid, which we also needed for our chemical reaction.

Once this task was completed, the students were shown an L.E.D. bulb. One of them was asked to place one prong of the bulb into the first compartment of the tray, and the other in the last compartment. If the bulb did not light up, the student could turn it around and switch the prongs into the opposite compartments, as each prong had its own polarity (polarity was not explained to the students). The bulb lit up.

General Modifications: I first demonstrated the steps of the battery making process, while explaining what I was doing. I then gave guided drawing instructions for students to create the following diagram in their notes.

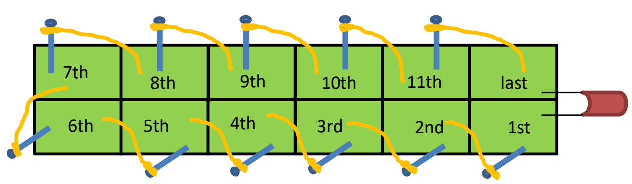


Figure 17: Diagram of a model battery

The students were reminded that this diagram did not have to be perfect. These were their own notes and would be a reminder for them. To add to this reminder, a key was created.

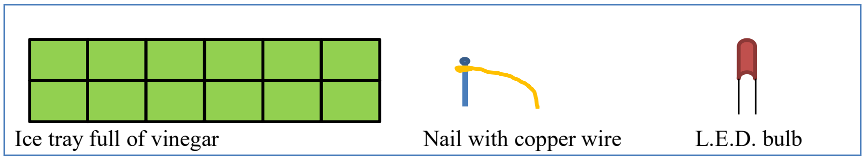


Figure 18: Key for student diagram of a model battery

Student Input and Unmet needs: Most students expressed dissatisfaction at producing electricity for only one L.E.D. bulb. Some asked why we did not try to light more bulbs.

Specific Modifications for Unmet needs: As with the activity in section 4.3.11, I interpreted this almost unanimous expression of dissatisfaction as students wanting to learn and do more. I warned them that this would take more time, but most students expressed a desire to persist.

I told these students that the compartments of the ice tray were like cells in a battery. If they wanted more lights, they needed more electricity. And if this was the case, they needed to create and link up more cells.

Some students did this by repeating the above activity in other separate ice trays. Others joined more ice trays to the existing first one. Both of these experiments were successful.

Finally, some students asked to 'make' their own copper wire from the wires taken from objects they had dismantled in section 4.3.5. I showed these students how to strip the outer plastic coating off these wires using the pliers. They did not have to strip all of the coating off, but they had to be sure that the wire wrapped around the nail, and the part of the wire that went into the vinegar in the next compartment, were completely stripped. These students found that when the wires were not stripped enough, the bulbs would not light. They then had to strip the ends of the wires more before the bulbs would light.

4.3.14 Water rockets

In this activity, students made large water rockets out of two litre plastic bottles and launched them with a ready-made air-pressure launcher. The aim was to show students how much force air-pressure can have. There was the further aim of letting students practice safety precautions to minimise perceived risks.

Equipment:

- Empty two litre bottles that previously contained carbonated drinks
- Ready-made rocket launcher
- Bicycle pump
- Measuring tape
- Water

Procedure: Students were told that air is all around us, but air under pressure can be very strong. As I did for the activity in section 4.3.7, I reminded students of the simplified catch-phrase ‘high pressure is a lot of stuff in a small space’. In this case, a lot of air would be pumped into a water rocket made out of a soft drink bottle. This would build up enough air-pressure to shoot the rocket at least as high as a three story building (I tested this height before-hand).

Students half-filled their bottles with cold water. When it was their turn, each student placed the opening of the bottle into the launcher. Some water usually spilled out, but a little was acceptable. Students were told that the launcher had a seal that did not let any more water out. Since the water could not escape, any air pumped into the bottle could not escape either, and this was how we increased the air-pressure in the bottle.

The launcher had both a long cord and the bicycle pump attached. Once the rocket was in the launcher, the students gently stretched the cord out to its full length and held on to the furthest end. I then used the bicycle pump, which remained adjacent and attached to the launcher, to fill as much air into the bottle as possible (usually about 60psi). I then stepped aside and said ‘fire’. The students were told that on the call of ‘fire’, they must pull the cord quickly to launch the rocket.

