The Launch Pad Gallery

The Design and Implementation of Classroom Experiments for Grade School Teachers

An Interactive Qualifying Project proposal to be submitted to the faculty of Worcester Polytechnic Institute in partial fulfilment of the requirements for the Degree of Bachelor of Science

Submitted by:

Steve Black
Kyle Dedmon
Klementina Gerova
Evan Graziano

Submitted to:

Project Advisors:

Prof. G. Salazar
Prof. W. Mott

Project Liaisons:

Sam Spicer and Alex Patrick, London Science Museum

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Abstract

The London Museum of Science is taking innovative strides to integrate inquiry-based, interactive learning methods into classrooms in an attempt to improve elementary education. Our project aimed to assist the Museum by researching, designing, building, and testing prototypes that could be incorporated into programs currently managed by the Museum. These activities, realized through our work, can ultimately be used in future museum demonstrations, shows, or Outreach visits as a way to inspire, teach, and instill a lasting interest in science amongst students.

Executive Summary

The London Science Museum is currently undergoing a redevelopment process through which they will be reinventing the Launch Pad Gallery. Although already highly successful, the museum hopes to cover a broader range of scientific topics in this gallery, through the use of a series of new interactive exhibits, which will be displayed in a much larger space. To further this objective, the museum will also be accompanying their project with a new show area, a school briefing room, a new outreach program, and a reworked webpage.

The goal of this project is to supplement the museum's effort by providing activities and demonstrations that are thematically related to exhibits in the new gallery. These activities may be used by educators who are planning on visiting Launch Pad or are covering similar topics in their classrooms. These particular experiments are geared towards children between the ages of 8 and 14 and comply with the principles set forth for Key Stages 2 and 3 in the National Curriculum.

We began our work with a brainstorming process that led to the design of several stand-alone experiments, known as "Quick and Dirty" experiments, as well as a series of inquiry-based learning activities, that we felt properly demonstrated curriculum concepts. When approved by museum staff, we refined these ideas to ensure that each of them would be able to demonstrate these principles, and so that educators would be able to incorporate them into the classroom with minimal difficulty.

Based on the designs that we had developed, we then began a construction process in which we aimed to create as many prototypes as possible. This was relatively straightforward, but occasionally would result in difficulties, such as trouble finding materials or complex setup, that would hinder the construction process, and require changes to be made to the experiment. Once this building process was finished, though, we took each of our prototypes to staff members in order to test for advice and reliability purposes. Based on our results, we made changes to some of the prototypes and then presented them to the public to gauge their reactions.

Using this feedback, we were able to develop a set of recommendations for each of the demonstrations, which were presented in the form of activity sheets. These sheets, aside from our suggestions for future use, also contained the materials required, project setup, what worked particularly well during the demonstration, problems that were encountered, and links to the

National Curriculum. The sheets are designed particularly for any member of museum staff who wishes to further develop any of these ideas, or simply wishes to obtain information regarding any one of their development.

Besides these activity sheets, we also provided the museum with a few other deliverables that they may use to progress with any of the work that we began. First, accompanying each of the inquiry-based learning activities is a lesson plan. Each of these lesson plans was created in order to maximize the effectiveness of each activity in the classroom and ensure that the teacher will be able to easily incorporate it into the children's studies. We also filled out a series of risk assessment forms that the museum may refer to if they wish to safely recreate any of the demonstrations that we developed. Lastly, we developed several presentations, designed to accompany the demonstrations that we presented to the public. These were used, both for "Quick and Dirty" demonstrations as well as for inquiry-based learning activities, to allow for a better presentation of scientific principles and setup, as well as to present safety tips that comply with the risk assessment.

This project has provided us with a completely different perspective of the efforts that must be put into teaching children of a young age. That is, it is important for children to retain knowledge presented to them, but just as vital to inspire wonder in them and create an interest in the subject matter, so that they will want to continue to learn. Through our work with the demonstrations and inquiry-based learning activities, we have attempted to bridge the gap between both of these aspects, and hope that the museum will be able to employ our recommendations to further their own efforts with the matter at hand.

Authorship Page

Acknowledgements
Primary Drafter – Evan Graziano
1st editor – Kyle Dedmon
2nd editor – Steve Black
3rd editor-Klementina Gerova

Abstract
Primary Drafter – KD
1st editor – SB
2nd editor – EG

Introduction
Primary Drafter – KD
1st editor – SB
2nd editor – EG

Executive Summary
Primary Drafter – EG
1st editor – KD
2nd editor – SB

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    1st editor – KG
History of the Science Museum - SB
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Launch Pad Gallery – EG and SB
    1st editor - KD
Future Launch Pad and Outreach – SB
    1st editor - EG
National Curriculum – KD
    1st editor – SB
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    1st editor – SB
Key Stage 3 – KD
    1st editor – SB
Learning Science in a Classroom - KD
    1st editor – SB
Benefits of Interactive Learning – KD and EG
    1st editor – SB
Potential Problems with Interactive Learning – KD
    1st editor – SB

Inquiry-based Learning Activities – SB
    1st editor – KD
Full Inquiry Science Lesson Planning – SB
    1st editor – KD
Lesson Planning for Teachers Planning to Visit the Museum – KD
    1st editor – SB
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    1st editor – KD
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    1st editor – SB
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    1st editor – KD
Written Tests – SB
    1st editor – KD

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    1st editor – KG
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    1st editor – KG
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    1st editor – EG
Exhibit Principles – KD
    1st editor – EG
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1st editor- SB

Recommendations
Primary Drafter – KD
1st editor – EG

Conclusions
Primary Drafter – KD
1st editor – EG

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KD and SB shared work in all appendices equally throughout this section.

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Introduction

Mark Twain once stated, “I have never let my schooling interfere with my education.” It appears Mark Twain was not the only person who felt this way. Many elementary school children exhibit this same attitude about learning Science. Interest in the problem of learning has been due mainly to two stumbling blocks of lasting learning: a) inert knowledge: pupils acquire facts that they can’t access and use properly; and b) passive learning: pupils do not readily engage themselves. These “diseases of schooling” can make creating lesson plans, which genuinely interest and educate children, an extremely difficult task (Brown, 1992). Using the traditional book and chalkboard approach may develop children who can regurgitate information and memorize facts, but often does not allow them to gain interest in the subject matter or learn how to apply concepts. Stimulating a child to develop concepts and take initiative to apply knowledge is a task which has mainly been placed upon teachers and classrooms. However, other avenues are becoming available to assist with this challenge.

The education of children is an age-old challenge experienced by people located in every corner of the globe. Schools in London are no exception. Institutions such as the Museum of Science have discovered they can assist with the challenge of educating children by offering creative solutions that would otherwise not be available for teachers. A school outreach program has been implemented by the museum, but in order for it to continue to grow new ideas must be conceived. This outreach program may help overcome hurdles teachers experience in the classroom with respect to stimulating children and helping their overall learning experience. However, there is room for the program to expand its influence and improve the quantity and quality of the activities it offers. Generating many ideas and creating activities increases the chance of schools utilizing the program to maximize its effectiveness and the benefits it offers.

An outreach program such as the one offered by the Museum of Science is a way to simulate a museum trip in a classroom. The excitement and interest generated by activities offered by the program resemble the feelings a child experiences on a field trip to the museum. Creating a classroom atmosphere which mimics that of a museum allows learning to take place through hands-on interactive activities which promote curiosity and encourage further exploration of the principles being taught. The existence of the Museum’s Launch Pad gallery is the best testament to the successful learning and understanding which can occur at a museum for visitors of all ages. Replicating this experience and emphasizing the positive aspects of a museum visit can allow for valuable educational gains within the classroom.

With the Launch Pad Gallery and the outreach program both being redeveloped the Museum has lots of work ahead. The Museum will redesign the current Launch Pad website and add more Do-It-Yourself examples based on exhibits which can be used at home or in the classroom. The creation of experiments accompanied by a museum-like informal atmosphere is not an exact science, and it is only as valuable as the assessment of this process. If proper assessment is lacking there is no way to determine if the actual demonstrations were anything more than a distraction. The creation and revision of a successful assessment process left the Museum of Science with two main benefits. First, it provided a set of criteria that can be applied to the design of current and future outreach activities. Second, it helped improve the overall effectiveness of the program by validating that the demonstrations are affecting the target audience in the desired manner.

Figure 1: Launch Pad Gallery

The purpose of this project was to develop a series of classroom activities which help pupils experience the scientific principles explored in the Launch Pad gallery in order to assist educators who may be planning to visit the gallery or covering similar content in their classrooms. In the design of these demonstrations we considered key aspects such as health and safety considerations, the National Curriculum, the use of cheap, easily sourced materials, and whether children could set up and perform the experiment. We created prototype demonstrations accompanied by an assessment process which was used to determine the overall effectiveness of the experiments. This process provided useful feedback which was then used to refine the demonstrations. Classrooms which implement the Museum's outreach program will be able to effectively demonstrate important scientific principles and genuinely stimulate an interest in science in their pupils.

Background

The London Science Museum is working to allow more pupils to obtain an experience similar to a visit to the Launch Pad gallery, the Museum's largest interactive gallery, from the comfort of their classroom. They currently offer an Outreach Program which enables teachers and pupils to construct activities demonstrating principles present in the Launch Pad Gallery. However, they would like to extend upon this. The purpose of this chapter is to explore the current Launch Pad gallery and Outreach Program, National Curriculum guidelines, lesson planning techniques, and concepts aimed at maximizing stimulation and education through interactive learning with elementary aged children. These topics provide a foundation for justifying and creating successful classroom activities which can meet educational needs in a manner similar to that of a museum.

2.1 London Museum of Science

According to its' manifesto, "The National Museum of Science and Industry (NMSI) is on a mission to redefine the role of the museums in the 21st century" (*National museum of science and industry.*2007). The London Museum of Science is one of three museums under the umbrella of NMSI. Located in South Kensington, the museum offers free admission to all. Funded mainly by the government, it is able to offer numerous galleries and exhibitions for people of all ages. Highlights of the seven floor building include the IMAX 3D cinema, the "Energy – Fuelling the Future" Gallery, and the Launch Pad Gallery for children. An example of NMSI's unique approach is the Science Museum's "Science Night" program where children are given the opportunity to stay in the Museum overnight (*Science museum.*2007).

2.1.2 History of the London Science Museum

Prince Albert's contribution to the Great Exhibition of 1851 laid the foundation for what is now known as the Science Museum. It was to be used as an institution to promote industrial innovations, yet most of the objects displayed were art. In 1884, the museum collection was boosted when London's Patent Museum passed on its patent stock.   From this point the art and science collections gradually began to grow apart, until in 1909 the Science Museum and the Victoria & Albert Museum were officially separated. In 1928, King George V formally opened the new Science Museum Building. The Museum's first children's gallery was opened in 1931, introducing its popular visitor-activated demonstrations of science. More recently, in 1983, the National Heritage Act was passed and Museum control was transferred from a government department to a board of trustees appointed by the Prime Minister. Under the control of these trustees the museum has experienced rapid expansion and implementation of interactive galleries such as Launch Pad (*Science museum.*2007).

2.1.3 Launch Pad Gallery

The purpose of a science museum is considered by many to be the satisfaction of the need for historical displays, showing the development of both science and technology and its roots in the past (Oppenheimer, 1968). A science museum, however, should not rely strictly on teaching, but should also act as a medium which enhances and maintains interest in the subject matter. This idea is particularly relevant to children and the subject of science. The Launch Pad gallery is a particularly effective example of an exhibit which serves educational purposes but also creates interest in science.

According to our sponsors, "Launch pad will inspire you to explore and question science and technology through hands-on experience of real phenomenon in an environment that promotes curiosity" (Spicer). The Launch Pad gallery is the largest interactive gallery in the Museum, aimed at children aged eight to fourteen. One million people visit each year in either school or family groups. The exhibits are the most important feature of Launch Pad. Children can pull, push, or experiment with and see, hear, or feel the effects of these exhibits. They challenge children to think about what's happening and why.

Figure 2: Grain Pit Exhibit

The exhibits are grouped into six themes: forces and motion, light, sound, electricity and magnetism, materials, and energy transfer. Each theme area contains a central exhibit indicating the content of the area. Exhibits are composed of four different types: demonstration, illustration, problem solving, and exploration. The demonstration exhibits are operated by explainers, or museum staff, hired to explain each of the concepts that are experienced through use of the exhibits. These exhibits present striking phenomenon and are held at regular intervals throughout the day. The illustration, problem solving, and exploration exhibits portray principles and enable visitors to interact with objects.

2.1.4 Outreach Program

The Science Museum currently provides a variety of outreach programs that can be booked by schools or community centres. The fees vary from £350 to £800 depending on the distance at which the venue is located from the Science Museum. Several programs are aimed toward KS2 and KS3 level children. The Science Museum webpage also offers a range of resources which can be downloaded, such as activity sheets and ideas for games. Currently, the Launch Pad website offers some “do-it-yourself” activities which can be performed at home or in the classroom. The site provides directions containing materials, setup procedure, scientific concept information, and a questions and answer section.

2.1.5 Future Launch Pad and Outreach

By late fall of 2007, the Launch Pad Gallery will be reorganized to contain 55 mechanical and electro-mechanical interactive exhibits, and will cover more floor space. Accompanying the Gallery there will be a science show area, a school briefing room, a webpage, and an outreach program. The gallery will contain no museum objects and there will be no set route through it. Instead, exhibits will be organized by teams, and learning will be promoted through the experience of real-life phenomena. Adult and child visitors will be encouraged to partake in the exploration of science exhibits through hands-on interaction.

Accompanying the new Launch Pad will be an updated outreach program. A new website will contain activities and demonstrations which may include variations of the prototypes we will be designing and building. The program will visit schools to promote science through demonstration and experience. Other avenues such as workshops for teachers, brochures, and promotions may be used to encourage the use of the resources offered by the outreach program as well.

2.2 National Curriculum

The National Curriculum implemented in the United Kingdom determines what should be taught and sets attainment goals of learning for all pupils up to age sixteen. Also, it determines how the performance of pupils will be assessed and reported. The British school system comprises four key stages, commonly referred to as KS1-KS4. Key stages two and three contain all pupils in grades three through nine, aged seven to fourteen, and they are the target audience for this project. For each subject and for each key stage, study programs set out what pupils should be taught, and attainment targets set out the expected standards of performance. It is up to schools to choose how they organize their curriculum in order to include these study programs, but all schools should be covering the same material from the National Curriculum (Becta, 2007).

The purpose of the National Curriculum is to emphasize the importance of education in society. The curriculum has two stated "aims" which foster education and development within children. 1: "*The school curriculum should aim to provide opportunities for all pupils to learn and to achieve.*" This aim is geared toward educating pupils by equipping them with necessary skills and stimulating interest to continue education by challenging themselves. 2: "*The school curriculum should aim to promote pupils' spiritual, moral, social and cultural development and prepare all pupils for the opportunities, responsibilities and experiences of life.*" This aim focuses on developing well-rounded individuals capable of functioning and contributing to society. This aim is focused on moulding pupils to be aware of social, cultural and spiritual aspects of life and to be able to apply concepts to make conscious decisions as they progress to later stages of development (Becta, 2007).

2.2.1 Key Stage 2

Four sections of knowledge should be attained in key stage 2 pupils in the subject of science: scientific enquiry, life processes and living things, materials and their properties, and physical processes. The National Curriculum provides several specific examples of knowledge and skills that children should attain in each section. Some examples of areas that children should develop competence in under the scientific enquiry section are "ideas and evidence in science" and "investigative skills" (Becta, 2007). These skills are important to this project because experiments will need to be designed to allow pupils to learn content but also to allow them to challenge skills such as investigative techniques and evidence gathering ability.

2.2.2 Key Stage 3

Key Stage 3 contains the same four subsections contained in key stage 2 but the objectives are different. Pupils begin to draw connections across different fields of science and emphasize more critical thinking relating to core concepts. This transition is appropriate since pupils contain a broader compilation of knowledge from previous years of study and are also older and more capable of processing somewhat complex ideas and subject matter. Another vital aspect to key stage 3 is that pupils begin to think scientifically, allowing them to approach problems in a more scientific method. Steps such as observing and analyzing evidence collected by themselves and others in order to draw conclusions all become important to pupils in this stage (Becta, 2007). These skill sets relate directly to the project because pupils will be asked to utilize skills such as observation and scientific analysis while demonstrations are conducted.

2.3 Learning Science in a Classroom

Several important factors influence the ability of a child to learn and apply information relating to science. Children learn best when they participate in activities which are engaging, entertaining and which provoke curiosity. Linda Ramey-Gassert has suggested, "Exploration and discovery are vital to fostering a child's natural curiosity, which lays the foundation for conceptual science learning." Learning through hands-on experiences in an informal setting can stimulate a child's desire to learn and in turn lead to more successful retention and application of the learned material.

2.3.1 Benefits of Interactive Learning

It has been said that explaining science and technology without props can resemble an attempt to tell someone what it is like to swim without ever letting them near the water (Oppenheimer, 1968). A child is much more likely to learn about electricity by interacting with mini Van de Graaff generators than they are by viewing a picture of Benjamin Franklin holding a kite. Even if they do not take away as much concrete information, the interest derived from the experience will often result in a heightened interest, and a desire to learn why things happen.

The Launch Pad gallery is a perfect example of the benefits of interactive learning. The museum encourages participation from visitors and the exhibits are intended to promote interest in different areas of science. The exhibits are presented in a way that is enjoyable and entertaining, but at the same time they fulfil their underlying purpose, which is ultimately to allow the visitor to learn as well as spur curiosity which will promote continued learning.

Success of the Launch Pad has been proved and, according to Gassert, “Stevenson (1991) investigated long-term retention of information by family groups visiting the interactive Launch Pad exhibit at London’s Science Museum. He found that most visitors recalled detailed information about their visit and that over one-quarter had spent time since the visit reflecting on the experience or had related the information gained to a recent event in their lives.”

Furthermore, by promoting a sense of enthusiasm, wonder, and interest, the museum can develop a positive attitude toward science in elementary school children. It has been shown that children who have a more positive attitude about science tend to participate more in science activities as well as show increased attention to classroom teaching (Jarvis & Pell, 2005). The museum experience is unique in many respects which cannot be simulated in the classroom. One particular difference is that the scale or financial budget of exhibits or demonstrations cannot possibly be matched by those of a school. However, the methods which make museums successful can be effectively translated to a classroom if they are properly identified.

The most obvious difference between a museum and a classroom is the environment. A classroom tends to be an extremely structured everyday occurrence which may become mundane to some pupils. Gassert describes the museum atmosphere as such: “Museums are non-evaluative, stimulating places to explore knowledge about the world that science and technology have generated.” One major difference between the classroom and a museum is that a museum does not “grade” pupils. Another difference is that museums use physical models, demonstrations, or depictions that pupils can interact with whereas classrooms generally rely on textbooks with occasional videos or other teaching aids. The classroom experience is inherently more passive than the museum experience. Any activities which allow children to learn through interaction or break the daily routine of textbook learning could significantly increase a classroom’s ability to mimic the museum experience.

2.3.2 Potential Problems with Interactive Learning

Museum learning is unique and there are many advantages of a museum visit and informal learning. However, as with any learning method, potential drawbacks exist, and must be taken into consideration. One flaw is that there is no real way to be “graded” in a museum.

Since children need to receive grades in their science courses, classrooms implementing a program which is mostly or entirely informal would develop a need for a new grading rubric. This problem could be alleviated through an appropriate assessment process which is able to analyze pupils' retention and understanding of subject matter relative to the demonstration or activity they participated in.

Another issue arising from interactive learning is the potential negative effects novelty can have on a child. Gassert concludes that an activity with a large amount of novelty can be detrimental if it is not presented in the correct manner. From the teacher standpoint it is important to remember that demonstrations and exhibits which are new and exciting must be used as a teaching apparatus and not as a way to please pupils and consume time. Hands-on engagement is not a guarantee that a pupil has engaged intellectually or will retain information.