General Modifications: Before beginning, students made diagrammed notes of how the air pressure builds up in the water rockets.

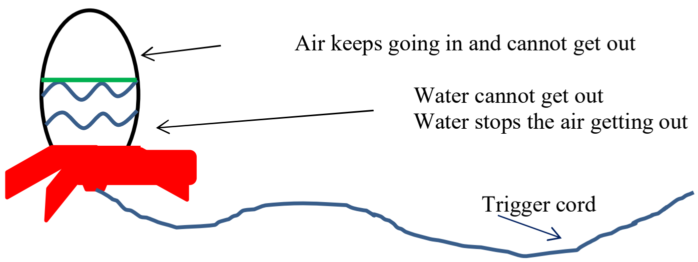


Figure 19: Large water rocket in launcher

A mark was made on the bottles to indicate when it was half full. This is the green line in Figure 19 above.

Before launching a water rocket outside, students practised going through the steps of launching inside, with an empty bottle.

We then talked about how strong the air-pressure must be to launch the water rocket so high. I asked what we could do to stay safe. We talked about how the trigger cord was long so that the person pulling it would be safe. We measured how long it was with the measuring tape (3 metres). I said that we would take the tape outside to make sure everyone stayed at least 3 metres away from the launcher. I asked what could be done for me, since I would be right next to the launcher. The students agreed that they should not pull the trigger cord until I stood clear and called ‘fire’.

Student Input and Unmet Needs: Although all students who were offered this activity wanted to participate in it, many expressed fear. Since part of the aim of this activity was about minimising risk, I encouraged students to talk about their fear, so that we could take precautions.

Many expressed a fear of the sound the rockets might make. Others were concerned that I would be hit by the rocket, either because it may explode while I was increasing its air-pressure, or because it was accidently released too soon.

Many students lacked the dexterity to place the rocket in the launcher without spilling all of the water. A few did not have the ability to pull the trigger cord. That is, they could pull the trigger on cue, but only gently or slowly.

Specific Modifications for Un-met Needs: The students who expressed a fear of noise were offered the same noise-cancelling headsets as those used in section 4.3.7. However, this raised the question of how these students would hear the call of ‘fire’. The simple modification was that every time I called ‘fire’, I would raise an arm. I would do this for all students. Therefore, students with noise-cancelling headsets would know when it was safe to fire, whether they heard me or not.

For the students that feared for my safety, I asked what they would do to minimise the risk to me. Many asked me to wear goggles. A few asked me to wear a hard hat or helmet. If the students came up with these risk management techniques themselves, I would comply. If they had no suggestions of their own, I would suggest practising the proper launching procedures again.

For those who had trouble with the trigger cord, an individual approach had to be taken. All of these students were asked to move their arms any way they could to make a quick, sharp movement. Once they mastered which movement best suited them, they were to practise the same movement holding the trigger. Some held it above their heads and dropped their arm down quickly, some held their arm outstretched at chest height and flicked the trigger like cracking a whip, and others had to hold the cord and take a quick step backwards. Each person developed and practised their own technique.

4.3.15 Pop Rockets

In this activity, students made ‘pop rockets’ out of vinegar, bicarbonate soda and a sealable canister. The aim was for students to build a small rocket that launched using air-pressure produced from a chemical reaction. The further aim was for them to learn how to keep a table of results.

Equipment:

- Sealable canisters (such as old camera film canisters or air tight medical canisters) at least 10cm long, with removable lids
- Vinegar in a bowl or open tub
- Bicarbonate soda
- Small funnels
- Measuring teaspoons
- Standard teaspoons
- A glass of water
- A flat catching tray with a low brim

Process: All work was done on the low tray to catch any spills. The students filled the open cap of the canister with bicarbonate soda and dusted off any excess in the rim, which might prevent it from closing tight. They then placed a drop of water onto the bicarbonate soda to moisten it. This stopped it from falling out of the lid when the lid was placed back onto the canister. It was not yet time to reseal the canister though.

Using the measuring spoon, vinegar was scooped up from the bowl and poured through the funnel into the canister. The students then sealed the canister with the lid, quickly flipped it upside down, and placed the upturned canister on the tray and stepped back. The canister popped like a rocket into the air.

The students were told that the vinegar and bicarbonate soda made a chemical reaction inside the canister to create bubbles of carbon-dioxide. The bubbles built up air-pressure, until it blew the canister into the air.

Students were told that, since they already fill the whole cap with bicarbonate soda, they now had to find out the best amount of vinegar to use for their chemical reaction. They were given the following table.

Table D: Students' table for testing vinegar amounts in pop rockets

VINEGAR	CAP FULL OF BI-CARB	WILL IT FLY?
0 Teaspoons	✓	
1 Teaspoon	✓	
2 Teaspoons	✓	
3 Teaspoons	✓	
4 Teaspoons	✓	
5 Teaspoons	✓	

The students were asked to fill in the 'Will It Fly' results column every time we added a teaspoon of vinegar. The column was wide enough for a comment, so that students could look at it later and tell me how much vinegar was needed for flight, how much created the highest flight, and how much was too much.

General Modifications: This activity was split into two parts. First the students took turns in making the pop rockets. Then I made the rockets, using increasing amounts of vinegar, while the students took notes of the results in their table. For the first part of the activity, students were given the instructions for making a pop rocket and made diagrams in their notes through guided drawing (see Figure 20). They then practised making the pop rockets, using their notes. I also gave them verbal reminders of the process. For this part of the activity, I told students to use 'a small splash of vinegar', so as not to disclose any accurate answers needed for the next part of the activity.

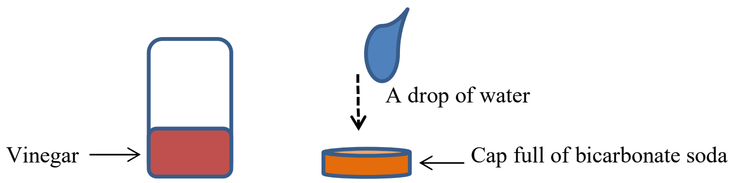


Figure 20: Pop rockets

For the second part of the activity, students were given Table D, as shown above. For every observation they were first asked what they saw, and then told to write this in the correct column.

Student Input and Unmet Needs: Many students had difficulty physically going through the steps of the rocket making process. However, it was not clear if this was a matter of strength and dexterity, or if it was a matter of not knowing how to *do* the movements involved in performing a task.

Others did not know how to read the results of their table. All students were able to fill in the table, once they were shown which column to write in, and how to list results one at a time, in each subsequent cell of the column. However, when asked questions about the table, such as 'when there was no vinegar, was there flight?' they were unable to read their own results.

Specific Modifications for Unmet Needs: A recurring issue for students who had difficulty physically fulfilling any process, was that the staff assistant would take it from them and attempt to do it for them. Instead, I insisted that students have a chance at doing as much as they could. For this, I modelled each step of the activity even more minutely, with the students copying every step. This modelling even included explicitly directing students to consciously move parts of their body, and in this way, was more advanced than the usual modelling used in disability education. Students requiring this extent of assistance would usually be given full physical prompts (as described in section 3.8.1), thus the staff insistence on doing the activity for the student. Instead, I gave the students the following instructions for opening their canister, modelling the actions for them, while they did them with me:

- Hold the canister in one hand

- Put the thumb of your other hand on the centre of the lid
- Put the fingers of the ‘lid’ hand on the edge of the lid – do not let them grip the top of the canister
- Push down with your thumb onto the centre of the lid
- With your fingers, peel the lid back like a banana

Such detailed steps were required just to begin the process, by enabling students to open the canister. Yet, it allowed the students to control their coordination enough to do the activity themselves. Similarly detailed instructions were needed for the rest of the activity. However, they allowed all students to participate fully. Some students still had difficulty dusting excess bicarbonate soda from the inner rim of the lid, or difficulty closing it. These students were assisted by peer mentors, but only for this step of the process.

Students who could not read their own results from the table were shown how they could follow a table by pointing. They were to first listen to the question, for example ‘what happened with 3tsp of vinegar?’ Then they were to locate something about that question, in this case 3tsp of vinegar, in one column and put their finger on it. Then they were told to run their finger across the row until they came to their answers in the flight column. All students understood the pointing concept, but many needed practise, as their hands sometimes deviated from the row they were following.