2.4 Inquiry-based Learning Activities

Whether a teacher is visiting the museum or planning to discuss topics similar to those found in the museum, it is important to have an appropriate lesson plan. A classroom demonstration as a pre-orientation tool is valuable for teachers who plan to visit the museum. An exciting, hands-on demonstration can also be incorporated into a lesson plan to encourage learning and promote subject interest amongst pupils. The product deliverables realized by this project will match curriculum guidelines and can be moulded to pupil learning behaviours. This will ultimately produce a successful lesson appropriate to either requirement.

2.4.1 Full Inquiry Science Lesson Planning

When creating a lesson plan based on hands-on activities, it can be difficult to avoid mundane, worksheet driven activities, while at the same time, enter the realm of true inquiry. As described by Huber (2001), full inquiry is a process in which pupils:

1) Form a productive question
2) Create an investigation directed toward answering that question
3) Execute the investigation collecting relevant data
4) Interpret and record their findings
5) Document or present their findings (A & J, 2001)

It will be essential for this project to present teachers not only with activities but also with lesson plans extending instruction toward inquiry. Huber (2001) describes a model for extending seemingly limited hands-on activities into full-inquiry science lessons.

The first step in the model is to select an activity. An ideal activity focuses on material the pupils are currently learning and can be introduced with a counter-intuitive remark. This can help capture pupils' attention as well as challenge their prior knowledge. Furthermore, at some point the activity should be able to be quantitatively analyzed by pupils.

The next step is for the teacher to present the challenge. It is at this point when the activity will become full inquiry. First, the teacher poses a "Can you think of a way to" question. Then the teacher facilitates a brainstorming session with the class without critiquing anyone's ideas. This brainstorming session is critical because first, it shows the pupils how to get started with a scientific investigation, and second, it provides structure that is essential later in the inquiry. Before they even know what is happening, the pupils are already retaining ownership over the experiment by designing it themselves.

After presenting the challenge, the next step is planning the inquiry. At this point the teacher should put the pupils in to groups based upon their brainstormed hypotheses. The teacher should assist the pupils in planning an investigation, and provide classroom instruction that is required to prepare the pupils for the inquiry. Each cooperative group should be allowed to test whatever variable they want. However, the teacher should aid in identifying practical options. The pupils should begin to change their focus from theory (Can you think of a way) to application (Can you find a way). Although each group may have different ideas, they are all focusing on the same question. Now the teacher should begin focusing the pupils' attention on their experimental design and establishing the reporting and product requirements. Pupils should record the question(s) they are trying to answer, the steps they will need to take to find an answer, and the results to be recorded. They should also be required to present and defend the results of their investigations to their classmates, and to create a graphical representation of the research findings. Furthermore, it is important that at this point the pupils are taught the scientific principles behind the experiment. Research suggests that in order for pupils to learn particular aspects of science, they must be explicitly taught rather than left to chance to pick it up during the experiment (A & J, 2001). In addition, teacher-guided, pupil-centred activities like this allow appropriate time for meaningful questioning by pupils, increasing their overall learning as well as allowing teachers to incorporate associated vocabulary in to the lesson.

The next step is for pupils to conduct the inquiry. With the framework now in place, pupils can attempt to answer their questions through hands-on investigation. At this point it is still necessary for teacher support, and a written job-performance aid can be helpful. By providing specific direction and instructions teachers can enhance learning outcomes.

Finally, the pupils must interpret and present their results. It is important for the children to interpret and record their data in an appropriate format. This can stress learning particular curriculum goals such as creating graphs. Next, the groups can present their findings, and in-class discussion can follow. Requiring an in-class presentation can encourage pupils to think critically during their experiment. Teachers should provide classroom instruction on the presentation after the hands-on portion of the work is completed.

After the presentations, classroom discussion or journal writing in which pupils reflect on their activities is important. During reflective activities, it is recommended by educators alike that teachers direct pupils to unassuming questions, such as the following:

- What is the scientific explanation behind the results of the experiment?
- What is a controlled experiment? How did your experiment represent this?
- Was your hypothesis correct? How much confirmation do you need to be sure of this?
- Did the experiment answer all of your questions? Did it raise new questions?
- If you could conduct the experiment again, what would you do differently? (A & J, 2001)

All of these questions encourage pupils to explore the science behind the experiment. Furthermore, they help pupils consolidate the information that they have already learned. Although hands-on does not guarantee inquiry, many seemingly limited hands-on activities can be presented in a way which encourages pupils to explore the "how" and "why" by using some form of this method.

2.4.2 Lesson Planning for Teachers Visiting the Museum

In order to create a successful trip to the museum and maximize the knowledge that children will take away, it is important to establish and implement a successful lesson plan. The Museum of Science has suggested tips on their website to make the most of a museum visit. The first step in the process is for the teacher to visit the museum ahead of time and become familiar with the layout of the museum and any activities the group plans to visit. The next step is to design a schedule which incorporates several activities that will reinforce similar principles. The final step is to give the pupils a pre-orientation to familiarize them with concepts and topics which they will be learning on their visit. Upon arrival at the museum the teacher should follow two steps to ensure that children learn as much as possible. First, encourage pupils to actively question and explore the experience. Second, give follow-up work in the classroom after the visit to reinforce concepts (*Science museum.*2007).

2.4.3 The Significance of Pre-Orientation

Most Launch Pad visitors are pupils who visit the museum as members of class groups. Many of these children are visiting the museum for their first time and have a high perceived novelty with the gallery and the exhibits contained in the gallery. A pupil's perceived novelty can be described as their state of mind when exposed to new, unfamiliar, or unusual sensory information. It has been suggested that the level of perceived novelty pupils experience on trips such as this can affect their curiosity and then consequently their overall cognitive learning results (Anderson & Lucas, 1997).   Curiosity, which tends to be generated by one's feeling of novelty, is a motivation to investigate, influence, and interact with one's environment. High levels of perceived novelty correspond with high levels of curiosity which tend to result in exploration and gathering of setting information, rather than the intended institutional learning. This "off-task" behaviour can result in low levels of cognitive learning (Lucas, 2000). On the other hand, low levels of perceived novelty correspond with low levels of curiosity which tend to cause less on-task behaviour and correspond to less overall learning. However, there is an appropriate amount of perceived novelty which results in an optimum learning outcome (Anderson & Lucas, 1997).

The Learning Curve as a Function of Curiosity

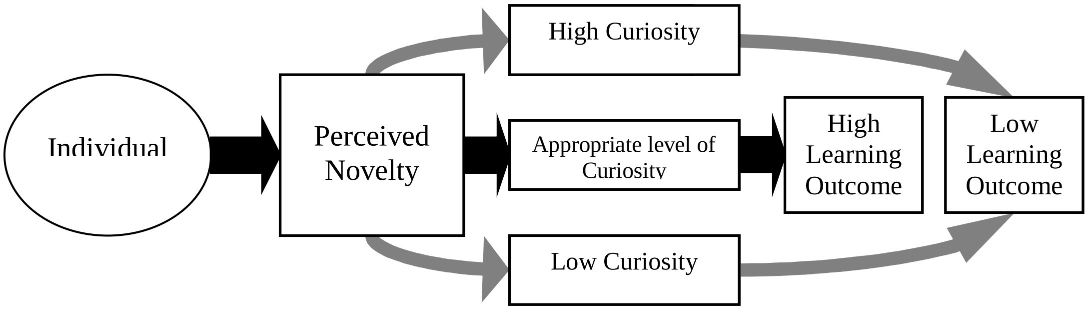

Figure 3: Relationship between Perceived Novelty, Curiosity, and Learning Outcome (Anderson & Lucas, 1997)

For most pupils the science museum is a setting that creates a high level of perceived novelty which can in fact hinder the intended learning outcome. Therefore, it would seem beneficial for schools to reduce pupils' novelty levels prior to visiting. Indeed, it has been shown that schools that give their pupils a pre-orientation of the visit focusing on the exhibits, physical environment, or both, reduce the perceived novelty of their pupils and increase their cognitive learning. Ensuring that pupils have an appropriate level of knowledge about the scientific principles demonstrated by exhibits and providing prior opportunities for pupils to practice skills relevant to the exhibits in Launch Pad can greatly influence the amount that pupils will learn. Furthermore, it has been found that it is difficult to reduce the perceived novelty so greatly as to hinder learning through the pre-orientation of pupils. (Anderson & Lucas, 1997). Clearly these findings suggest that teachers need to take action in preparing their pupils for class visits to informal science learning centres; however the majority of teachers either don't know of, or don't listen to of these suggestions (Lucas, 2000). This is where our project will play a key role. Providing direct pre-orientation activities for teachers to perform with pupils will alleviate burdens of research and extra work. This will likely make a teacher more apt to perform such pre-orientation activities prior to visitation, which will allow the visitors to come away with as much knowledge as possible.

2.5 Designing an Experiment

The design and implementation of classroom demonstrations should serve purposes which are useful to both the pupil and teacher. For the pupil, the activity should act as a medium which demonstrates scientific concepts translating to physical effects in the real world. The activity should incorporate several ideas and allow the pupil to develop a deeper understand of all concepts as well as a sense of how they relate. Furthermore, in order to optimize learning, these experiences should be with in the children's cognitive level. For the teacher, the activity should serve as any other teaching aid. It should demonstrate concepts previously taught which serves to reinforce prior knowledge while stimulating a continued interest in the subject.

2.5.1 Learning through Experience

Every pupil brings different knowledge to the classroom and not every pupil interprets an experiment in the same way. Magnusson and Palincsar elaborate on a teaching approach which allows pupils to learn through trial and error on their own part and on behalf of their peers. This teaching approach obviously favours an activity which allows children to test their own ideas and observe the ideas and potential solutions of other children in regards to the same problem. The potential advantages of designing an activity with multiple solutions in which children can learn through testing and re-testing ideas are vast. Most of the exhibits in Launch Pad are based on this theory. In the Grain Pit exhibit, for example, children can use a conveyor belt, bucket lift, and Archimedes' screws to move grain from one place to another. They are able to experiment and find that the more people you have, the faster the grain will move. This exhibit challenges children to think about what's happening and why. Many of science's greatest developments have come from scientists who have refined or built upon the work of others or previous work they have performed. Learning to perform these tasks at an early age may increase a child's understanding of both the subject matter and the scientific method.

2.6 Assessment Processes

Creating an experiment or other classroom activity would be trivial if there was not an effective way to gauge the results. Designing an effective assessment process for pupils is as crucial as designing the activities the pupils will participate in. Children's learning may be assessed in two ways: summative and formative. Summative assessments are designed to determine the overall performance of a child as well as the extent of their learning of material for the purpose of grading and evaluation. This type of assessment usually occurs at the end of a unit, course, or key stage. Primary schools in England use Standard Assessment Tasks (SATs) as a form of summative assessment to gauge pupil's abilities (Heaney, 1999). Formative assessment, on the other hand, generally occurs all throughout learning and can serve as a means to adapt teaching in lieu of evidence about the success of previous episodes (Wiliam & Black, 1996). Observing and interacting, questioning and discussing, grading work, and analyzing test results are all forms of formative assessment. It should also be noted, however, that assessments originally designed to fulfil summative functions can be used formatively, as is the case of using a standardized test to determine the effectiveness of a curriculum. Furthermore, it is widely seen that formative assessments can be used as summative judgments of pupils' achievements (Wiliam & Black, 1996). In the context of our work, it will be appropriate to create some kind of formative assessment process in order to elicit evidence from which we can interpret actions that will improve our classroom endeavours.

2.6.1 Strategy for Creating an Assessment Process

Creating an assessment process in an educational setting is vital to determining if a particular lesson has accomplished its purpose. In our case, we want to be able to determine if pupils actually learn certain scientific principles through our experiments. Creating a successful assessment process entails several steps which have been depicted well by Mcgourty and Heaney. It seems logical that the first step in the process is to figure out exactly what the lesson was supposed to teach. We must identify what we want the children to know, do, and understand. For every lesson there should be a set of tangible educational goals taken from a curriculum, and a set of outcomes that should be achieved. Furthermore, the strategy for teaching this lesson should also be defined, and it is generally better to use a range of teaching styles (Heaney, 1999). The second step is to create a method which will appropriately capture the results of the lesson. This step is important because it is necessary to match the methods with the material. An assessment method for a gym class would obviously be quite different than an assessment method for a science classroom. After a method is selected, it must be tested and evaluated. If the method seems to be extracting useful results and obtaining required data, then it may serve as an acceptable way to perform the assessment. Once the system is found to be sufficient for the required task, it is time to put the system to use. The system must be used and improved. Flaws with the method or its ability to collect useful data must be analyzed and corrected in order to continue the assessment process. The last step is to utilize the results in order to determine the lesson's overall success. Changes to the lesson can be made based on the data that was received and the process can begin again contingent to the newly formed lesson plan (McGourty, 1998). As

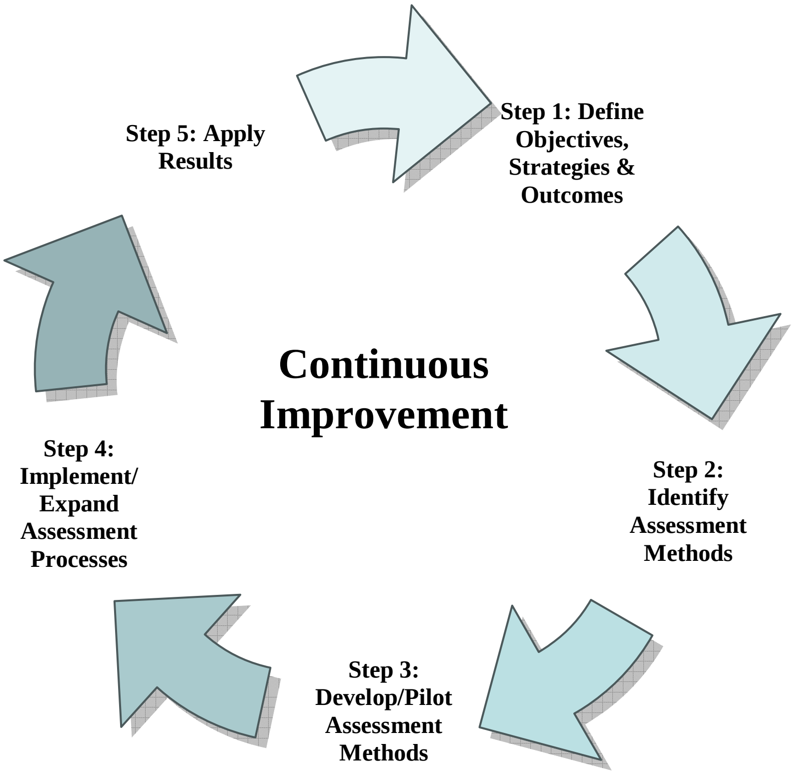

Figure 4: Five Step Assessment Process (McGourty, 1998)

Figure 4 demonstrates, a successfully organized assessment process leads to new lessons which require new assessment, and a cycle which improves both the lessons and the assessment processes is formed.

2.6.2 Formative Assessment Methods

There are a large variety of methods which can be used in the classroom to assess learning outcomes. Some of these methods include:

- Questioning and listening to children during classroom lessons
- Listening to children explain what they have seen and achieved, as well as what they understand
- Conducting written tests
- Observing children at work individually or in a group setting
- Talking with a child about an assignment, class work, or a test
- Grading a child's work and taking notes

(Heaney, 1999)

By using a range of approaches to assess our experiments we will be able to more readily evaluate the successfulness of our strategies. Increasing the number of assessment methods that can be properly applied to each experiment will expand the understanding of the knowledge that pupils were able to digest. It will allow the evaluator access to more levels of understanding from the child and it will be easier to tell if the child has only breached the surface of the subject and content matter or has actually grasped core concepts and can relate and apply them. These are just two extremes and many children will most likely lie somewhere in the middle where some mild understanding and application of content takes place.

2.6.3 Written Tests

Tests are another way to assess the needs and performance of children in the classroom. There are three main types of assessment tests: Diagnostic, Norm referenced, and Criterion referenced. Diagnostic tests are generally used to identify a pupil's strengths and weaknesses in a particular subject area. Norm-referenced tests can be used for formative and summative assessment and are generally used to compare the results of one child to the national average. Criterion reference tests measure a pupil's ability against a specified set of learning objectives or aptitudes (Heaney, 1999). For the purposes of this project, criterion reference tests appear to be the most appropriate for assessing our classroom activities. These tests are often used for end-of-topic tests and help the teacher evaluate what the pupils actually learned from his/her teaching.

When assessing our classroom experiments, it is going to be important to determine what the pupils actually took away from the experiments, as it is this information that will decide as to whether or not the experiment was a success.

Methodology

This project developed a series of activities and demonstrations which helped pupils experience the scientific principles explored in the Launch Pad Gallery in order to assist educators who were planning to visit the gallery or covering similar content in their classrooms. These activities introduced children ages 8-14 to scientific concepts exhibited by the Launch Pad gallery and also comply with the National Curriculum standards specified for KS2 and KS3 students. This project began on 12th March and ended on 27th April 2007. We achieved our goal by completing objectives created at the beginning of the project and following the process described throughout this chapter. Our objectives were as follows:

- Design experiments/activities that promoted inquiry-based interactive learning of proper curriculum concepts with target audience
- Build and test experimental prototypes for reliability, performance and feedback
- Create revisions and recommendations for improvement of experiments and activities

We followed a schedule similar to the one shown below, varying only in weeks 5 and 6, as time constraints did not allow for the development or testing of any new ideas. Experiments were created and tested on a rotating basis. One week was dedicated to researching ideas, creating lesson plans, instruction sheets and lists of materials. The next week was spent collecting materials, building prototypes, and finding an audience to test out the demonstrations.

Project Development Schedule

		12-16 March (Week 1)	**19-23 March** (Week 2)	**26-30 March** (Week 3)	**2-5 April** (Week 4)	**10-13 April** (Week 5)	**16-20 April** (Week 6)	**22-27 April** (Week 7)
Inquiry Based Learning	Develop	🟥		🟥		🟥		
	Test		🟦		🟦		🟦	
“Quick And Dirty”	Develop	🟥		🟥		🟥		
	Test		🟦		🟦		🟦	
Finalized Project	Final Paper	🟥	🟥	🟥	🟥	🟥	🟥	🟥
	Final Presentation							🟦

An overview of the process followed to create each experiment is depicted below. Again, this process lasted approximately two weeks and serves as a guideline to the steps required to produce an experiment or set of experiments. The ideas contained in red and blue colored boxes represent the research and initial design tasks. The orange and green boxed items represent the construction and testing of selected designs.