4.3.16 Attacking the Castle

In this activity, students launched foam rockets at a large model of a castle that I previously built for this purpose. The aim was for students to practise aiming and also to practise adjusting their own trajectory.

Equipment:

- A large castle façade (1.5m x 1m) made out of corflute
- Corflute props for holding up the castle
- Ready-made foam rocket cannon, with movable firing barrel
- Three foam rockets

Process: The props were used to hold up the castle within firing range of the cannon (this was tested before hand). The cannon was placed in a fixed position, but students were shown how to move the firing barrel in all directions. Each student was given all three foam rockets to load into the cannon, aim and fire at the castle.

After each shot the student would say why they think they did not hit the castle, and then re-adjust the cannon barrel and try again. If they hit the target, they said why/how, and tried to recreate the shot.

After all students had their turn, they had the option of trying again.

General Modifications: The castle façade that I built was large enough for students with lower vision to see. It also had three features for students who did not know the terms right, left, higher and lower. Specifically, it had towers for students who needed to aim higher, a door for students who needed to aim lower, and a window on one side but not on the other.

An instructional diagram was made on the whiteboard, which the students copied with guided drawing (see Figure 21). A circle with an X in the diagram marks where the foam rocket might land if it misses the castle. It shows the students what would happen if they aimed too high, to low, too far towards the window (their right), too far to the tower without the window (their left), so that they could adjust their aim.

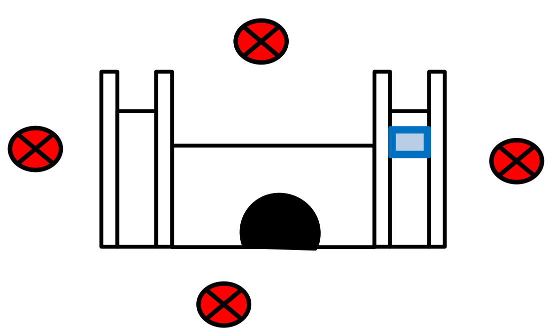


Figure 21: Cannon shots that miss the castle

Student input and Unmet Needs: All students wanted to hit the castle, and knew they could move the barrel of the cannon. However, when they missed and it was explained that their shot was 'too much towards…' many did not know what to do with the information. Simply knowing that they had shot too much in one direction, did not indicate to them that they should adjust in the opposite direction.

Some students aimed the cannon straight up for loading the rockets, but then would leave the barrel straight up for firing. Similarly, some students overshot the castle by firing too hard, but would continue to fire too hard in following attempts. Some students also found that their rockets hit the ground in front of the castle every time, due to a lack of strength (the cannon was powered by depressing an air-pressure cushion).

Specific Modifications for Unmet Needs: As in previous activities, when students said they did not know which way to adjust the cannon, the school staff attempted to do it for them. I had to insist that staff neither did it for them, nor told them the answer directly. Instead, I talked students through the logical steps needed to come to the answer themselves. These steps were as follows:

- 'Where did the rocket land?'
- 'Was it too high, too low, too much to the window side, too much to the other side?'
- Then standing near the cannon and facing the castle I would ask, 'since it was too much this way (I made a line from the cannon towards the point where the rocket missed with my outstretched arm), why not try it another way?
- 'What is a different way to the way I am pointing?'
- When students gave an answer (*A*) I would ask, so why not point it at (direction *A*) and see what happens?

This rarely brought an immediate hit, and the process had to be repeated with me talking them through the steps of thinking several times. Eventually these students would say the steps for me. Then they would do the process independently, without speaking the steps out aloud.

Similar steps of thinking had to be used for students who kept firing too hard, or straight into the ceiling. I would ask, 'why does it always hit there?' This would be followed by 'where did you want it to hit?' The final question would be, 'if you point it at the roof and it always hits the roof, where will it hit if you point it at the castle?' Alternatively, 'if it always goes too high if you fire so hard, what will happen if you fire gently?' These steps seem more direct as they specifically mention hitting the castle, or firing gently. However, since they are put as questions, they still cause the student to follow a logical train of thought.

For those who did not have the upper body strength to fire the cannon far enough, there were two options. Some had the castle brought forward. Others were shown how to fire it with their feet by stepping on the air cushion.

4.3.17 Gravity and weight

In this activity, students practised using a balance scale and dropping things from a mezzanine level to a target area below. The aim of the scale was for students to see the difference between heavy and light objects by their effect on the movement of the scale. The aim of dropping items of various weights was to see that gravity pulls all things down towards the earth; both heavy and light objects.

Equipment:

- Balancing scale
- Balloons
- Handheld air pump
- Water
- Funnel
- Sand
- Access to a mezzanine area
- Cautioning tape
- Traffic cones
- Painters' drop sheet

Process: Knowing whether students knew the difference between heavy and light was particularly problematic, due to the subjectivity of the question. Different students may consider different things heavy; some students may find all things heavy, and amongst different objects everything is comparatively lighter and heavier than other things. Instead of presuming that students had the complexity of language to express any of this, a visual and experiential approach was taken.

First, I inflated a balloon to half its potential size using an air pump. I used the funnel to fill another with water to the same size, and did the same with a third balloon and sand. One at a time, the students held the air filled balloon in one hand and the water filled balloon in the other. They were asked which felt heavy, and which was harder to hold up for a long time? They then put both balloons in the balance scales to see the one they recognised as heavy go down, while the lighter one rose. This was repeated as many times as necessary until students felt they understood the sensation of a heavy object, and its visual effect on the balance scale.

They were then asked to hold the water filled balloon in one hand and the sand filled balloon in the other. The questions were repeated: which one felt like it was heavy/harder to hold up? Again, they placed the balloons in the balance scale to see the heavier balloon descend and the lighter rise.

Next, the students went to a mezzanine floor. They were shown a target area below which was cordoned off with traffic cones and caution tape. The students were then allowed to drop several balloons filled with air, water or sand onto the drop sheet in the target area. They were asked if all balloons fell. Upon giving an affirmative answer, they were told that gravity is the force that pulls all things down to the earth – even light things. They were told that even though the balloons were different weights, and some fell more slowly, the pull of gravity was just the same for all of them.

Finally, the students were told that they would learn why things fall at different speeds later as outlined in the next activity.

General Modifications: Students made the following diagrams in their notes through guided drawing.

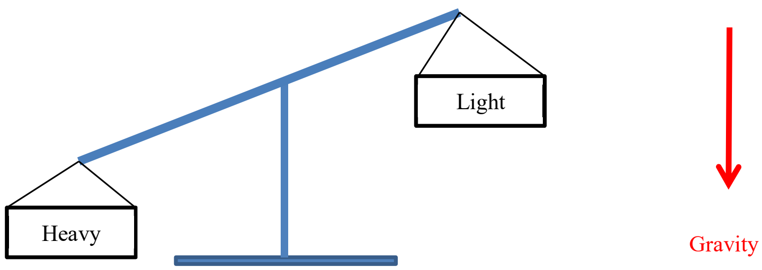


Figure 22: Heavy and light objects in a balance scale

To further engage students, I asked questions about weight. For example, all balloons were about the same size, did this make them the same weight? Was the water balloon heavier or lighter than the air balloon? Was the water balloon heavier or lighter than the sand balloon? Did gravity pull everything down, or just the heavy things?

Student Input and Unmet Needs: Across all case studies the recurring concern from students was that they did not work with balloons. Some said that it was because they were scared of them, and some did not know why. Some expressed fear by screaming and running out of the room at the sight of balloons. Accompanying staff from the school confirmed that balloons were generally not used at the school in case they scared students. This was probably to avoid a reaction to sensory overload, which is a known difficulty for some students with ID.

Some students also expressed an extreme fear of heights, so they did not want to drop balloons from the mezzanine.

Specific Modifications for Unmet Needs: To assist students with their fears, I employed the steps of thinking, as described previously (see 4.3.16) to help students deal with their emotions. Firstly, I asked what it was about balloons that might scare them. Those who knew answered that they were scared they might 'pop'. I explained that there were two problems here, they were *scared* of the *pop*. So, we could deal with the first problem, being scared. Or we could deal with the second, the sound of the pop. The second problem was easier. We could deal with the sound of the pop by taking away the sound. This was done using noise cancelling headsets.