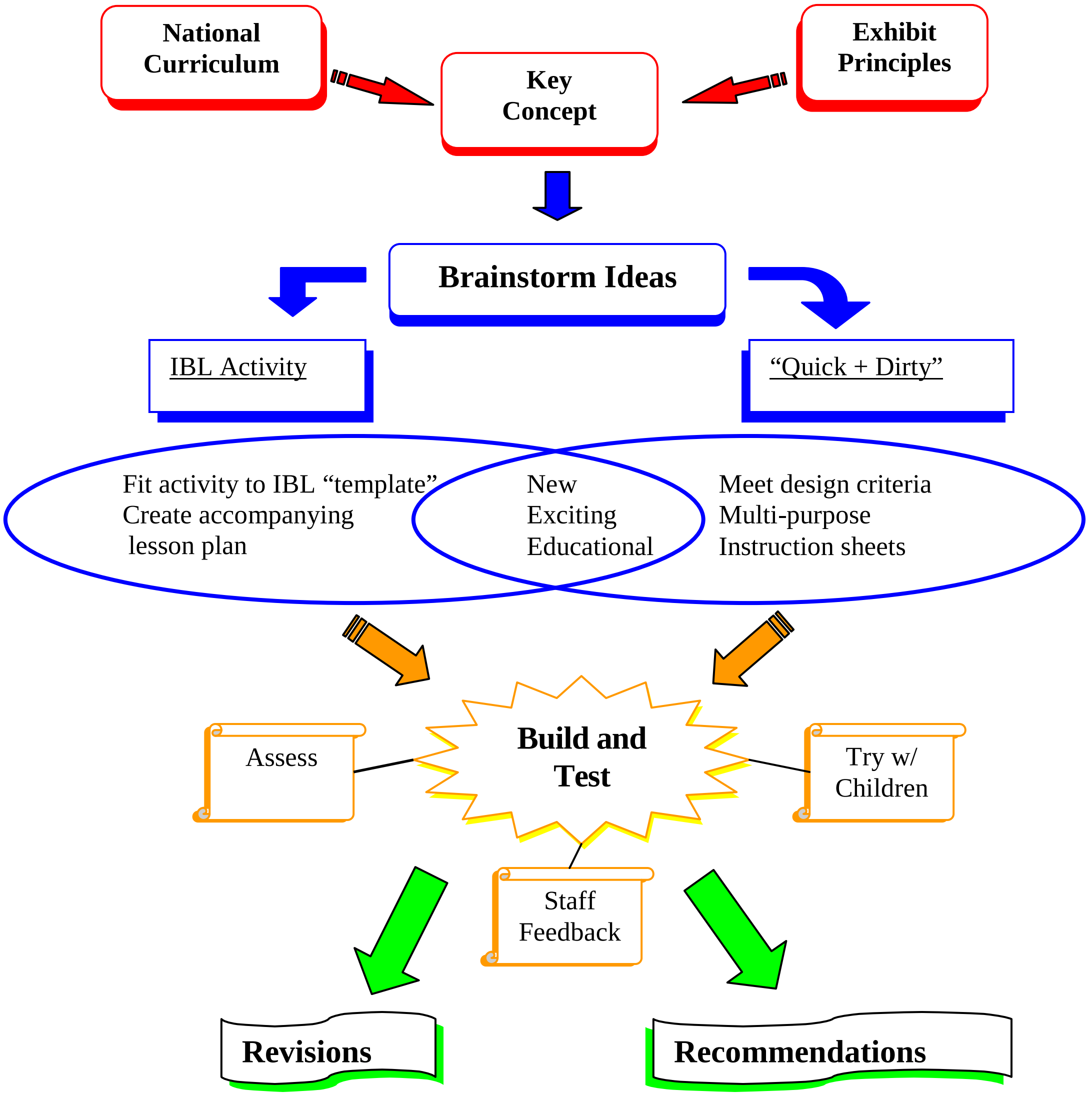

Figure 5: Project Overview Graphic

3.1 Identifying Key Concepts

The first objective we completed was to match scientific principles found in the Launch Pad gallery with content present in the United Kingdom National Curriculum. This process involved two distinct tasks that together formed the foundation for our experiment design. Identifying and matching exhibit and curriculum principles correctly was necessary in order to create experiments that had significant educational value.

3.1.1 Exhibit Principles

From our project description packet provided by our sponsors, our group was given a descriptive list of several exhibits which will be contained in the future Launch Pad gallery. From this list we conducted an analysis of scientific principles which are demonstrated by each exhibit.

3.1.2 National Curriculum

After reviewing the ideas for the future Launch Pad exhibits, we analyzed the United Kingdom National Curriculum for the target age group. Key Stage 2 and Key Stage 3 pupils were the target audience since children in these key stages fall within the 8-14-year-old age group. Children in these key stages are responsible for various principles, many of which correspond closely with principles demonstrated in the Launch Pad gallery. The following tables illustrate the correlations discovered from the analysis of exhibit principles compared with guidelines from the National Curriculum for the target audience.

Table 1: Key Stage 2 Exhibit Principles

Key Stage 2	
Principle in National Curriculum	Launch Pad Exhibit
Learn how to measure forces and identify the direction in which they act.	*Yacht Racer*
Understand that sounds are made when objects [for example, strings on musical instruments]vibrate but that vibrations are not always directly visible	*Invisible Visible*
Understand the forces of attraction and repulsion between magnets, and about the forces of attraction between magnets and magnetic materials	*Electro Magnetic Induction Man*
Understand that light is reflected from surfaces [for example, mirrors, polished metals]	*Image relay*

Table 2: Key Stage 3 Exhibit Principles

Key Stage 3	
Principle in National Curriculum	Launch Pad Exhibit
Understand that unbalanced forces change the speed or direction of movement of objects and that balanced forces produce no change in the movement of an object Understand that forces can cause objects to turn about a pivot	*Big Machine*
Learn how electromagnets are constructed and used in devices [for example, relays, lifting magnets]. Learn about magnetic fields as regions of space where magnetic materials experience forces, and that like magnetic poles repel and unlike poles attract	*Electro Magnetic Induction Man*
Learn how light is reflected at plane surfaces	*Image relay*
Learn the relationship between the loudness of a sound and the amplitude of the vibration causing it Learn the relationship between the pitch of a sound and the frequency of the vibration causing it.	*Invisible Visible*
Understand that unbalanced forces change the speed or direction of movement of objects and that balanced forces produce no change in the movement of an object	*Yacht Racer*

It is clear that many exhibits in Launch Pad demonstrate concepts applicable to each Key Stage. Correctly identifying this information was important for the remainder of our project because our design ideas needed to encompass a curriculum principle in a manner similar to the Launch Pad gallery exhibits. Any design which was deemed unable to demonstrate an important concept did not proceed past the brainstorming phase.

3.2 Designing an Activity

The design process is the art of creating a product that satisfies criteria and produces desired results. For this particular project there were several criteria that needed to be met during the design process. Some of the criteria were tangible while others were subjective. The group brainstormed multiple ideas for each exhibit in order to derive products with the best combination of desirable traits. We also considered the needs of the museum during the design process. The museum desired the production “Inquiry-based Learning Activities” as well as “Quick and Dirty” activities so our ideas needed to be sorted and developed appropriately.

3.2.1 “Brainstorming” Phase

The first step in the design process we followed was, “Brainstorming.” During this phase the group researched any ideas relevant to the scientific principles in the theme area that we were interested in. The process of brainstorming consumed several days during the periods designated as research and design weeks, and was essential to uncovering the wide variety of ideas which were required. The process was so lengthy mainly because every group of ideas had to be measured against criteria created by either the group or museum staff. Also, since two distinct groups of activities were needed (inquiry-based and "quick and dirty"), two groups of criteria were also needed. The brainstorming became sorted based on the distinctions between the two groups of activities. Half of our group would search for activities which seemed better suited to meet the inquiry-based specifications while the other half researched ideas which seemed better suited to act as quick demonstrations or do it yourself activities. If either half of the group encountered an idea that did not seem to fit but still seemed particularly interesting they would simply pass it off to the other group to see if they could develop it further. The group met weekly with the museum staff to collaborate and agree on experiments to develop further during the next week. During this meeting decisions were ultimately made to approve or disapprove both the experiment ideas themselves and classification we had given them.

3.2.2 "Quick and Dirty" Activities

Each of the two groups of activities had certain characteristics which distinguished one from the other. In particular, the "quick and dirty" activities were required in greater number than the inquiry-based learning activities, and required instruction sheets listing materials that were required as well as setup and procedure directions. The criteria that were considered when the group researched ideas of this sort are as follows:

- The experiment should be linked to the future Launch Pad Gallery exhibits and fulfil the educational outcome set for in the National Curriculum
- The activity must have a WOW factor and should provoke children to question what they see and experience
- Safety is critical both for the person performing the demonstration as well as for the audience
- The experiment must be reliable so that the person demonstrating will be sure of the outcome each time

Originally, we had thought that our experiments should be small-scale and easily constructed at home or in the kitchen. However, this did not prove to be the case, as we soon discovered the important focus of our project. The museum prefers exciting demonstrations that may require adult supervision or presentation as it long as it accomplishes its goal of captivating and teaching children. The experiments that we developed were to be relatively practical, in that they are not overly expensive or dangerous, but otherwise, the bigger the better. Whether this meant simply scaling up a past experiment, or completely redesigning one so that it incorporated fire, explosions, or other exciting phenomena, it was now evident what the museum hoped to procure from our stay with them. A summary of the, “Quick and Dirty,” design criteria are depicted in Figure 6: Quick and Dirty Design Criteria.

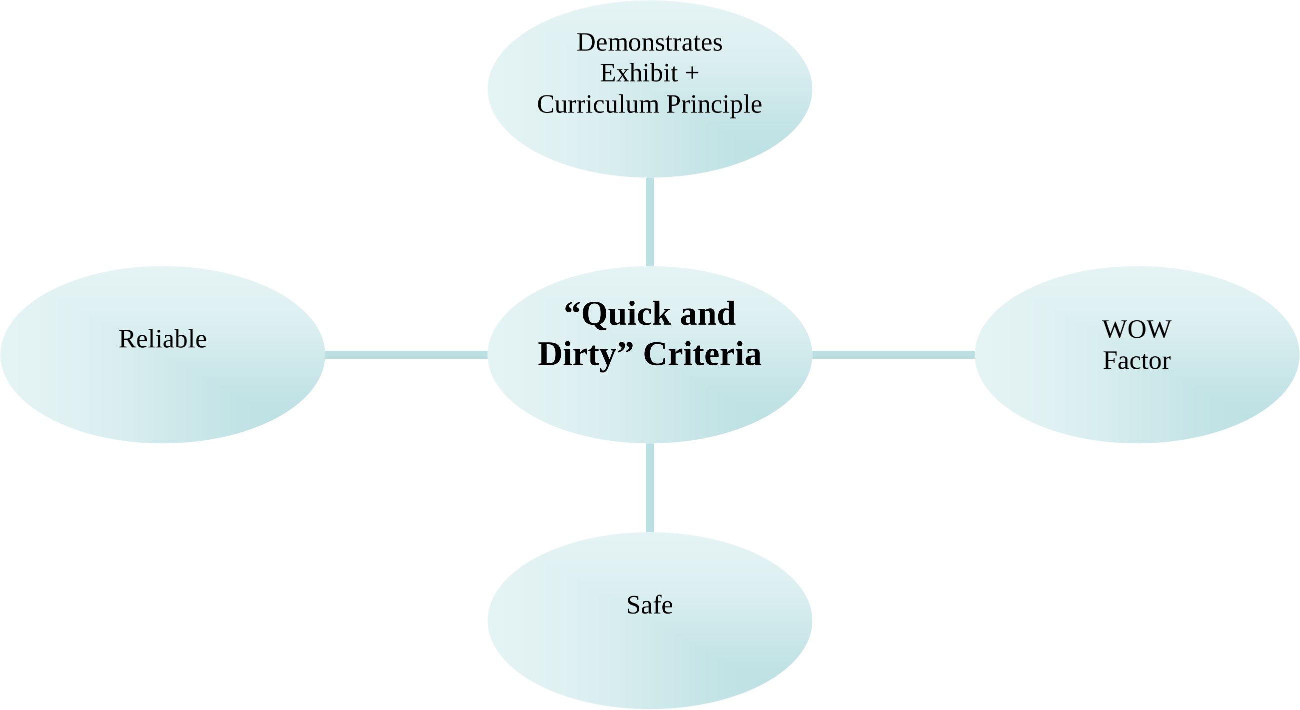

Figure 6: Quick and Dirty Design Criteria

3.2.3 Inquiry-based Learning Activities

In order for teachers to bring the designed activities into their classrooms, they must have a lesson plan. First, the activity should be associated with material the class is currently learning. By establishing links to the National Curriculum for every activity we designed, teachers will be able to choose which activity most appropriately conveys their current program of study. Once teachers select the appropriate activity, our work also provides an outline for a full inquiry science lesson revolving around it.

In designing the inquiry-based learning activities (IBL), a set of key factors was faced to ensure that the experiment could be used in a full-inquiry science lesson (Figure 7):

- The activity needed be new and surprising to pupils. In this way it can be introduced with a counter-intuitive observation.
- Ideas about the outcome of the experiment could be brainstormed with pupils. They should be able to identify variables that can be changed in order to change the outcomes.
- Pupil Groups could test these ideas. The experiment should be able to be modified by pupils in order to test their hypotheses.
- Outcomes could be quantitatively analyzed. Pupils should be able to graphically represent outcomes.

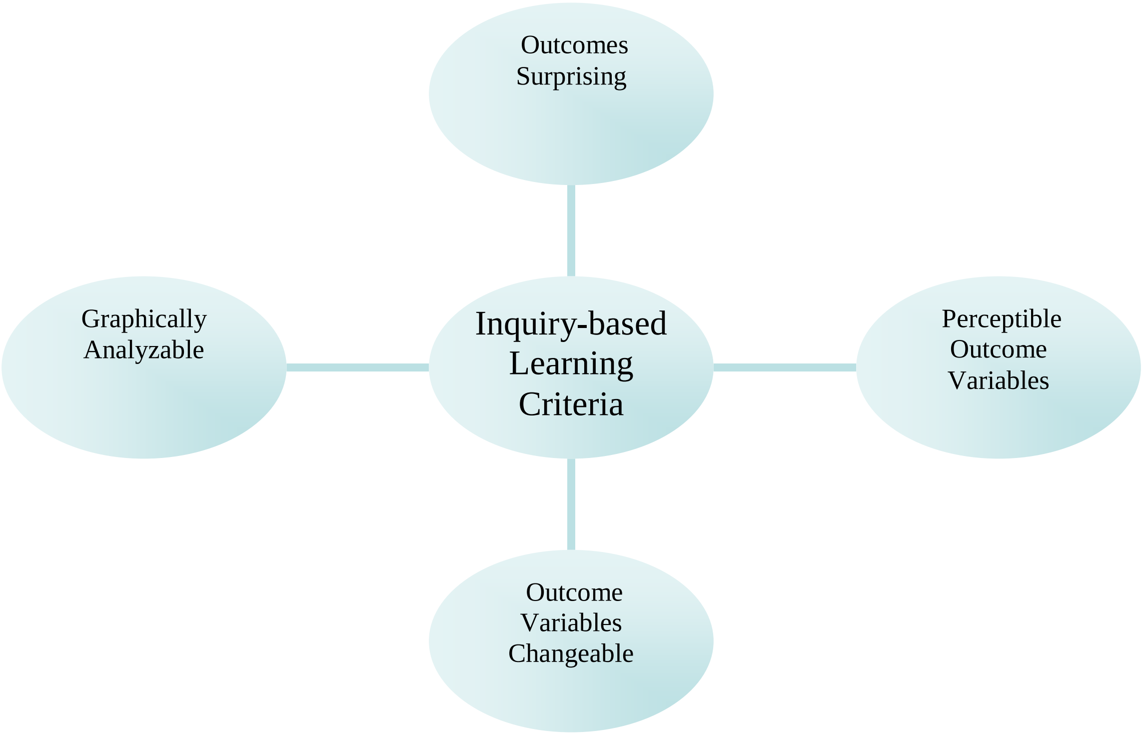

Figure 7: Lesson Plan Design Criteria

Once these criteria were met, we created lesson plans specific to each experiment following Huber's model:

1. Teacher introduces pupils to experiment engaging them in direct inquiry
2. Teacher-supported brainstorming activities enable pupils to plan investigations
3. Effective written job performance aids are introduced to provide structure and support
4. Cooperative groups conduct their experiments
5. Pupils are Required to provide a product of their research, usually done through a class presentation and a graph

6. Teacher leads a class discussion and writing activities which enable pupils to reflect on their activities and learning.

3.3. Build and Test Prototype

After we designed either an IBL or ‘Quick and Dirty’ experiment satisfying all of our criteria and it was approved by the Museum staff, the next step was to build a prototype. The prototype was tested for reliability and performance and the success of each prototype was recorded through a series of pictures and written documentation which was presented to our sponsors weekly. At this point, we had a good idea about what the experiment looked like and it was just a matter of putting this idea into a working physical form.

3.3.1 Setup and Procedure

For each designed experiment we created a materials list and pictures or diagrams with explanations that depict how it should be set up and conducted. The first step in building the prototype was to gather all materials needed. These were found in various hardware and arts and crafts stores in the area as well as educational supply catalogues. When this was accomplished, we set up the activity as planned. Depending on the type of activity, there were different sets of criteria to consider when building. If the activity was meant to be a demonstration by the museum staff, then the setup could be complicated and the materials rather expensive. If the activity was meant to be set up by a teacher and demonstrated by students, then the activity needed to be simpler and cheaper. After the prototype was built, we followed the procedure created to run the experiment. While building the prototypes and creating instruction sheets, we kept in mind whether someone who is unfamiliar with the experiment would be able to run it successfully. If the activity was targeted toward pupils, then the directions needed to be concise and easy to follow. Also, inquiry-based learning activities were appropriately timed in order to fit into one or two class sessions.

3.3.2 Reliability

Each experiment went through a rigorous set of test runs to ensure it operated as planned. During these test runs we used a worksheet appropriate to the experiment in order to determine any failures in the prototype. Any aspects of the experiment not working properly were recorded and improved upon. These improvements were added to our design. For every experiment completed, our final setup and procedure was simple, repeatable, and mostly failure free. A worksheet we used while testing prototypes can be seen in Appendix B25: Sample “Quick and Dirty” Staff Feedback Form.

3.3.3 Staff Testing and Approval

After completing prototypes our work was once again presented to the staff. Ensuring their awareness of our research into the National Curriculum connections as well as our rigorous testing, we asked them to follow our setup and procedure. They then got a chance to examine our prototype and give us any feedback they deemed fit and subsequent changes were made accordingly.

3.4 Assess Success

Following approval from the museum staff, we assessed our experiments’ success in teaching children the proper scientific principles. The outcomes of this formative assessment were derived from actual interaction with children of the target age. By giving in-museum demos to visitors willing to participate, we were able to obtain a wealth of information on the success of our activities. This pertained particularly to “WOW” factor, as well as scientific principles demonstrated, and the novelty of each idea. Our group assessed the activity’s performance through worksheets, written tests, observation and interaction, questioning and discussion, and teacher feedback.

3.4.1 Worksheets and Written Tests

From worksheets and written tests we determined important information regarding the entertainment value and principles of our activity’s performance. Worksheets were critically analyzed to decide whether the students were grasping the concepts intended. A great deal was learned by asking certain open-ended questions, such as:

- What is the scientific explanation behind the results of the experiment?
- What is a controlled experiment? How did your experiment represent this?
- Was your hypothesis correct? How much confirmation do you need to be sure of this?
- Did the experiment answer all of your questions? Did it raise new questions?
- If you could conduct the experiment again, what would you do differently? (A & J, 2001)

3.4.2 Observation, Interaction, Questioning, and Discussion

During the demonstrations, a great deal of data was derived from direct observation. It was a challenge to measure exactly how difficult an experiment was to understand, or how much a participant actually learned, so we relied on how well the children seemed to be grasp concepts, and how willing they seemed to pursue the topic in the future. For instance, it was easier to tell whether or not a young child was bored with what they were doing, or if they were overly confused by the activity, than it was to tell if they had learned the properties of Newton’s laws. Furthermore, by engaging in conversation with the children we were able to confirm some of these observations. Although this was a rather informal method of analysis, the information provided us with a large portion of the raw data required to mould the experiments into useful learning modules.

Results and Analysis

The outcome of the work performed during this project is multifaceted. The project has provided several tangible final products that can be implemented by the Museum. We have also analyzed the products created and processes employed, both of which are less tangible but equally as valuable.

4.1 Final Products

The deliverables presented by our group range anywhere from working prototypes, to lesson plans, to recommendations for the future. These final products are a culmination of all of the brainstorming, designing, building, and testing that have occurred during the time spent here, and will allow the museum to further develop the work that we began.

In some cases, such as with the prototypes, the museum will be able to physically manipulate what has been given, either in an attempt to reconstruct, or to simply improve. In other instances, such as with lesson plans or presentations, these final results may be used to provide for teachers or to bridge the gap between classroom and museum.

4.1.1 Prototypes

One of the primary deliverables was the prototypes developed throughout the course of the project. These models were one of several important aspects of our work, and serve as a basis for many of the other results that were developed. Upon completion of the project, our group had developed two working Inquiry-Based Learning activity prototypes and six working “Quick and Dirty” demonstration prototypes. We were able to test one of the IBL activities with both the staff and public, and four “Quick and Dirty” demonstrations with staff and one with the public.

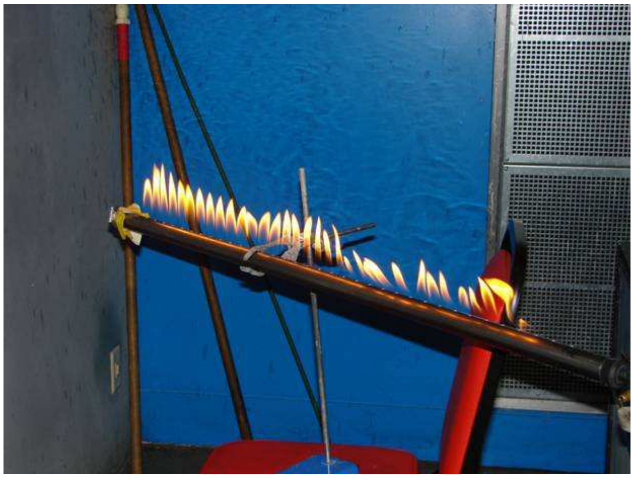

Figure 8: Ruben’s Tube Prototype

These prototypes will be left with the museum, and will likely provide insight into future projects, or demonstrations, that may be taken to schools in the UK. Although nowhere near finalization, each of these demonstrations exhibit numerous principles set forth by the National Curriculum, and will hopefully be used to ease any future work by the museum in this area.

4.1.2 Activity Sheets

As shown in Appendix A: Inquiry-based Learning and Appendix B: “Quick and Dirty”, we provided an activity sheet for each staff approved idea, regardless of whether or not it had the opportunity to be transformed into a physical prototype. These sheets contain information regarding each experiment including: a) the materials required; b) step-by-step instructions to create the demonstration; c) what worked well for the experiment; d) problems encountered during design and testing; e) possible improvements; f) recommendations; and g) links to National Curriculum concepts. They are essentially the heart of our project, and all of the information provided draws from each aspect of the work done, including prototypes, risk assessment, presentation, and feedback from staff and public.

4.1.3 Risk Assessment

Each of the working prototypes required a risk-assessment form. These forms are used by the museum to reduce potential hazards associated with each activity. Slight risk was tolerable as long as all dangers were identified and solutions were proposed. Each risk was assigned numerical value based on severity and likelihood of occurrence, and was sent to Health and Safety for approval before production and testing could be initiated. Completed and approved risk assessment forms for the activities we pursued can be seen in Appendix A: Inquiry-based Learning and Appendix B: “Quick and Dirty”.

4.1.4 Lesson Plan

Lesson plans were created to accompany each inquiry-based learning activity that was developed. The purpose of the lesson plan was to ensure that the activity was presented in a way that would maximize the inquiry-based effectiveness and make it easy for a teacher to incorporate the activity into a classroom. The lesson plans contained step-by-step instructions for the presentation, setup and performance of the activity and also included supplemental material such as worksheets, steering tips and additional suggestions to extend the activity. Examples of lesson plans are included in Appendix A: Inquiry-based Learning.

4.1.5 Presentations

Presentations for the public were created to accompany activities which proceeded to the public testing stage. Presentations were used to increase excitement amongst the audience and also ensure that all important steps of the lesson plan were covered. The presentations, such as the one shown in Appendix A8: Mousetrap Car Presentation, contained slides listing materials, brainstorming ideas, the challenge, and the instructions for the activity. Presentations were also used in compliance with risk assessment, as a method to defray any safety concerns. Safety briefings containing proper operation of dangerous materials and potential hazards alleviated risks associated with an activity.

4.2 Analysis

4.2.1 Inquiry-based Learning Activity Analysis

As described in the Methodology, every IBL activity was scrutinized against certain criteria. Throughout the project we developed a weight scale to account for the importance of many factors included in each activity. Each of the criteria was weighted based upon what we learned from museum staff and public testing. The following table summarizes the six designed IBL activities in terms of these weighted factors. A final rating was assigned to each activity based upon the overall success, as a total of each of the scored criteria.

We decided that the most important factor in designing IBL activities was the “wow” factor. The goal of these activities is to get kids excited about science and learn through questioning. If they are interested and enthusiastic about a science activity, then the gains are threefold: 1) they will retain the knowledge learned for longer periods of time; 2) they will tend to participate more in science activities in the future; and 3) they will show increased attention to classroom teaching. These gains are further enhanced by creating a sense of wonder towards IBL activities. Promoting pupils to explore and discover knowledge on their own is essential to developing the groundwork for conceptual science learning. Clearly we could not realize these achievements directly while testing, but it was fairly obvious that when kids became uninterested they stopped listening or applying themselves. When kids were enthusiastic, however, it was easy to see that they were much more intellectually engaged, regarding the task at hand.

Table 3: IBL Activity Scoring Rubric

	Activity Name	Wow (25)	IBL Fit (20)	Safety (20)	Skill Level (15)	Supplies (8)	Time (7)	Content (5)	Total Score (100)
IBL Activities	Mouse Trap Cars	24	19	16	13	7	5	5	89
	Rube Goldberg Design	24	17	18	13	6	4	4	86
	Windmill	18	20	19	11	6	6	5	85
	Paper Bridge Building	15	19	20	10	8	7	5	84
	Egg Bungee Jump	23	18	17	10	6	5	3	82
	Dinosaur Egg	10	15	18	8	6	4	3	64

The second most important factor we took into account when scoring our activities was how closely each activity could be fit into an inquiry-based science lesson. The template we developed was fairly strict, and did not lend itself to activities that did not match our criteria. Activities in which kids could not think up new ideas themselves or could not see the effects of changing different variables during the activity were usually not considered any further. If the pupil is not actively brainstorming, then the activity leaves the realm of IBL. Because we were designing these activities strictly to promote IBL, we had to take this criterion very seriously.

A third factor that was strongly considered was the safety of every activity. The Museum is held accountable for any ideas given to teachers in which accidents can happen. It was important to consider not only the danger of each activity, but the precautions taken to eliminate dangers as well. All activities designed were safe and appropriate for classrooms but some required precautions on the part of the presenter both before and during the activity.

Making activities that were the appropriate difficulty or skill level for the target age group was a fairly important factor. We found that if the difficulty was too high, then pupils became confused and got frustrated. If the activity was too easy, however, then they became bored and disinterested. This factor is not weighted as highly as others because teachers can use more or less steering tips in order to make the activity the correct difficulty level.

Activities with unattainable or expensive supplies were never even considered, so in our final scoring system cost and availability were not very important. We did not completely disregard these criteria, however, as teachers still need to be able to get these materials themselves. For each activity, it ended up mattering *how* cheap and attainable the materials were rather than *if* they were cheap or attainable.

Class sessions in the UK generally last about an hour. However, a true IBL process can sometimes take longer. This is true because the teacher is not just feeding information directly to the pupils. Instead, he/she is getting the pupils to figure things out for themselves. A few of our more complex IBL activities were planned for two class sessions, while a few were crunched into an hour session. Because of the flexibility to make children do homework assignments prior to the activity, or have the teacher cover the material the class before, time was not weighted very heavily.

The curriculum content was the least important factor in ranking our activities. For most activities we started with a general curriculum concept and then created an idea based upon said concept. If the activity passed we would then go back and relate it to specific portions of the curriculum. This was dissimilar to the other criteria that were used, as they were taken into consideration before and during construction. We found it very easy to link activities to science concepts relative to making the experiments stimulating.

4.2.2 Case Study: Mousetrap Car IBL Activity

The best in depth example of an IBL activity is the Mousetrap Car because it was pursued further than any other. We tested it with Museum Explainers, Outreach staff, and families visiting the museum. By completing our methodology cycle with this activity we were able to gain insight into the importance of different criteria on our IBL analysis chart.

The idea of powering a vehicle with a mousetrap proved to be exciting to adults and youth alike. When first proposing the idea we were given an emphatic "yes" to proceed with creating prototypes. While building prototypes, outreach staff in our office were anxious to see results and test runs. An average score of 7.5 out of 10 was given to the question "How interesting do you think youth (age 12-14) will find this activity?" when testing with explainers and outreach staff. Every single youth tested within family groups stated that they thought their friends would have fun doing the activity. In one instance while approaching families to see if they would like to complete the activity an initially uninterested mother was convinced by her two sons after they heard they would be building cars. We found that it was easy to keep youth on task when doing the activity because of the fact that they were so interested. Furthermore, based upon feedback given by museum staff, we made the public presentation exciting and engaging. This helped capture the children's attention, focus them to the task at hand, and give them ownership over their ideas and work. Through these findings, we concluded that without the "wow" factor, it would be tremendously more difficult to carry out an IBL activity.

The Mousetrap Car activity proved to be a great activity to use for the purposes of inquiry based learning. After a bit of tweaking, we found it successful to have pupils brainstorm ideas about essential parts of a car, how those parts could be created using materials provided, and lastly how the different parts could be connected together. It was during this stage that the activity became IBL, because we were no longer giving directions or telling children what to do; rather they were coming up with all ideas on their own. An example of ideas brainstormed by children can be seen in Figure 9: Mousetrap Car Brainstorming Session.

Figure 9: Mousetrap Car Brainstorming Session

Groups were then allowed to either draw out their design or begin building. One important aspect that was hard to grasp for youth as well as adults was how to link the axle to the mousetrap in order to power the wheels. This problem was alleviated in two ways. The first was by bringing it to everyone's attention during the group brainstorming session. This way if one person could think of a good idea then everyone else would be able to work and adapt off of that. The second solution was to do a quick demonstration of a prototype mousetrap car in order to give pupils an idea of how it could work. This was the only aspect of the activity that wasn't ideal for an IBL activity, because in giving a demonstration you are giving up knowledge that could be learned by critical thinking. We found this necessary for public testing in the museum however, because we only had a time block of one hour.

The hazard of getting your finger snapped in a mousetrap was an obvious safety concern throughout the course of this activity. This risk was assuaged in a few ways, which can be further seen in the mouse trap car risk assessment form in Appendix A7: Mousetrap Car Risk Analysis. A mousetrap safety presentation, seen in Appendix A9: Mousetrap Car Safety Presentation, was given to students before building started. During the presentation we put a piece of chocolate in the set trap and showed how a trap could shatter it, reinforcing the idea that mousetraps are not to played around with. Also, youth were not given mousetraps until their cars were built and ready for them. Lastly, it was required that an adult set the mousetrap when groups were ready. Although originally thought it might be too significant of a risk, these precautions were successful in that not one finger was caught in a mouse trap during three testing sessions.

We determined an appropriate age group to complete this activity would be KS3 pupils, students aged 12-14. After testing, feedback from Museum staff indicated that this was an appropriate age level, however that some "hinters", or steering tips might be needed to help students grasp concepts. At this age pupils are old enough to construct a complex device without assistance, and they are also mature enough to realize the dangers of a mousetrap.

The materials required to complete a mousetrap car were cheap and easily attainable. The only supplies not found in a common household were mousetraps and PVC piping. During testing no groups actually used the PVC piping, so this material was fairly unnecessary. Teachers can have their pupils bring in many of the supplies, such as paper towel rolls and juice containers.

Because of the complexity of the activity and the time needed for construction, we decided that optimally it would take two class periods of fifty minutes each to complete. When testing, we only had time blocks of 50-70 minutes, and this tended to make the activity rushed. Appropriate design time, summing up important concepts, and a debriefing going over what could have been improved were all altered from our original plan. When we asked explainers and outreach staff “How appropriate is the time period (2 class modules) for this activity?” we received an average score of 8 out of 10, with only one person suggesting a different time of an hour and a half.

When originally designing the activity we started with the general curriculum theme of forces and motion. Later, we tied this to specific topics and learning objectives for KS2 and KS3 students, which can be seen in Appendix A1: Mousetrap Cars. When asking museum staff “How strongly do you feel scientific content could be tied to this activity?” we received an average score of 9 out of 10. When asked “What scientific themes do you feel are most appropriate for this activity?” we received answers of “forces and motion”, “friction”, “levers”, and “Newton’s laws”, all of which related to our original ideas. Depending on a teacher’s current course study, they could relate this activity to a number of topics.

4.2.3 Quick and Dirty Activity Analysis

Much like the Inquiry-based Learning analysis chart, the “Quick and Dirty” chart summarizes the overall quality of each demonstration. Based on staff feedback, criteria that were found more important were weighted heavier and those not as important were weighted less. Eighteen demonstrations were designed and looked at in-depth in comparison to the following factors.

Once they have been approved, however, each of these “Quick and Dirty” ideas must then be transformed into a working prototype. This means that materials must be gathered, design needs to be tweaked, and the finished product will need to be tested. It is during this lengthy process that particular attention must be given regarding the listed criteria, as in the end, they will ultimately decide how efficient or worthwhile the demonstration is.

As with the Inquiry-based Learning activities, the “WOW” factor, safety, and supplies are all rather important when it comes to rating whether or not a “Quick and Dirty” demonstration is effective. Obviously, it is very important for the demonstration to be exciting and interesting, but whereas inquiry-based learning activities have many other factors, such as skill level and classroom fit, to turn to for success, “Quick and Dirty” demonstrations rely heavily on this “WOW” factor.

Table 4: Quick and Dirty Scoring Rubric

	Activity Name	*Wow (40)*	*Safety (20)*	*Reliability (15)*	*Supplies (10)*	*Setup Time (10)*	*National Curriculum (5)*	*Total Score (100)*
“Quick and Dirty” Demonstrations	Burning Money	40	13	13	10	10	5	91
	Air Cannon	32	20	15	10	8	5	90
	Mirror Dish	30	20	15	0	10	5	80
	Oobleck	19	20	15	10	10	5	79
	Supercool Water	40	20	2	10	2	5	79
	Electro-Magnet	25	17	15	10	5	5	77
	Lissajous Figures	17	20	13	10	7	5	72
	Ruben’s Tube	40	7	5	5	7	5	69
	Collapse Can	25	15	11	8	5	5	69
	Balloon Rocket	16	19	11	10	6	5	67
	Trebuchet	27	16	7	6	4	5	65
	Periscope	10	20	15	10	5	5	65
	Coloured Shadows	15	20	11	6	6	5	63
	Sound in a Bag	20	18	11	4	4	5	62
	Hover-Craft	28	15	8	4	1	5	61
	Magnetic Water	20	20	4	10	2	5	61
	Electric Generator	10	20	12	7	5	5	59
	Electro-Magnetic	35	5	10	0	2	5	57

🟥	Can Crusher							▨

This is because with each IBL, children are actively participating in the demonstration, whereas with particular “Quick and Dirty” demonstrations, children may only be allowed to act as bystanders. Therefore we found it necessary to catch their attention with things such as fire, explosions, or loud noises, to ensure that they will not only remember the presentation, but so that they will have a much greater potential to remember the scientific principles demonstrated by it.

Unlike IBL activities, however, “Quick and Dirty” demonstrations depend on their reliability, setup time, and links to the National Curriculum for overall efficiency. When presenting a “Quick and Dirty” experiment, it is very important that it will produce the desired results, or the experiment may be viewed more as entertainment than anything, leaving the audience with little desire to pay further attention. An experiment may claim to exhibit numerous scientific principles as well as display an incredible “WOW” factor, but if the presenter is unable to make it work, then it is all in vain. Therefore it is very important not only to test repeatedly, but to also ensure that the nature of the project (setup time, react-ability, etc.) will not in anyway impede it.

Somewhat similar to these criteria is setup time, as a demonstration can be amazing, in essence, but without the ability to be performed in the allotted classroom time, could be quickly discarded. Therefore, it is very important during development to take notice of how long setup actually takes. Often this may mean a lengthy redesigning of experiments by scaling them down or changing materials, although in the end this process is usually the wiser choice. Another factor to account for is performance time. If a demonstration takes a very long time to perform, for instance longer than a class period, or displays gradual changes, then it is very likely children will lose interest and move on to something new.

The last, and least ranked, criterion is the demonstration’s link to the National Curriculum. Although important, when developing the experiments we were told to focus on this last; if an experiment were exciting and reliable enough, then we could worry about finding links later on. The importance of this standard, however, is that without links to the curriculum, teachers will be unwilling to use the demonstrations, as they will be viewed more as a waste of classroom time. By being able to link it to the curriculum, an experiment will prove to be much more effective educationally. With these particular demonstrations, the main goal is to intrigue the child based on what they see. By presenting principles to children along with the experiment, they will not only remember what happened during the demonstration, but also what they learned from it.

4.2.3 Case Study: Air Cannon "Quick and Dirty" Demonstration

During the brainstorming process we looked into all the criteria we set forth in the methodology and concluded that this was an appropriate activity to develop. The Air Cannon demonstration not only complied with the basic requirement for a demonstration to be approved, but also possessed the extremely important "wow" factor.

Our observations while testing with explainers enabled us to evaluate the air cannon demonstration and led us to important conclusions concerning the "wow" factor it exhibits. While testing with explainers we received positive feedback on the activity. When asked if they enjoyed the demonstration, the explainers responded with an average score of 8 out of 10. Testing with the public reinforced the idea that this was indeed an interesting activity for children. After trying out the prototype the children's response to how interesting the prototype averaged to a 9 out of 10. For the question "Is this something that you would like to see done in a classroom?" the answers were "it would be really fun" or "I would love to see it".

The second most important criterion was the safety of the prototype. After scrutinizing the set up procedure as well as the materials used to make the air cannon demonstration we were able to predict that it would not pose any danger to either the person building it nor to the one demonstrating it. The use of a bucket for the base and a shower cap for the vortex launching device proved to be safe. Specific attention was paid to safety while testing with the public. We took notes on how the children would hold the Air Cannon and if they experienced any difficulty that would be seen as a potential hazard. None of the children testing the prototype had any problem using it nor were they in a situation that would cause them harm thus enabling us to give the air cannon a perfect score on the safety evaluation.

Evaluating how children react to a demonstration made out of common household materials was also part of our testing. Easily sourced materials are something that teachers want, but would it be something that the students would appreciate in a demonstration? This question was also answered during testing. After talking to the children partaking we confirmed that children are amazed by the fact that simple household objects can make a really entertaining demonstration. When asked what they think the material of the launching device is they all came up with complex materials never guessing that is was a simple shower cap. When revealed what the actual material is they stared with amazement and commented on how clever that was.

The time required to set up the demonstration was one of the main topics discussed with the explainers. We realized that a demonstration with a fairly short and easy set up would enable teachers to implement the demonstration into their lesson plans and be able to use it in support of the material they teach. Building the Air Cannon was fairly easy and quick. The demonstration is also instantly usable hence making it something that a teacher would love to use in a classroom activity.

One of the most important things for the quick and dirty demonstration is for it to be reliable, because we want teachers performing the demonstration in their classroom to be certain of the final outcome. In the case of the Air Cannon little could go wrong. The prototype is set up in such a way that the only thing that could happen is for the shower cap to get torn but is an easily replaceable thing. Because of the nature of the prototype we were able to perform the demonstration multiple times without encountering any problems.

Last but not least the demonstration should be educational. While testing with the explainers we realized that the demonstration needs to be presented in a way that would capture the attention of the audience. This was very important because unless children take interest in what they are shown they would not be able to benefit from the educational outcomes of the demonstration. For testing with the children we developed a full demonstration which was made up of a series of components including an explanation of what the air cannon is, a presentation on the scientific principles behind it as well as a series of games to test the demo. This enabled us to observe how children learn through playing. After presenting the Air Cannon we asked the children how they think it works and none of them could answer the question. Once we explained the principles behind it and gave them the opportunity to tray the air cannon out they could actually take a closer look at the demo and try to figure out how exactly things worked. This testing session taught us that unless a child is explained what principles lie behind the demonstration they would just see it as a fun toy and not even consider the science behind it.

Air Cannon demonstration not only met all of our expectations but exceeded them. Taking it thought all the stages set forth in our methodology proved that this is a true example of what a quick and dirty demonstration should be.