The first problem was more difficult and needed more steps of thinking. I asked what they were scared of and many repeated it was the 'pop'. I reminded them that they had done many activities with things that exploded and went 'pop' and that they enjoyed these. I then asked if it was really the 'pop', or that they couldn't control this 'pop'; the balloon might unintentionally 'pop' at any stage. Usually, these students answered that they feared not knowing when the balloon might 'pop'. I explained to them that the big problem then was lack of control. They did not feel in charge of the balloon.

To assist with this, I gave them an uninflated balloon and told them to throw it around and then cut it with a pair of scissors. Next, I told them they could do the same with a balloon full of sand and no noise would occur. They could even tear the sand balloon apart with their hands. I then told them they could burst a water balloon by throwing it or jumping on it and only dull low noise would come out, together with the water. If students tried this, I explained that it was the small amount of air trapped in the top of the water balloon that made the dull noise. So, since they were not afraid of that small noise, they could try a balloon without water, but with only a small amount of air. As the students' confidence increased, they were allowed to increase the air in the balloons themselves, and then burst them.

Most students opted to learn how to control their fear, so I gave these students the title of 'Pop Doctors', for they helped themselves and could help peers get over the fear of balloons. A few students chose to use the headsets. This was also a logical and acceptable way of participating, so they were given the title 'Noise Control Captains'.

For students who were afraid of heights, I also took them through steps of thinking. I asked what it was they were afraid of. They generally knew it was fear of 'being up'. So, then I asked where they could stand to make them feel safe. This sometimes took effort to get an answer. It involved the middle step of asking, 'if being up makes you scared, where are you not scared?' Once they understood that they would feel safe if they stayed on the ground, I asked where on the ground floor they could stand and still observe the balloons that would be dropped. They could then allocate a place within clear sight of the target area.

4.3.18 Parachutes

Although this activity did not require greater specific modifications than those previously described, it does follow immediately from the activity above (4.3.17).

In this activity, students made model parachutes and dropped them from a mezzanine to the ground floor of a building. The aim was for students to construct a device with multiple parts as independently as possible. It was also for them to observe the effects of air resistance.

Equipment:

- Plastic bags (without handles) measuring 35cm x 25cm
- Two-ply wool
- Scissors
- Single Hole-punch
- 50mm fold-back clips
- Traffic cones
- Caution tape

Process: Students were reminded that gravity pulls all things to the earth. They were asked to look back on their own notes about this. They were told that, even though gravity pulls everything down, some things take longer to hit the ground than others. They were told that one of the reasons for this is air resistance. Gravity pulls everything down, but air gets caught in some things, which slows down the fall. Students were told that this is called air resistance. Students were then told that they were going to drop large fold-back clips from the mezzanine to watch how quickly they fell. They were then going to attach the same fold-back clips to parachutes, and then drop the parachutes. They would then observe how the air resistance affected the fall of the parachute.

To make the parachute, students cut along the side and bottom creases of the bags. This produced two flat sheets of plastic. Students were shown where the side creases were. They were then told to use the hole-puncher to make holes in the four corners of one sheet, but not so close to the corner that the hole tore into the edge of the bag. Again, students were given an indication of where the corners were. If holes were made too far or too close to the corners, the second sheet of plastic (from the unused side of the bag) was used to try again.

Students were asked to tie one end of the wool to one hole and run it diagonally across the sheet of plastic until they came to the diagonally opposite hole. They were asked to allow a little more wool for tying, and then cut off the length of wool. This cut end of wool was tied to that diagonally opposite hole. This process was repeated for the remaining two holes with a second piece of wool. This was how students made their parachutes.

Students then took two fold-back clips and their parachutes to the mezzanine. They first dropped a fold-back clip and watched it fall. They then attached the second clip to their parachute (by opening the clip, sliding both pieces of wool into the body of the clip, and then closing it again). They dropped this clip attached to a parachute and watched how air got caught in the parachute and helped to slow the fall.

General Modifications: Each step of the parachute building was modelled for the students while they did it with me. Although each student started with one plastic bag, they were allowed to use as many as they needed if mistakes were made, or there was some other difficulty.

Students made the following diagram using guided drawing.