Recommendations

One of the most extensive deliverables of this project is the set of recommendations created as a result of our work. If any group is going to attempt to continue with our work or pursue a task similar to that presented to our group, these recommendations should serve as a useful guideline. We will discuss potential testing methods and the activity sheets will also provide suggestions for actions to be taken regarding each experiment. Also included are propositions, based particularly on research and feedback, on how to proceed with the development of activities similar to those created during this project.

This project did not thoroughly test a large portion of the ideas researched and created due to time constraints. Before any of the ideas proceed to a classroom or outreach activity they need to be tested to determine their effectiveness. Based on our background research, formative assessment is one of the most effective methods commonly used to test the types of activities created during this project. The testing sessions that we did conduct attempted to employ formative assessment methods and were relatively successful at extrapolating valuable data from the sample audience. Written worksheets and tests can also be used by educators, in a classroom setting, to supplement observation and interaction techniques of the students, and reinforce conclusions drawn from these methods.

Classroom testing is vital to determine the effectiveness of the overall lesson plan template and the activities themselves. The presentation and lesson plan were evaluated briefly during the course of this project for select activities but they were not placed in context or with an appropriately sized audience. In order to gain a more appropriate perspective and gauge the effectiveness of the lesson plan template and individual activities, classroom testing sessions are necessary. Lastly, classroom testing is essential because the testing performed by our group is not comparable to the skill with which a teacher or other trained professional might present the activity. Although we attempted to create a classroom-type atmosphere as a substitution for our inability to travel to schools, it is nearly impossible to do this in the museum since most members of the public visit the galleries to enjoy the exhibits and learning is of secondary importance.

All activities researched and developed by this project contain a unique set of recommendations. These recommendations are contained within each activity sheet and can be found in Appendix A: Inquiry-based Learning and Appendix B: “Quick and Dirty”. Some activities are not feasible for any future development, due to various factors and these are all discussed within the activity sheets. We have also included activities we were unable to develop but feel they would be worthwhile if pursued further. These sheets should be referred to by any museum staff attempting to recreate the activities developed by the group or who are interested in refining or redeveloping some of the more successful activities.

Much of our background research implies the importance of a child's perceived novelty with an activity. After conducting testing we have confirmed that the excitement and interest levels displayed by a child do indeed correlate with the novelty of the activity. A new and original idea which creates a significant amount of interest and curiosity can in turn foster learning, understanding, retention and application of knowledge. Therefore, ideas which the students are familiar with or appear to be fairly common do not contain the same amount of novelty or create the same amount of interest and as a result may not be as effective. Our group recommends selecting a balance between new ideas and older more reliable ideas. As shown in Appendix A1: Mousetrap Cars, the idea for a car powered solely by a mousetrap is by no means conventional, yet with the proper presentation and application can be just as effective, if not more so, than many of the shows already implemented by the museum. By introducing this notion through inquiry-based learning, a relatively new concept, and working in group dynamics, a more reliable means of performing public activities, we were able to create an a completely unheard of experience for most of the participants, that was successful in many ways. Although it is more difficult to make a less proven activity work or create an activity with no prior basis, the results produced by this type of work are worth the time and effort.

Lastly, we suggest measures which should be taken, regarding materials, setup, and presentation, when pursuing future activities similar to those contained in this project. It is important to attain the mindset of a child and approach each activity with the same thought process as the target audience. Sometimes this task requires disregarding physics knowledge and returning to simpler ideas of cause and effect. Equations, theories and higher education can all cloud the ability to interpret a child's reaction to a particular activity. It is difficult to envision an activity from a child's perspective but it will help create more effective activities if one is able to do this.

The work performed during this project can be continued and built upon either by future IQP groups or museum staff alike. Each team which attempts to tackle this task will undoubtedly learn valuable knowledge about both the process and creation of the products. The recommendations will be useful and the lessons learned during this project can be incorporated by groups attempting to complete similar work.

Conclusions

Clay P. Bedford, an author, once wrote, “You can teach a student a lesson for a day; but if you can teach him to learn by creating curiosity, he will continue the learning process as long as he lives.” The task of inspiring wonder and creating interest in students is often recognized as a crucial job but is not always sought after because of the high level of difficulty. The Science Museum realizes the importance of stimulating children to learn and discover because the staff there are genuinely interested in the subject matter. The Launch Pad gallery and the Outreach program are both good examples of the effort by the Museum to encourage an interactive, inquiry-based style of learning. Our project served as a supplement to both the gallery and the Outreach program and attempted to consider these same aims while also trying our best to accomplish our everyday writing and design tasks.

Certain teaching methods have withstood the test of time and have proven worthy in educating students. The traditional book and chalkboard approach can never be abandoned but as time and knowledge of educational techniques progress, new methods are uncovered. Inquiry-based, interactive learning is a relatively new and unproven form of educating students but most research seems to suggest it is an excellent way to stimulate children and create interest. In the broader scope of education, creating curiosity within students and classrooms is equally as important as ensuring that students have retained knowledge. Creating a solution to this bridge this gap, which is able to incorporate the positive aspects of both techniques, is extremely difficult but after performing this project we have concluded that it is definitely feasible.

First and foremost, a conscious effort must be made to create activities that are designed as inquiry-based activities from start to finish. Our project created activities with exactly this purpose. The activities contained elements important to inquiry-based learning before they were further pursued and attempted to carry this element throughout every phase. It is easy to desert the inquiry-related aspects of an activity during the testing stage but it is vital to conduct the activity as originally planned. It seems paradoxical to continue to answer questions with more questions but if done correctly and for an appropriate amount of time it does prove to be an effective way to guide a group of students through the reasoning process. The desired results of this inquiry-based style are certainly elusive but the rewards of persevering are worthwhile and impressive.

However promising the results of inquiry-based learning are, it is important to remember that there is no simple solution to the problem of educating students. Inquiry-based learning is often effective but it is not a standalone strategy to educate all students. In theory the ideas behind interactive learning are all based on extensive research, and are designed to create a valuable learning experience with various self-fulfilling rewards. During the course of this project it became evident, however, that translating theory into practice is not a particularly easy task. Even the best laid plans and ideas can go astray when applied to an anxious group of young children.

Maintaining the undivided attention of a young group of children is a task of supreme difficulty. No matter how much effort is applied to an activity, it is difficult to satisfy all of a child's educational needs and maintain an appropriate interest level at the same time. Some of our activities seemed to be extremely exciting and foolproof to demonstrate, but when it came time to build and test, these activities did not perform as expected. There are too many aspects regarding this attention problem, that all criteria could never remain satisfied at the same time. However, an effort to balance the educational content and still keep students interested leads to the best chance of a successful activity. Creating presentations which surprise the audience and allowing them to participate in a new activity all add to the chance that the inquiry-based activity will correctly serve its purpose.

Figure 10: Public Testing Session

The task undertaken by the Science Museum and this project group is certainly not an easy one. Educating children in a new, exciting fashion while still trying to drive home age-old concepts is a balancing act fit for an Olympic gymnast. However, the attempts made by the museum and by this project demonstrate the greater significance of the issue at hand. Research on educational theory has shown that inquiry-based learning is rooted in positive results and any effort to increase the usage of this strategy in classrooms through new and exciting activities is definitely time well spent.

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Appendix A: Inquiry-based Learning

Appendix A1: Mousetrap Cars

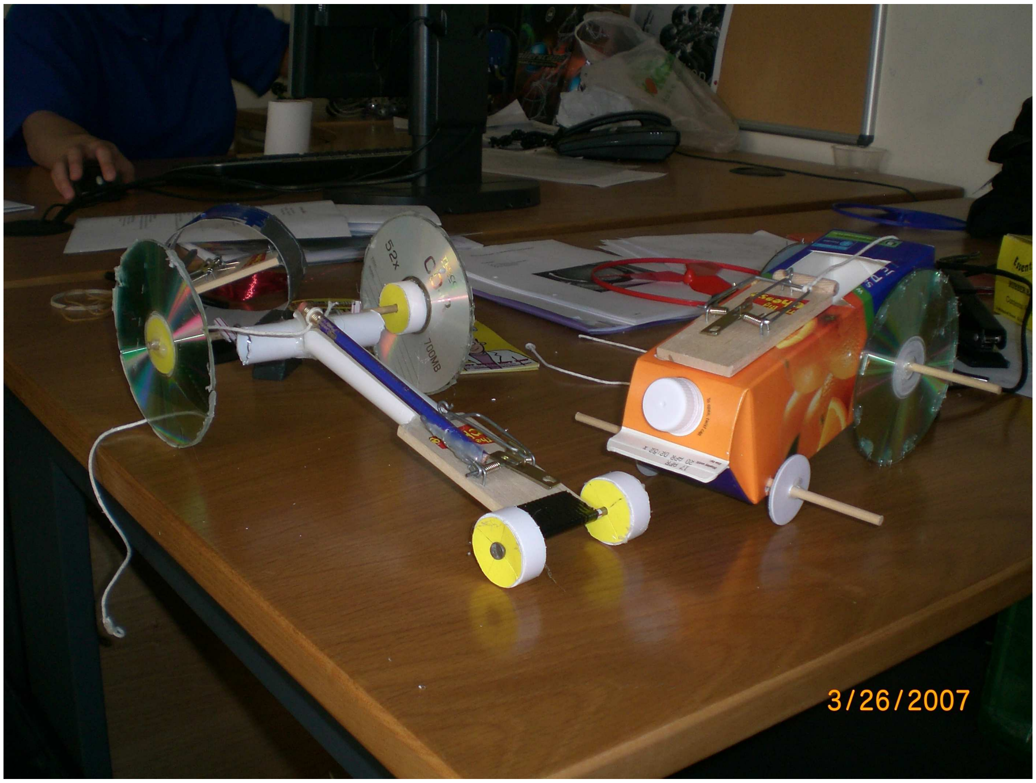


Photo By: Steve Black and Kyle Dedmon

Materials:

- Mousetrap
- PVC piping
- Clothes pegs
- Glue gun
- Glue sticks
- String
- Rubber bands
- Wooden dowels
- Egg cartons
- Duck tape
- Nails
- Mallet
- Staples
- Cardboard
- Paper towel holders or toilet paper holders

- Blank CD's
- Scissors
- Tape measure

Setup and Procedure:

- Goal is to create a car-like device using only the supplies provided
- Success of the vehicles will be tested by measuring the distance that the cars are able to travel along a straight track laid out along the floor or hallway
- Each group will receive the same cluster of materials which they will be able to experiment with at their own desire

What Worked?

- PowerPoint presentation and brainstorming session increased chances of successful completion
- Groups of 3-4 were ideal so tasks were shared equally and all members were able to participate
- Activity held the attention of most children involved
- Steering tips to guide students to the important steps were vital
    - Students needed to be pushed most to understand:
        - How the mousetrap could be attached to the axel
        - How the axel could turn the wheels
        - How to attach the wheels to the axel
        - How to attach the axel to the body

Problems Encountered:

- Activity was difficult if there was not enough steering
- Required a significant amount of time to be successful (approximately 1.5 hours)

Ways to Improve:

- The presentation of the activity could be more exciting
- The presentation could include specific scientific content that the students would be dealing with so they are familiar with the science topics going into the activity

Recommendations:

After testing with a live audience we have concluded that the mousetrap car activity is definitely worth pursuing. The audience consisted of 3 family groups of approximately 3 children each. Each group was able to complete a working prototype in just longer than 1 hour and 15 minutes. Also, the safety briefing and demonstration proved to be successful since no children attempted to misuse the mousetrap and there were no accidents during the testing session. The activity can be safe, exciting and educational if all guidelines are followed and overall it is a good inquiry-based learning experience.

Curriculum Topics Addressed:

KS2

From this activity, students can learn:

- how to measure forces and identify the direction in which they act.
- about friction, including air resistance, as a force that slows moving objects and may prevent objects from starting to move
- that when objects [for example, a spring, a table]are pushed or pulled, an opposing pull or push can be felt

KS3

From this activity, students can learn:

- ways in which frictional forces, including air resistance, affect motion [for example, streamlining cars, friction between tyre and road]
- the principle of moments and its application to situations involving one pivot
- that unbalanced forces change the speed or direction of movement of objects and that balanced forces produce no change in the movement of an object

Appendix A2: Bridge Building

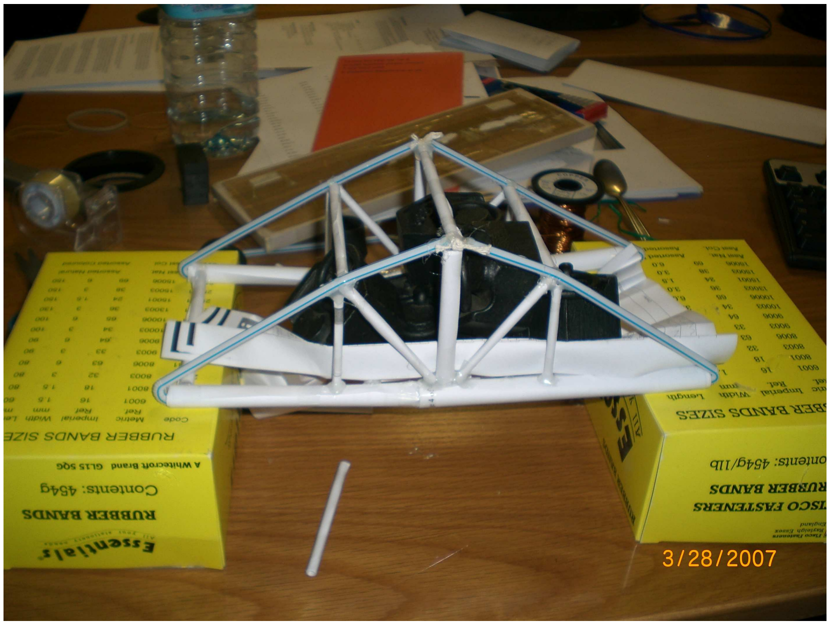


Photo By: Steve Black and Kyle Dedmon

Materials:

- Paper
- Straws
- Tape
- Glue Gun
- String

Setup and Procedure:

- Goal is to create a bridge which can support the most weight
- Students will receive only 5 pieces of paper, 5 straws and (5) 5 inch pieces of tape
- Bridge must span a gap of at least 12 inches

What Worked?

- Using the materials listed above it is possible to create a bridge which can support approximately 10 lbs
- Being familiar with trusses and famous bridge designs drastically increases performance of the designs
- Sketching ideas prior to building improves overall product

Problems Encountered:

- Activity is not as exciting as some of the other activities
- Activity may not be challenging enough for children familiar with principles associated with bridges

Ways to Improve:

- The activity could require a more specific or challenging task such as supporting a set amount of weight that is fairly large (15 lbs or so)
- Different materials could be offered such as various types of wood, plastic or metal which would drastically increase the ability of a student to create a strong bridge

Recommendations:

The activity is simple and can be conducted in one classroom session. It does contain useful scientific content and could be used as a supplement to a classroom lesson. The major positive aspects are that it is cheap, easy and reliable so a teacher can be confident the activity will work and will not be too strenuous.

Curriculum Topics Addressed:

KS2

For this activity students can learn:

- to compare everyday materials and objects on the basis of their material properties, including hardness, strength, flexibility and magnetic behaviour, and to relate these properties to everyday uses of the materials
- that objects are pulled downwards because of the gravitational attraction between them and the Earth
- how to measure forces and identify the direction in which they act.

KS3

For this activity students can learn:

- that unbalanced forces change the speed or direction of movement of objects and that balanced forces produce no change in the movement of an object
- that the weight of an object on Earth is the result of the gravitational attraction between its mass and that of the Earth
- that forces can cause objects to turn about a pivot
- the principle of momentum and its application to situations involving one pivot

Appendix A3: Rube Goldberg Machine

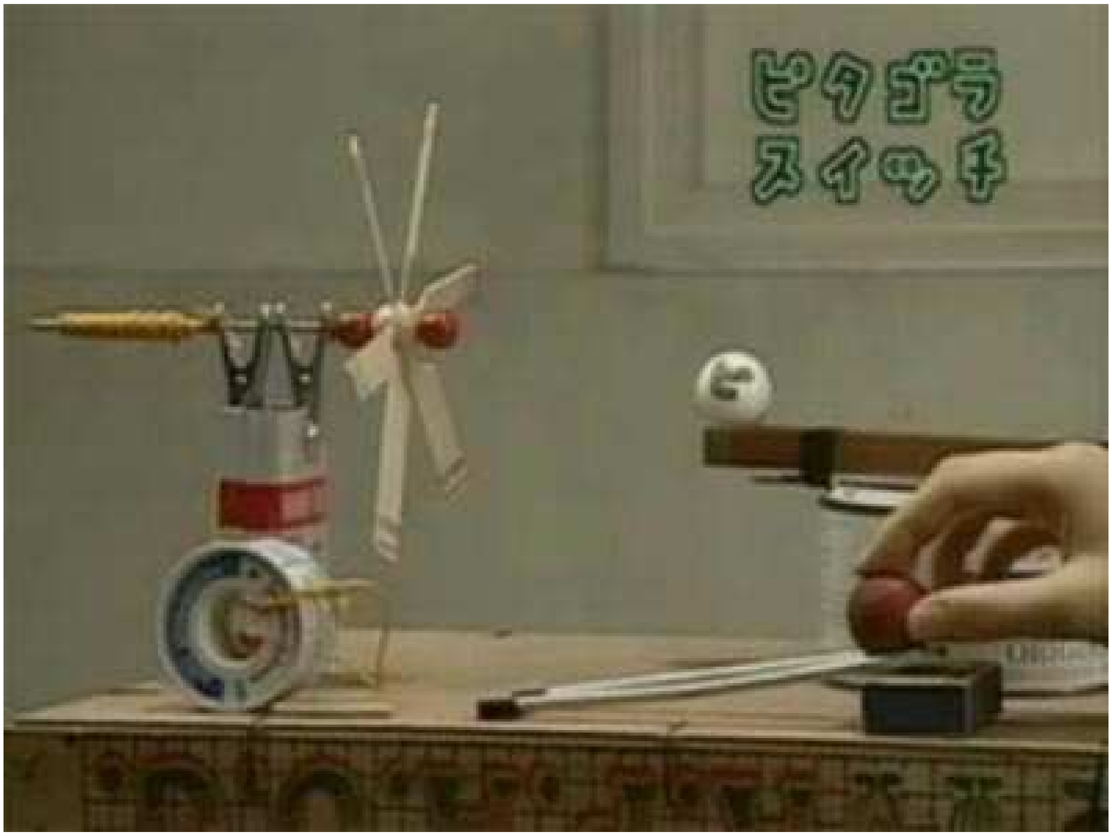


Photo By: www.nickwade.com

Materials:

- Marbles
- Cardboard
- Tape
- Glue Gun
- String
- Paper or plastic cups
- PVC pipe
- Wooden dowel
- Magnets
- Rubber bands
- Scissors
- Paper
- Mousetrap

Setup and Procedure:

- A Rube Goldberg machine is a deliberately complex machine that performs a very simple task in a very elaborate way
- Goal is create a Rube Goldberg machine that turns off a light switch
- There are 12 elements which must be contained in the machine: bridge, lever system, conveyer, pulley, dominos, fan, gate, scissors, water, mouse trap, projectile, magnets (hundreds of solutions to these elements can be seen in videos)
- Each group of students will design and build one element of the machine
- Certain materials can be used with all groups (dowel, marbles, etc.) while certain materials will be task specific (magnets, mousetrap, etc.)

What Worked?

- By having each group create only one part of the machine, it is possible to complete the activity in one class
- Stresses communication between groups
- Very hands-on and interactive

Problems Encountered:

- Building a prototype is time consuming
- Pupils need to be older (14+) in order to possess skills required
- By giving students set elements that need to be included the activity is slightly limiting the inquiry process
- Testing is difficult because it requires 20 + people

Recommendations:

Complete testing on this activity. Perhaps this can be done in a mini version first with only a few steps and less people. Students who aren't familiar with Rube Goldberg design will need examples or steering tips in order to get their minds around the idea.

Many Rube Goldberg videos are available on YouTube; the Japanese ones are the best.

Curriculum Topics Addressed:

KS2

For this activity students can learn:
- to think about what might happen or try things out when deciding what to do, what kind of evidence to collect, and what equipment and materials to use
- about the forces of attraction and repulsion between magnets, and about the forces of attraction between magnets and magnetic materials
- that when objects [for example, a spring, a table]are pushed or pulled, an opposing pull or push can be felt

KS3

For this activity students can learn:
- carry out preliminary work and to make predictions, where appropriate
- considering ways in which science is applied in technological developments
- that unbalanced forces change the speed or direction of movement of objects and that balanced forces produce no change in the movement of an object
- that forces can cause objects to turn about a pivot
- that although energy is always conserved, it may be dissipated, reducing its availability as a resource.
- ways in which energy can be usefully transferred and stored

Appendix A4: Windmill Activity Sheet

http://static.panoramio.com/photos/original/34345.jpg

Materials:

- Styrofoam
- Cardboard
- Paper
- Straws
- Paper towel tube
- Wooden dowel
- Plastic
- Fan
- Scissors
- Rulers
- Tape
- Glue
- Tape measures
- Pencils
- Paper
- Graph paper
- Stopwatch

Setup and Procedure:

- There will be a main base which students attach there blades to
- Another fan will be placed in front of the base to power each groups windmill
- Students will be able to select the number, size, angle, material, and shape of blades.
- When running, the windmill will perform a task (i.e. Light a light bulb, Amplify an Ipod, move marbles throughout a contraption).
- The faster the blades spin the better the task is performed.
- Points will be awarded based on the time the windmill takes to perform the task or the quality of the performance (i.e. brightness of light, clarity of music).

What Worked:

- Similar activity used at Boston Science Museum.
- Is simple enough to be tested, retested, and have conclusions drawn in one class period.

Problems Encountered:

- Designing base that will power something else requires complicated electronics.
- Will be near impossible for a teacher to build a contraption such as this.

Ways to Improve:

- Make it simpler so a teacher could build it, or make it as part of outreach box.
- Design set instructions for a teacher to build.

Recommendations:

- This would be a great activity for the outreach box. Boston Science Museum uses an activity similar to this in their Design Challenges Field Trip program and has had great success.
- Making it part of the outreach box would eliminate complicated set up and allow for a fun and meaningful lesson.

Curriculum Topics Addressed:

KS2

Forces and motion

Pupils should be taught:

- How to measure forces and identify the direction in which they act.
- That it is important to test ideas using evidence from observation and measurement.

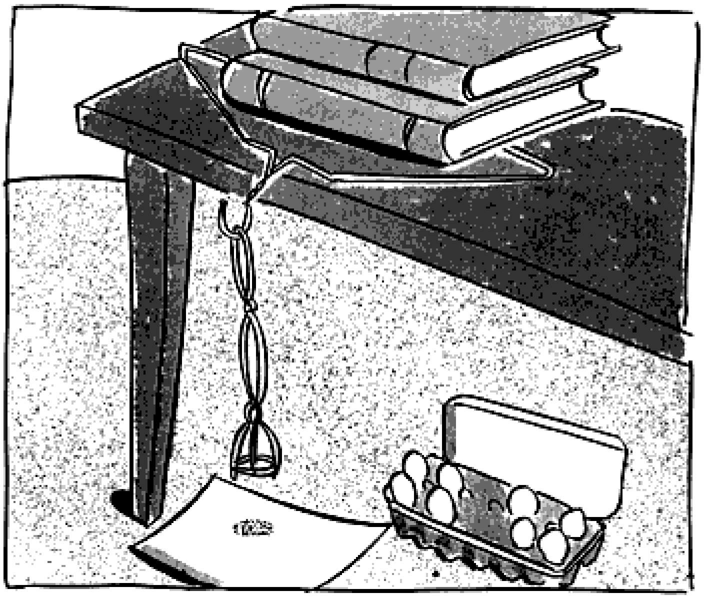
KS3

Forces and motion

Pupils should be taught:

- That unbalanced forces change the speed or direction of movement of objects and that balanced forces produce no change in the movement of an object
- That forces can cause objects to turn about a pivot
- the principle of moments and its application to situations involving one pivot
- ways in which energy can be usefully transferred and stored
- that although energy is always conserved, it may be dissipated, reducing its availability as a resource.

Appendix A5: Egg Bungee Jump Activity Sheet



http://www.pbs.org/wgbh/nova/teachers/activities/images/2016_rollerco.gif

Materials:

- Rubber bands
- Hair Ties
- Tights
- String
- Eggs
- Egg cartons
- Water Bottles
- Paper clips
- Duct tape
- Plastic bags
- Ball bearings
- Nail
- Board
- Rulers
- Tape measure

Setup and Procedure:

- Groups will create a bungee cord which will be attached to a nail screwed to a board.
- The goal is to create a cord which allows the egg to fall close to the ground without breaking the egg.

What Worked:

- Providing many different forms of elastic materials allows for maximum variance in successful design.
- Activity can be performed and wrapped up in one class period.
- Bungee jumping and breaking eggs are both exciting ideas to kids.
- Unique alternative to familiar “Egg Drop” activity.

Problems Encountered:

- Some groups are too cautious and don’t test the limits.
- Measuring aren’t exactly precise.

Ways to Improve:

- Make height larger to create more excitement
- Familiarize students with important concepts

Recommendations:

- Source Materials and test activity.
- Worth pursuing idea if time permits

Curriculum Topics Addressed:

KS2

Forces and motion

Pupils should be taught:

- How to measure forces and identify the direction in which they act.
- That it is important to test ideas using evidence from observation and measurement.
- that objects are pulled downwards because of the gravitational attraction between them and the Earth

KS3

Forces and motion

Pupils should be taught:

- That unbalanced forces change the speed or direction of movement of objects and that balanced forces produce no change in the movement of an object
- That the weight of an object on Earth is the result of the gravitational attraction between its mass and that of the Earth

Appendix A6: Dinosaur Egg Activity Sheet

Materials:

- Rope
- Duct tape
- Wooden dowel
- Ramp
- Ramp Support
- Wooden boards (2x4)
- Skateboard or other wheeled device
- Clips
- Shower Curtain

Setup and Procedure:

- Large Sac containing mysterious Dinosaur egg is placed in the middle of the room (really just contains sand)
- goal is to create a method to move the sack out of the classroom into the hallway
- The method must be safe and students are not allowed to move or attempt to move the sack to any location through brute force

What Worked:

- Hands-on application to simple machines

Problems Encountered:

- Materials too expensive
- Not much “wow” factor
- Never tested but seems it would be hard to get it to work as planned

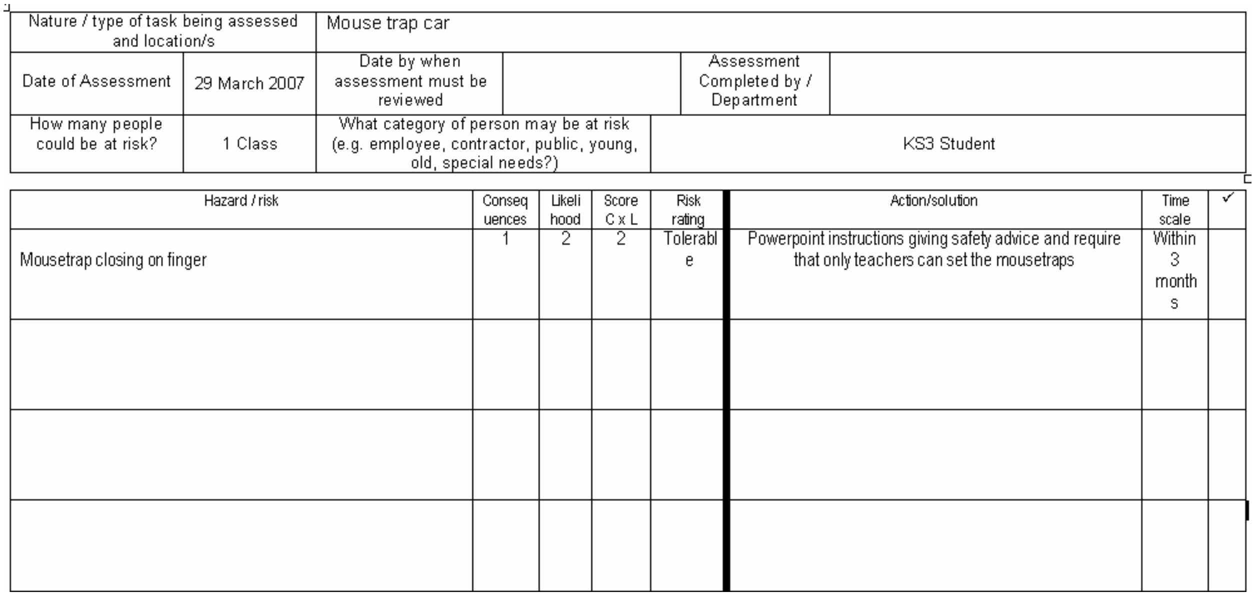
Ways to Improve:

- Make more exciting… I’m not sure how

Recommendations:

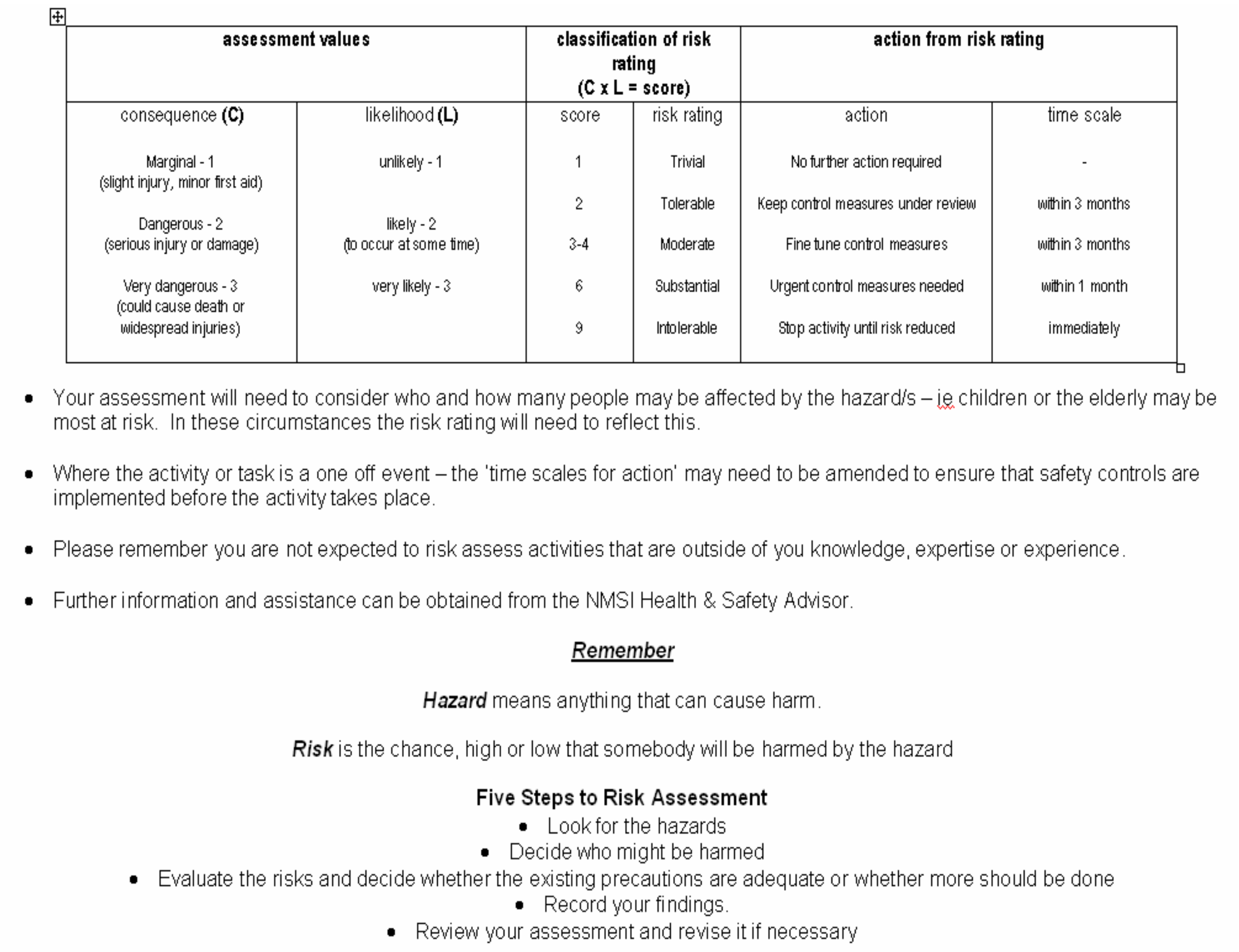
Don’t pursue this IBL activity any further

Appendix A7: Mousetrap Car Risk Analysis



Nature / type of task being assessed and location/s	Mouse trap car				
Date of Assessment	29 March 2007	Date by when assessment must be reviewed		Assessment Completed by / Department	
How many people could be at risk?	1 Class	What category of person may be at risk (e.g. employee, contractor, public, young, old, special needs?)	KS3 Student		

Hazard / risk	Consequences	Likelihood	Score C x L	Risk rating	Action/solution	Time scale	✓
Mousetrap closing on finger	1	2	2	Tolerable	Powerpoint instructions giving safety advice and require that only teachers can set the mousetraps	Within 3 months	



assessment values		classification of risk rating (C x L = score)		action from risk rating	
consequence **(C)**	likelihood **(L)**	score	risk rating	action	time scale
Marginal - 1 (slight injury, minor first aid)	unlikely - 1	1	Trivial	No further action required	-
		2	Tolerable	Keep control measures under review	within 3 months
Dangerous - 2 (serious injury or damage)	likely - 2 (to occur at some time)	3-4	Moderate	Fine tune control measures	within 3 months
Very dangerous - 3 (could cause death or widespread injuries)	very likely - 3	6	Substantial	Urgent control measures needed	within 1 month
		9	Intolerable	Stop activity until risk reduced	immediately

- Your assessment will need to consider who and how many people may be affected by the hazard/s – ie children or the elderly may be most at risk. In these circumstances the risk rating will need to reflect this.
- Where the activity or task is a one off event – the 'time scales for action' may need to be amended to ensure that safety controls are implemented before the activity takes place.
- Please remember you are not expected to risk assess activities that are outside of you knowledge, expertise or experience.
- Further information and assistance can be obtained from the NMSI Health & Safety Advisor.

<u>Remember</u>

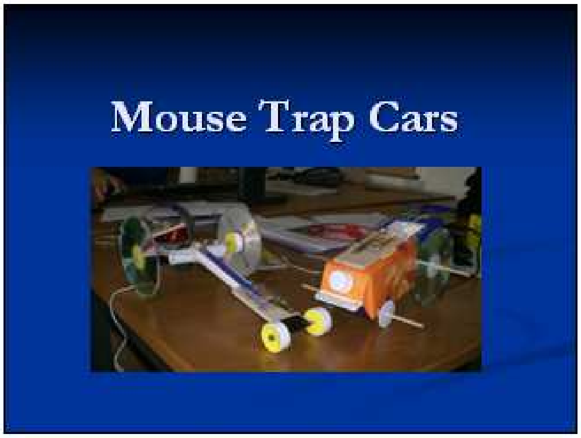
Hazard means anything that can cause harm.

Risk is the chance, high or low that somebody will be harmed by the hazard

Five Steps to Risk Assessment

- Look for the hazards
- Decide who might be harmed
- Evaluate the risks and decide whether the existing precautions are adequate or whether more should be done
- Record your findings.
- Review your assessment and revise it if necessary

Appendix A8: Mousetrap Car Presentation



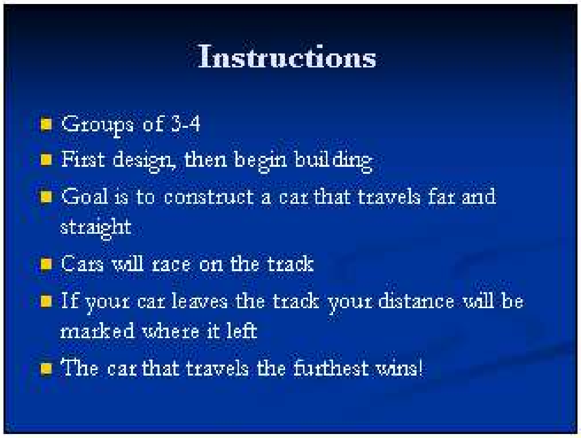
Mouse Trap Cars

Challenge

- Build a working car with household materials that is powered solely by a mousetrap
- How can you power a car with just a mousetrap??!!

Materials

- Mousetrap
- PVC piping
- Clothes pegs
- String
- Rubber Bands
- Nails
- Blank CDs
- Pens
- Straws
- Wooden dowels
- Zip ties
- Duct tape
- Eye hooks
- Staples
- Juice containers
- Toilet paper rolls
- Cardboard
- Pencils



Instructions

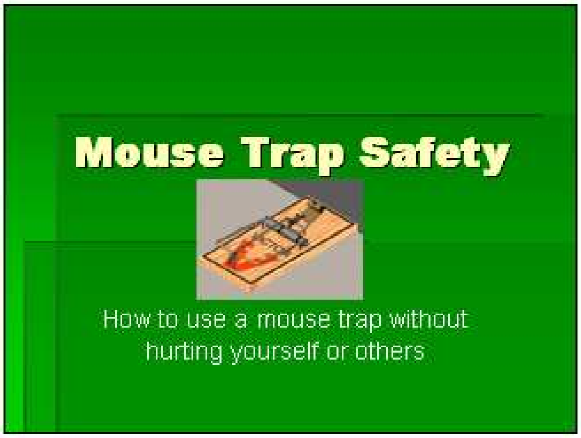
- Groups of 3-4
- First design, then begin building
- Goal is to construct a car that travels far and straight
- Cars will race on the track
- If your car leaves the track your distance will be marked where it left
- The car that travels the furthest wins!

After building…

- Everyone can take home the cars they have completed
- For the winning team…

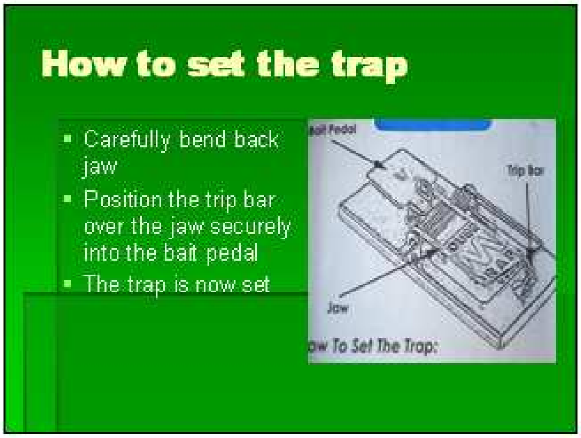
  A chance to challenge the CHAMPS

Appendix A9: Mousetrap Car Safety Presentation



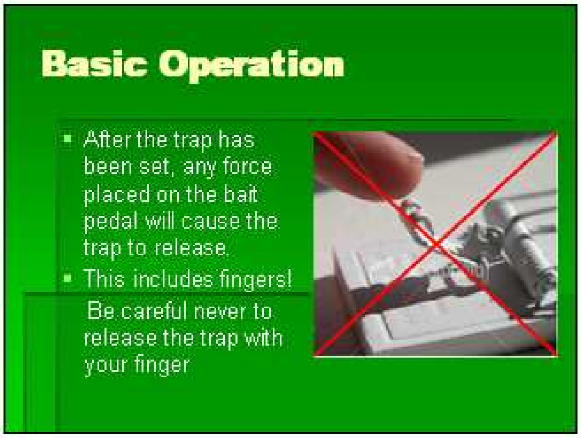
Mouse Trap Safety

How to use a mouse trap without hurting yourself or others



How to set the trap

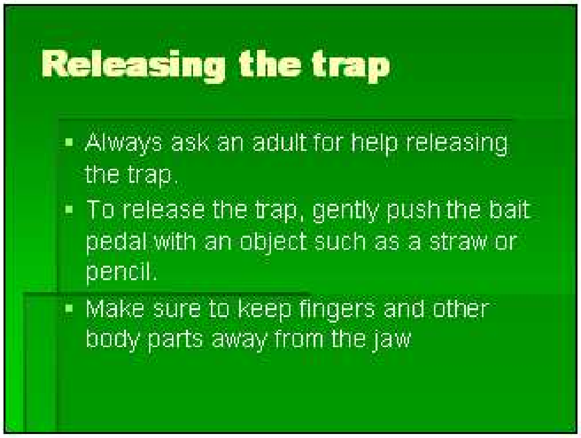
- Carefully bend back jaw
- Position the trip bar over the jaw securely into the bait pedal
- The trap is now set



Basic Operation

- After the trap has been set, any force placed on the bait pedal will cause the trap to release.
- This includes fingers!