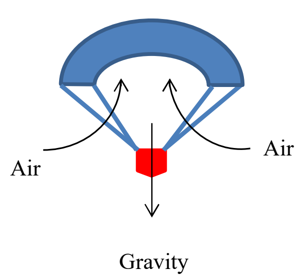


Figure 23: Air resistance in a parachute

Student Input and Unmet Needs: Some students expressed a fear of heights, as they did in activity 4.3.17. Other students found it difficult to use the hole-puncher without tearing the edge of the plastic. Some could not tie the wool.

Specific Modifications for Unmet Needs: Students who expressed fear of heights were taken through the same steps of thinking, as in 4.3.17. However, in this present activity, these students were able to participate more by building their own parachute. They also chose who was to drop the clip and then the parachute for them, and had to give explicit instructions as to when and how the drops were to occur.

Students who had trouble using the hole-puncher were allowed to keep practicing using several plastic bags, until they became familiar with it. Students who did not know how to tie the wool, or who did not have the dexterity to do so, were able to seek help from the staff assistant. However, the staff assistant was instructed to only comply with the directions of the student. The student had to show that they knew what to tie and where. In this way the student maintained active and empowered participation.

4.3.19 Solutions

In this activity, students mixed a solution of warm water and salt, and then attempted to mix sand into water, and then oil into water. The aim was for students to understand what a solution is. Students also poured sugar solutions of different concentrations into the same test tube. The aim here was to show that solutions can have different weights.

Equipment:

- Test tube rack
- Test tubes
- Test tube corks
- 4 x 100 ml beakers
- Measuring jug of 300 ml of warm water
- Sugar

- Salt
- Sand
- 50ml of cooking oil
- Food colour
- Teaspoons
- Access to a kettle and fridge

Process: Preparation was needed the night before this activity. When preparing (without the students), I boiled water and poured 80mL into each of the four beakers. I mixed different coloured dye into each beaker. I then stirred 2tsp of sugar into one beaker, 4tsp into another, 6tsp into the third, and left the final one without sugar. I then placed all solutions into the fridge to cool until the activity.

When the activity began, students were asked if they knew what a solution was, or if they could give examples. I made them aware that I did not mean a 'solution' that is the answer to a problem, but a different kind. I told them that a solution is a special kind of liquid that has something else completely mixed into it.

I showed them the example of water and salt. I asked a student to pour some warm water from the jug into a test tube, but not to fill it. I then asked them to put a little salt into the same test tube and close it with a cork to avoid spills. I allowed the student to shake the test tube for about 30 seconds, then I asked all of the students to look closely into the test tube. They were asked if they could see any salt or if it was mixed all the way through. Since it was mixed all the way through, this was a solution.

Another student was then asked to repeat the process using sand instead of salt. The students were asked if the sand was mixed all the way through or if they could see some of it. They were asked to point to the floating particles of sand and the sand resting at the bottom of the test tube. Since they could see sand, it was not mixed all the way through, so this was not a solution. Finally, another student was asked to repeat the process using oil. Students were asked if they could see any oil, or if it was mixed all the way through.

Students were asked to point to the oil at the top. They were asked, since they could see the oil, and it wasn't mixed in at all, was this a solution?

The coloured beakers were then removed from the fridge. Students were told that one of these, for example the yellow one, had nothing but colour mixed into it. They were asked if the colour was mixed all the way through, like the salt, or could they see unmixed parts like the sand and oil. Since the yellow dye was mixed all the way through, this was a solution. The students were told that the other beakers had sugar mixed into them. They were asked to observe if the sugar was mixed all the way through in all the beakers. Since it was, all the beakers contained coloured sugar solutions.

Students were then told the amount of sugar in each solution. They were asked to put these beakers in a row from the least sugar to the most. I then slowly poured about 5ml of each solution into a single test tube, in order of least to most sugar content. Since each consecutive solution was heavier than the previous one, it dropped below the colour that was poured before it. The final result was a coloured layered effect in the test tube, shown below.

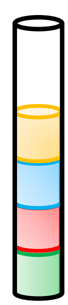


Figure 24: Coloured solutions of different weights

While this was being done, students were told that more sugar means a heavier solution, so the heavier solutions were sinking below the lighter ones.

General Modifications: The general modifications involved giving step by step explanations and instructions as presented above. The students were also told the simplified catch-phrase