Be careful never to release the trap with your finger

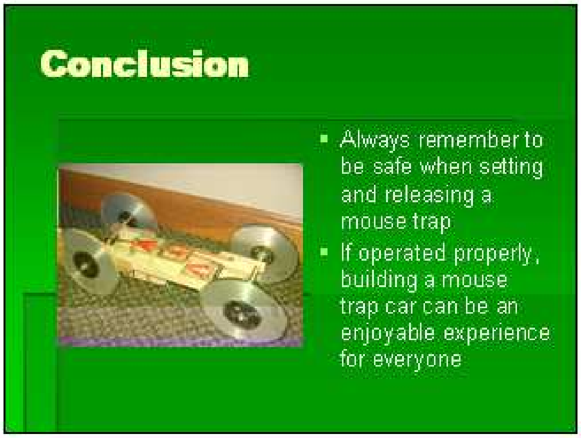


Releasing the trap

- Always ask an adult for help releasing the trap.
- To release the trap, gently push the bait pedal with an object such as a straw or pencil.
- Make sure to keep fingers and other body parts away from the jaw

Incorrect release

- Incorrect release increases the chances that your fingers will get caught in the trap.
- Always be careful when operating mouse traps and ask for an adults help if you do not feel comfortable operating the mouse trap.



Conclusion

- Always remember to be safe when setting and releasing a mouse trap
- If operated properly, building a mouse trap car can be an enjoyable experience for everyone

Appendix A10: Sample IBL Staff Feedback Form

Feedback on Mousetrap activity

When completing this survey, please rate questions according to the following scale:
1 corresponds to lowest possible value and 10 corresponds to highest possible value

Youth reaction

How interesting do you think youth (age 12-14) will find this activity?

1 2 3 4 5 6 7 8 9 10

Can you suggest any ways to make this activity more interesting?

How difficult do you think this activity will be for youth aged 12-14?

1 2 3 4 5 6 7 8 9 10

Can you suggest any ways to make the difficulty level more appropriate?

Child Mindset

How much guidance do you feel pupils will need to successfully complete this activity?

1 2 3 4 5 6 7 8 9 10

Can you suggest specific areas/concepts during building that you think youth will have the most difficulty and will need more guidance (Axel operation, Lever arm mechanics, Wheel construction and mounting, etc…)?

How strongly do you feel scientific content could be tied to this activity?

1 2 3 4 5 6 7 8 9 10

What scientific themes do you feel are most appropriate for this activity?

Logistics

How appropriate is the time period (2 class modules) for this activity?

1 2 3 4 5 6 7 8 9 10

Can you suggest any ways to change the activity to make the time period more appropriate?

How appropriate do you feel the provided materials were for completing the activity?

1 2 3 4 5 6 7 8 9 10

Are there any easily sourced materials that you think we should also include?

Presentation

How effective do you feel the presentation will retain pupils' attention?

1 2 3 4 5 6 7 8 9 10

Can you suggest any ways to improve the presentation to make it more effective in capturing the students' attention?

Do you have any other suggestions to improve the overall quality or effectiveness of the activity?

Appendix A11: Completed IBL Staff Feedback Form

Feedback on Mousetrap activity

When completing this survey, please rate questions according to the following scale:
1 corresponds to lowest possible value and 10 corresponds to highest possible value

Youth reaction

How interesting do you think youth (age 12-14) will find this activity?

1 2 3 4 5 6 [✓ 7] 8 9 10

Can you suggest any ways to make this activity more interesting?

Fast pace and put a point to it Scrape Heap Challange

How difficult do you think this activity will be for youth aged 12-14?

1 2 3 4 [✓ 5] 6 7 8 9 10

Can you suggest any ways to make the difficulty level more appropriate?

may be add a clue or Have a hinter

Child Mindset

How much guidance do you feel pupils will need to successfully complete this activity?

1 2 3 4 5 6 7 8 9 10

quite a bit of prompting but once they get going they would be

Can you suggest specific areas/concepts during building that you think youth will have the most difficulty and will need more guidance (Axel operation, Lever arm mechanics, Wheel construction and mounting, etc…)?

transferring the energy from the mouse trap

How strongly do you feel scientific content could be tied to this activity?

1 2 3 4 5 6 7 8 [✓ 9] [✓ 10] also museum object ties

What scientific themes do you feel are most appropriate for this activity?

Forces, movment. martrieals

Logistics

How appropriate is the time period (2 class modules) for this activity?

1 2 3 4 5 6 7 [✓ 8] 9 10 over run a bit Rushed

Can you suggest any ways to change the activity to make the time period more appropriate?

Clues prompts. (in the 1st few minutes might call them in an show examples)

How appropriate do you feel the provided materials were for completing the activity?

1 2 3 4 5 6 7 8 [✓ 9] 10 - use. storage box's

Are there any easily sourced materials that you think we should also include?

one way ties are good card wheels.

Presentation

How effective do you feel the presentation will retain pupils' attention?

1 2345678910 need more work on it (Just learn from one already made)

Can you suggest any ways to improve the presentation to make it more effective in capturing the students' attention?

See one for hot air balloons

Do you have any other suggestions to improve the overall quality or effectiveness of the activity?

more punch in the 1st preshion.

Stronger dead lines.

Have a boffing to give Hints

Appendix A12: Mousetrap Car Lesson Plan

Mousetrap Car

*Note: This activity will take 2 classes. The first class is a preparation session and the second class is a performance and testing session. This activity is better suited for older children because of the materials involved.

Activity Introduction (1 minute):

Your challenge today is to build a car powered solely by a mousetrap. You will be given only simple household materials to construct this car. The group that creates the most successful car will be given a chance to compete against the reigning mousetrap car champions. The winning group will also be rewarded (some sort of incentive).

Materials (7 minutes):

Present the materials available to the students that they can use to complete the task. Materials can include but are not limited too:

- Mousetrap
- PVC piping
- Clothes pegs
- Glue gun
- Glue sticks
- String
- Rubber bands
- Wooden dowels
- Egg cartons
- Duck tape
- Nails
- Mallet
- Staples
- Cardboard
- Paper towel holders or toilet paper holders
- Blank CD's
- Scissors
- Tape measure

Kits can be ordered from sites such as http://www.docfizzix.com/shop/vehicle-kits/index.shtml but the group design ideas will likely be more similar if there are fewer options available.

Class Brainstorming Session (12 minutes):

Brainstorm ideas as a class and record ideas on a chalkboard, whiteboard or any other place where students will be able to see the ideas they have generated. Pose questions such as:

- What are the most important elements of a car?
- What items are essential to make a car run?
- What materials can be used to create these elements?
- How do these elements work together to make the car move?
- How can these elements be linked together using the given materials?

During this session it is important for students to determine that a car requires an engine, wheels, axel and body. They can use a mousetrap for the engine, various answers suffice for wheels and axels and most common answers for body are Pringles containers or juice containers.

Instructions (7 minutes):

Instruct students that their goal is to create a car using only the supplies provided. The success of the vehicles will be tested by measuring the distance that the cars are able to travel along a track laid out along the floor or hallway. Each group will receive the same cluster of materials which they will be able to experiment with at their own desire (except the mousetrap). The students will be able to construct only 1 device in class because of time constraints so make it clear that they should make adequate use of the time they have been given to brainstorm ideas and test materials. Points will be rewarded based on the ability of the car to travel further distances and along a straight path. Points will be awarded on a scale of 1-10 in each category for a maximum of 20 total points. An overall score of 20 corresponds to the car that traveled furthest and kept along the straightest path since that group would receive the full 10 points in each area. Cars deviating from the path will be awarded points based on the distance they are located away from the closest point on the path. If the car is off the track but only slightly then that car would be awarded more points than a car that is located extremely far away from the track. Similarly, cars will be awarded points based on their relative performance to other cars. The car that travels the furthest distance will receive a 10 and points will decrease as the distance traveled decreases.

Individual Group Brainstorming (23 minutes):

At this point it is time to split the students into groups and allow them to create their designs. Split students into groups of 3 or 4 depending on the size of the class. Give students time to brainstorm ideas and instruct them that at the end of the time a sketch of the final design will be required. A sample activity sheet which can accompany the brainstorming session is shown below. A sheet such as this can guide students thinking in the right direction and tends to cause the students to focus their ideas and stay on task.

Mousetrap Car

Group Members:

We are going to use these materials to create wheels:

We are going to use these materials to create an axel:

We are going to connect the wheels to the axel using:

We are going to connect the axel to the body using:

Draw your design idea on the back of this sheet

Performing and Observation (50 minutes):

Allow each group time to construct their car and offer any help that might be needed with tools. Some students may need assistance cutting, gluing or attaching items or other such tasks. This should not prevent them from being able to create their design. Students should have a good idea exactly what materials they will need and how the materials will need to be assembled since they should have worked through these issues during their brainstorming sessions. At the end of the building period allow each group a chance to test their devices on the track. Students should use a tape measure to record their performance and measure the distance which they strayed off the track if they have done so.

Appendix A13: Bridge Building Lesson Plan

Bridge Building

*Note: This activity will take 1 class

Activity Introduction (1 minute):

Your challenge today is to build a bridge which can support a large amount of weight. The bridges will be constructed from paper, straws, tape, string and glue only. Weight will be added in increments until each bridge fails. The winning team will receive (some sort of incentive).

Materials (2 minutes):

Present the materials available to the students that they can use to complete the task. Materials:

- 5 pieces of paper
- 5 straws
- (5) 5 inch pieces of tape
- Glue Gun
- String

Instructions (2 minutes):

The bridge must span a gap of at least 12 inches. The goal is to create a bridge capable of supporting more weight than other groups in the class. No additional supplies may be used.

Individual Group Brainstorming (15 minutes):

At this point it is time to split the students into groups and allow them to create their designs. Split students into groups of 3 or 4 depending on the size of the class. Give students time to brainstorm ideas and instruct them that at the end of the time a sketch of the final design will be required.

Performing and Observation (30 minutes):

Allow each group time to construct their bridge. Students should have a good idea exactly what materials they will need and how the materials will need to be assembled since they should have worked through these issues during their brainstorming sessions. At the end of the building period allow each group a chance to test their devices by slowly adding weight. Students should record the final weight their design was able to support. As a supplement to this activity, students can observe various bridge designs throughout London either before or after the activity to reinforce concepts related to successful bridge design.

Appendix A14: Rube Goldberg Machine Lesson Plan

Rube Goldberg Design

*Note: This activity is designed to take up two 50 minute class sessions. Also, it is better suited for older children (14+) because of skills required.

Activity Introduction (8 minutes):

A Rube Goldberg Machine is a deliberately complex machine that performs a very simple task in an elaborate way (Show Rube Goldberg Cartoon and YouTube videos. This will ensure everyone has grasped the idea and will jumpstart creative thinking). Today your challenge is to construct a Rube Goldberg Machine that turns off the lights in the classroom as a class. The more complex and creative you are the better!

Materials (2 minutes):

Present the materials available to the students that they can use to complete the task. Materials can include but are not limited too:

- Marbles
- Cardboard
- Tape
- Glue Gun
- String
- Paper or plastic cups
- PVC pipe
- Wooden dowel
- Magnets
- Rubber bands
- Scissors
- Paper
- Mousetrap
- Straw

Class Brainstorming Session (7 minutes):

Brainstorm ideas as a class and record ideas on a chalkboard, whiteboard or any other place where students will be able to see the ideas they have generated. Pose questions such as:

- Looking at the materials available, what are some creative and elaborate ways to make the machine work?
- What are some ways to connect these mechanisms together?

These types of questions will jumpstart students to think about forces and motion and prepare them for the activity they are about to take part in.

Instructions (10 minutes):

Instruct students that their goal is to create a Rube Goldberg Machine that will turn off the classroom light switch using only the materials provided. Tell them that they will be working in groups of 3-4, and that each group will construct one step of the machine. They must work with the groups that come before and after to ensure the machine operates flawlessly.

Each group will have to include a special element in their design. These elements are meant to give slight guidance to each group and should not hold back the infinite number of design ideas. Go over the elements and ensure the students know what each entails. The elements include: bridge, lever system, conveyer, pulley, dominos, fan, gate, scissors, water, mouse trap, projectile, and magnets.

The group with the bridge element will have to have a bridge form in front of a moving object and have it pass over. The lever system group needs to include some form of levers in their operation. If a group gets conveyer than they will have to construct some sort of a conveyor system incorporated in to their step. The group with pulley will need to incorporate pulleys in designing. Dominos are pretty self explanatory, however abstractness should be stressed. The group the gets fan will need to have wind power contribute to their step. The gate element needs to use some form of a gate to let an object pass. The scissors element needs to use the operation of scissors at some point. Water and a mousetrap will need to be used in any creative way in those elements. The group that is assigned the projectile will need to have some kind of projectile launched in their step. Lastly, the group that gets magnets will need to find a creative way to use magnets in their mechanism.

Split the class up into groups. Write the elements on a piece of paper and cut them out. Place them in a hat and have groups randomly pick. The group that picks first will be the first step in the machine and the group that picks last will be the last step in the design and have to flick the light switch.

Individual Group Brainstorming (23 minutes):

Each group will now know the element they need to include in their design as well as the groups in front of and behind them. Give students time to brainstorm ideas and instruct them that at the end of the time a sketch of the final design will be required. During this time allow them to tinker around with the materials available. They should first come up with their step’s main operation and then decide how that will translate to the groups in front of and behind them. A sample activity sheet which can accompany the brainstorming session is shown below. A sheet such as this can guide students thinking in the right direction and tends to cause the students to focus their ideas and stay on task.

Rube Goldberg

Group Members:

The element we need to include in our design is:

We plan to include our element in this way:

The group before us will start our mechanism in this way (Doesn’t apply to first group):

The group after us will start our mechanism in this way (Doesn’t apply to last group):

Draw your design idea on the back of this sheet

Performing and Observation (50 minutes):

At the beginning of the second class period groups are allowed to begin building. Make sure students are on task and provide any steering tips or guidance that is necessary. Books and desks can be used to bring different steps to the same heights. Glue guns and tape should be provided for construction. Encourage groups to test their ideas throughout to make sure they work as thought. Leave 15 minutes at the end of class to allow for a few trial runs in case any last-minute fixes need to be made. Run the Rube Goldberg Machine and watch the excitement on the pupils’ faces. Video Taping the machine is an optional way to record all of their hard work. Reflection activities covering forces and motion (Newton’s Laws, Kinetic vs. Potential energy) as well as material properties can be covered.

Appendix A15: Windmill Activity Lesson Plan

Windmill Activity

- Note: this will a be a 2 class activity

Activity Introduction (1 min):

The school has just discovered that they no longer have enough energy to power the classroom. They have given us the task of creating windmills that can be used to generate power. We need to assemble these windmills before the lights are shut off.

Class Brainstorming Session (10 min):

Questions can be asked such as:
What are some other alternative sources of energy?
How will a windmill create energy?
How does a windmill work?

Instructions (7 min):

Groups will all receive the same base to attach the blades they have created. Students will be able to decide all other variables on their own. Students will be able to select the number of blades, size of blades, angle of blades, material of blades and the shape of blades. When running, the windmill will perform a task (i.e. Light a light bulb, Amplify an ipod, move marbles throughout a contraption). The faster the blades spin the better the task is performed. Points will be awarded based on the time the windmill takes to perform the task or the quality of the performance (i.e. brightness of light, clarity of music).

Materials (7 min):

Different materials can be used for the base and blades. Some suggested ideas are:

- Styrofoam
- Cardboard
- Paper
- Straws
- Paper towel tube
- Wooden dowel
- Plastic

Other materials which would be required are:

- Fan
- Scissors
- Rulers
- Tape
- Glue
- Tape measures
- Pencils
- Paper

- Graph paper
- Stopwatch

Individual Group Brainstorming (25 min):

The class will be split up into groups of 3-4 students. Groups can contemplate how different variables might affect the performance of the windmill which they are about to create. During this period they can choose the materials they want to use and also select designs for the other variables mentioned previously such as size and shape of the blades. At the end of this process students should be required to hand in a sheet detailing:

- Shape of the blade they have selected
- Angle of blade
- Size of blade
- Material of blade
- Number of blades

The sheet should contain a sketch of an example blade as well as a list describing all of these factors.

A sample activity sheet which children could fill out during this period could be similar to the one provided below.

Making a Windmill

Group Members:

We want to use these materials for the blades, and we think they are good because:

During the activity we will record the following information:

Some parameters we changed between our first and second trial are:

We think these will work better because:

Performing and Observation (50 min):

This process should give children enough time to test and observe their initial creation and also have time to revise their design based on what they have learned. In 1 class period they should be able to test the design and build and test a second design with improvements built in. The children should be observing and recording data from each design and should be able to identify factors and how they affect the performance of each groups' windmills. Follow up activities such as graphical analysis of the data for each variable versus the performance of the windmill can also be assigned.

Appendix A16: Egg Bungee Jump Lesson Plan

Egg Bungee Jump

Activity Introduction:

The school has been recruited by a bungee jumping company. In order to receive the job the school must demonstrate adequate knowledge of forces and motion. In order to test our knowledge we must create a bungee jump device for an egg.

Class Brainstorming Session:

- What types of forces affect a person on a bungee jump?
- How does the material of a bungee cord affect its performance?
- What are some factors you need to consider when designing a bungee jump?

Instructions:

Groups will create a bungee cord which will be attached to a nail screwed to a board. The board should be approximately 2 m with the nail attached toward the end furthest from the floor. Each group will attach the bungee cord and drop the egg from a height of approximately 2 m. The goal is to create a cord which allows the egg to fall close to the ground without breaking the egg. Points will be awarded by the teacher based on 2 factors. The highest number of points will be given to the teams which can create a cord which places the egg nearest the ground. Points will also be awarded based on the final resting distance of the device. The shorter the distance is between the nail and the egg once the cord has come to rest will receive the highest amount of points. Also, groups will be given all materials and be able to test them as they wish but they will not be able to receive their egg until they are finished with their design and ready to perform the actual test.

Materials:

- Rubber bands
- Hair Ties
- Tights
- String
- Eggs
- Egg cartons
- Water Bottles
- Paper clips
- Duct tape
- Plastic bags
- Ball bearings
- Nail
- Board
- Rulers
- Tape measure

Individual Group Brainstorming:

Groups will create a design for a bungee cord that they think will best meet specifications above. It is a good time to address issues and pose questions such as what happens when 2 rubber bands are used in series or what happens when 2 rubber bands are used in parallel? The students should be testing materials and should be filling out a worksheet asking them to explain which properties they are looking for and how they think these properties will affect the egg drop. At the end of the brainstorming session the groups should all have a completed cord contraption ready to be attached to the nail for the egg drop.

A sample activity sheet which children could fill out during this period could be similar to the activity sheet provided below.

Egg Bungee Challenge

Group Members:

We tested these design ideas:

We plan to use these materials to hold the egg:

We plan to use these materials to make the bungee cord:

During the experiment, we will record these things:

Performing and Observation:

Groups should observe which designs place the egg nearest the ground without causing it to break. Groups should take note of what factors they think are responsible for best performance. They can be given a worksheet to detect understanding of factors such as forces and performance.

Appendix A17: Dinosaur Egg Lesson Plan

The Eggciting Eggscape

*Note: This activity will take 2 classes

Activity Introduction (1 minute):

The large sack located at the centre of the room contains an extremely important and dangerous treasure. Inside the sack lies the egg of an unborn Tyrannosaurus Rex. The egg was dug up underneath the basement of the school and it is preparing to hatch. We have to find a way to move the egg out of the classroom before it is too late!

Class Brainstorming Session (12 minutes):

Brainstorm ideas as a class and record ideas on a chalkboard, whiteboard or any other place where students will be able to see the ideas they have generated. Pose questions such as:

- Can anyone think of any tools which would make it easier to move a heavy object?
- Are there any ways to move a heavy object besides lifting it?
- What are some methods people have used to move heavy objects in the past?
- Are there any jobs or situations that require people to lift heavy objects everyday? How are they able to lift these objects?

These types of questions will jumpstart students to think about forces and motion and prepare them for the activity they are about to take part in.

Instructions (7 minutes):

Remind students that the sack contains an "egg" and because of this there are several important rules which must be followed when interacting with the sack.

- Students are not allowed to lift or carry the sack without the use of equipment (levers, ramps, wheeled device, etc.).
- The "egg" must be handled with caution so it should not be dropped, thrown or transported in any other unsafe manner.
- The sack cannot be dragged across the ground with no equipment supporting it however it can be pulled if it has an object underneath it

Instruct students that their goal is to create a method to move the sack out of the classroom into the hallway. They are able to transport the sack as long as the rules mentioned above are followed. The method must be safe and students are not allowed to move or attempt to move the sack to any location through brute force. The students will soon be presented with various materials which can be used in order to complete their task. Instruct students that each item will have a fictional price. A rope for example may "cost" £1 whereas a wheeled device may cost £10.

Next, instruct students that points will be awarded based upon 3 criteria:

- Students will be awarded points for successfully transporting the “egg” out of the classroom.
    - A scale ranging from 1-10 can be used where a score of 10 corresponds to complete removal of the sack into the hallway and a 1 corresponds to no movement of the sack at all
- Students will be awarded points for creating a design with a low cost.
    - A scale ranging from 1-5 can be used where a score of 5 corresponds to the designs with the lowest cost and a 1 corresponds to the designs with the highest cost.
- Students will be awarded points for completing the task in a short amount of time.
    - A scale ranging from 1-5 can be used where a score of 5 corresponds to the fastest groups and a 1 corresponds to the slowest groups (Note: Students can’t receive points if they don’t attempt to move the sack)

Materials (7 minutes):

Present the materials available to the students that they can use to complete the task. Be sure to include the “cost” of each material so that they can keep this in mind when they begin to brainstorm ideas. A list of materials and a suggested price list are shown on the following page:

Material	Price
Duct tape	£1 per roll
Wooden dowel	10 p each
Ramp	£5
Ramp Support (Various sizes)	£1 each
Wooden boards (2 x 4)	£1 each
Skateboard or other wheeled device	£10
Clips	50 p each
Shower Curtain	£2

Other materials that would be required are:

- Stopwatch
- Pencils
- Paper

Individual Group Brainstorming (23 minutes):

At this point it is time to split the students into groups. Split students into groups of 3 or 4 depending on the size of the class. Give students time to brainstorm ideas and instruct them that at the end of the time a sketch of the final design as well as a cost list containing prices for all materials used and final costs are to be handed in. Urge students to find creative ways to use materials and implement force and motion concepts they are familiar with. Prod students to make connections between simple machines and moving a large object. Materials can be used to create levers, ramps and wheeled devices are also available so there are several possibilities to construct a simple machine. Furthermore, at this point you can provide groups having trouble by identifying practical options.

Ask each group probing questions such as:

- Why would it help to have a wheeled device?
- What could you use the wooden boards for?
- How is this design going to work?

A sample activity sheet which children could fill out during this period could be similar to the activity sheet provided below.

Forces and Motion classroom activity

Planning to Move the Dinosaur Egg

Group Members:

We have these ideas to move the egg:

We plan on trying this idea:

We predict that this will happen:

During the activity, we will record the following information:

Draw your plan on the back of this sheet

Performing and Observation (50 minutes):

Allow each group approximately 5 minutes to attempt to complete the task of moving the sack out to the hallway. After a group has completed the task allow students time to give feedback to their peers while returning objects to their original positions so that they are ready for the next group. Areas that students can address in regards to their work and that of their peers are what worked well, what did not work so well, what they could have done better and what other groups can do to improve the designs.

Additional Suggestions:

This activity can be taken even further by requiring pupils to create a graph or chart of the class's results. This would facilitate discussion about what the groups that scored the highest did and why that could've worked (Did students who took longer score higher overall than students who rushed? Was it better to use cheaper or more expensive materials?).

Also, a scale attached to the equipment used to pull the sack could be introduced, which measures the force the forces that act on the object. Pupils could measure and record the force of each team and analyze this as well. This would facilitate discussion about friction and give proof that it is more difficult to directly lift the sack than to slide/role it.

Appendix B: “Quick and Dirty”

Appendix B1: Electromagnet

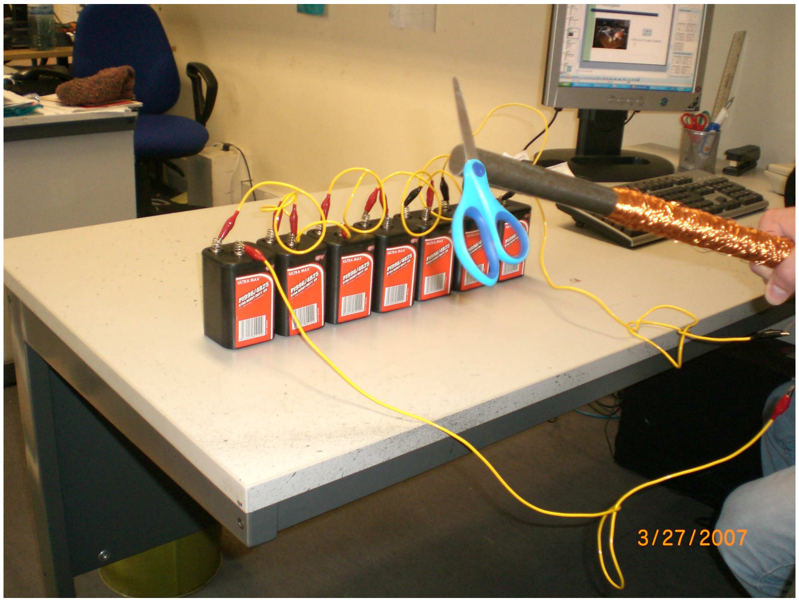


Photo By: Evan Graziano and Klementina Gerova

Materials:

- A long steel rod
- 100 m of insulated copper wire
- 16 Crocodile clips
- 7 x 6-volt batteries or 4x12-volt lantern battery
- Wire cutter
- Some paper clips and scissors
- Oven mitts

Setup and Procedure:

1. Wind all of the insulated wire around the steel rod. Leave enough wire free at both ends so that you will be able to make connections to the power supply.
2. Connect the batteries in series, positive to negative, using the crocodile clips.
3. Connect the ends of the wire to the batteries using crocodile clips, so that current flows round the coil.
4. This should magnetize the core. Place the core near a metallic item to test whether or not it has worked.

What Worked?

The electromagnet is simple to set up and proves to be quite reliable. The strength can be easily manipulated through the use of various batteries, but will still produce similar effects.

Problems Encountered:

- Determining the appropriate number of batteries to use
- Inability to determine how strong the batteries would make the magnet

Ways to Improve:

- Use of a power pack rather than a series of batteries. This allows for easier transport as well as the ability to control the current traveling into the magnet.

Recommendations:

This is a great experiment that may be used to show the connection between electricity and magnetism, and is suitable both for KS2 and KS3 pupils. As it was initially much smaller, the scaled up design enables the demonstrator to present the experiment to a larger audience. Also, while demonstrating, the winded copper wire gets very hot with time, so using oven mitts when handling the electromagnet is essential.

Links to National Curriculum:

- **Key Stage 3 – Electromagnets**
  - A current in a coil produces a magnetic field pattern similar to that of a bar magnet
  - How electromagnets are constructed and used in devices

Appendix B2: Magnetic Water

Photo By: http://geekologie.com/2006/08/how_to_make_magnetic_water.php

Materials:

- Cup of Water
- Lime Juice
- Spinach Leaves
- Strong Magnet

Setup and Procedure:

1. Get a glass and put about one half cup of water in it.
2. Grab four limes and squeeze the juice into the glass.
3. Take three sizable leaves of spinach and submerge them in the water.
4. Place the glass in a refrigerator, and leave overnight.
5. The next day, carefully remove the spinach leaves from the glass.
6. Place the magnet near the glass, and try to move the water.

What Worked?

This experiment was approved but, due to the level of difficulty associated with extracting iron from food, was unsuccessful.

Problems Encountered:

- It is very hard to extract the iron from the spinach

Ways to Improve:

- Try to chopping up the spinach in order to enable the lemon juice to extract the iron easer
- Try boiling the leaves beforehand in order to extract iron that way. Then use the remains with the lemon juice.

Recommendations:

This experiment is very hard to perform and requires prior knowledge in regards to the extraction of iron from the spinach. If a simple way can be found for such an extraction, then the experiment may be worthwhile, but otherwise the actual demonstration may not be worth the effort.

Links to National Curriculum:

- **Key Stage 2 – Forces and Motion**
    - Forces of attraction between magnets and magnetic materials

Appendix B3: Concave Mirrors Mirage

Photo By: www.grand-illusions.com

Materials:

- (2) Parabolic Concave Mirrors
- Knife or Other Cutting Device
- Object to Create a Mirage of

Setup and Procedure:

1. Using the knife or cutting device, cut a small hole into one of the mirrors, being sure not to crack or damage it.
2. Place the object at the bottom of the uncut mirror.
3. Take the mirror with the hole in it and place it on top of the uncut mirror, ensuring that light is unable to get in or leave through the sides.
4. A hologram of the desired object should form.

What Worked?

This particular “quick and dirty” idea was approved for continuation of its development, but was deemed impractical for continuation due to availability and cost of materials.

Problems Encountered:

- It is very difficult to find parabolic concave mirrors that will work properly with the experiment.
- Once found, the cost of the mirrors makes the experiment impractical for both the museum and teachers at schools.

Ways to Improve:

- Not Applicable

Recommendations:

Although the idea was deemed very good, the overall availability and cost of the materials make it very difficult to create. Even if mirrors were obtained, however, there is still the risk of destroying one of the mirrors when cutting a hole in it. It is therefore suggested that if you were to actually use this experiment, it would be most beneficial to order it online or at a store, as it already comes pre-constructed.

Links to National Curriculum

- **Key Stage 2 – Light**
    - Light travels from a source
    - Light is reflected form sources (i.e. mirrors, polished metals, etc.)
- **Key Stage 3 – Light**
    - Light is reflected at plane surfaces
    - Light is refracted at the boundary between two different materials

Appendix B4: Periscope

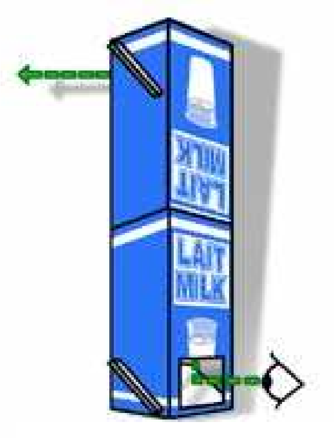


Photo and Setup By: www.natrel.ca

Materials:

- (2) 1-Quart Milk Cartons
- (2) Small Pocket Mirrors
- Utility Knife
- Ruler
- Pencil or Pen
- Masking Tape

Setup and Procedure:

1. Cut a hole at the bottom of the front of one milk carton. Leave about ¼ inch of carton on each side of the hole.
2. Put the carton on its side and turn it so the hole you just cut is facing to your right. On the side that's facing up, measure 2 ¾ inches up the left edge of the carton, and use the pencil to make a mark there. Now, use your ruler to draw a diagonal line from the bottom right corner to the mark you made.
3. Starting at the bottom right corner, cut on that line. Don't cut all the way to the left edge of the carton – just make the cut as long as one side of your mirror. If your mirror is thick, widen the cut to fit.
4. Slide the mirror through the slot so the reflecting side faces the hole in the front of the carton. Tape the mirror loosely in place.
5. Hold the carton up to your eye and look through the hole that you cut. You should see your ceiling through the top of the carton. If what you see looks tilted, adjust the mirror and tape it again.

6. Repeat steps 2 through 6 with the second milk carton.
7. Stand one carton up on a table, with the hole facing you. Place the other carton upside-down, with the mirror on the top and the hole facing away from you.
8. Use your hand to pinch the open end of the upside-down carton just enough for it to slide into the other carton. Tape the two cartons together.

What Worked?

This particular “quick and dirty” idea was not approved for continuation of its development. It did not provide much of a “WOW” factor, and was very similar concept-wise to other activities and demonstrations currently used by the museum.

Problems Encountered:

- Not Applicable

Ways to Improve:

- Scale up the periscope so that it is significantly larger and more durable. Perhaps try using wood and larger mirrors, and making it a classroom activity rather than an individual one.

Recommendations:

Although the idea was not approved, the Periscope could still prove to be a reliable classroom experiment. Provided enough thought is given, the experiment could be significantly scaled up, providing a greater “WOW” factor and generating a greater interest from students in the age group of 8-14.

Links to National Curriculum

- **Key Stage 2 – Light**
    - Light travels from a source
    - Light is reflected form sources (i.e. mirrors, polished metals, etc.)
- **Key Stage 3 – Light**
    - Light is reflected at plane surfaces
    - Light is refracted at the boundary between two different materials

Appendix B5: Ruben's Tube

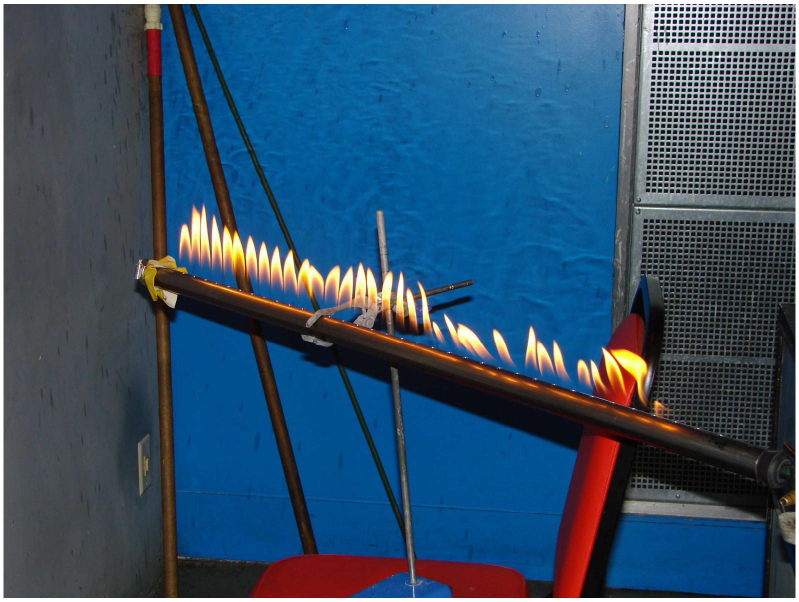


Photo By: Evan Graziano and Kyle Dedmon

Materials:

- Metal Pipe (The less heat conductivity the better)
- Rubber Glove
- Rubber Door Stopper
- Lighter/Matches
- Metal Fastener
- Drill
- Gas Supply (i.e. propane, butane, methane)
- Stand
- Speakers (2)
- Switch Box
- Sine Wave Signal Generator
- Boom Box

Setup and Procedure:

1. Begin by drilling a series of holes in a straight line along the pipe. Each hole should be roughly 4mm in diameter and about an inch apart.
2. Next, take a rubber glove and cut out a square large enough to fit over one side of the pipe. Stretch the rubber, until it is fairly tight, and fasten it into place with one of the metal fasteners.
3. Take the rubber door stopper and stick it into the other end of the pipe. Make a hole in the stopper large enough for a gas valve.

4. Place the pipe onto a stand and take a valve, attached to a gas tank, and stick it through the rubber stopper.
5. Place one of the sound sources next to the other end of the pipe so that it is in direct contact with the rubber membrane (glove).
6. Turn on the gas and carefully light it shortly thereafter. Once all of the flames are burning, turn on the sound source and take notice of the fire's motion.

What Worked?

Providing exact materials may be a more effective way of recreating this demonstration, as the steps required can prove to be quite troublesome if not impossible if the proper resources are not readily available. Once created, however, the tube is very easy to set-up and light, providing a fairly high reliability and a relatively low health or safety risk if used by a responsible adult.

Problems Encountered:

- If the tube is not perfectly level in the stand, then many of the flames will not light. This caused a great deal of confusion at first, but was easily remedied once the problem was identified.
- The sounds from the source must travel directly into the membrane. It must not be given room to dissipate or the tube may not work properly. To solve this, the speaker must be a perfect fit, or that a funnel must be used between the speaker and the membrane.

Ways to Improve:

- If the tube is longer, then it will allow for the drilling of more holes, which will ultimately grant the flames the ability to mimic larger sound waves.
- Smaller holes placed more closely together may allow for the creation of a better visual.

Recommendations:

Although a highly effective demonstration, the required materials may provide somewhat of a problem for teachers to obtain, as well as the setup being somewhat difficult to perform. Therefore, unless the materials can be shipped out by the museum, it might be best if the demonstration was associated solely with Launch Pad or the Outreach program.

Links to National Curriculum:

- **Key Stage 2 – Vibration and Sound**
  - Sounds are made when objects vibrate, but that vibrations are not always directly visible
  - Vibrations from sound sources require a medium through which to travel to the ear
- **Key Stage 3 – Vibration and Sound**
  - Relationship between the loudness of a sound and the amplitude of the vibration causing it

- Relationship between the pitch of a sound and the frequency of the vibration causing it

Appendix B6: Trebuchet

Photo By: Evan Graziano and Klementina Gerova

Materials:

- PVC Pipe
- Rubber Door Stopper (5)
- String
- Wooden Board/Plank
- Duct Tape
- Nail
- Paper Clip
- Weights
- Adhesive Velcro Strips

Setup and Procedure:

1. Begin by constructing the frame for the Trebuchet using the assorted lengths of PVC piping. Once completed, place the rubber door stoppers on the legs of the structure as well as on the end of the lever arm.
2. Next, attach a Velcro strip to each end of the wooden plank, as well as to each side of the trebuchet's supports. Place the wooden plank into the frame, aligning the strips of Velcro.

3. Tie down the arm with a piece of string, and begin to add weight to the other side. It may take several attempts, but ensure that the frame is able to support the weight, and that it will not buckle once the arm is released.
4. Construct a sling similar to the one shown either out of duct tape or another material. Tie a piece of string through one end and attach to the end of the lever arm. Tie another piece of string through the other end and tie the end to a paper clip.
5. Stick a nail through the door stop on the end of the lever arm and hook the paper clip onto it. Ensure that the paper clip will be allowed to release once it is about half through its arc.
6. Tie down the arm, load a projectile into the sling, and release.

What Worked?

In order to provide for the simplest and most efficient set-up, pre-measured lengths of PVC piping should be provided, as well as a pre-constructed sling. However, working from scratch also proves to teach a great deal about the machine itself, and gives the experimenter a greater appreciation for the demonstration.

Problems Encountered:

- Determining the amount of weight to attach to the lever arm (too little and the projectile will not travel far enough/too much and the frame will buckle)
- Determining the proper way to construct/attach the sling to the lever arm
- Unreliability of the direction and distance of the projectile

Ways to Improve:

- Use thicker PVC piping, or another stronger material, to provide for a stronger frame. This will allow for heavier weights, longer trajectory, and a greater reliability.

Recommendations:

Although we were able to successfully construct a prototype that was both safe and suitable for a classroom, in the end, we found that the trebuchet was too unreliable to test with the public. Due to the unpredictable distance and direction of the projectile, we had to abandon this prototype as we moved closer and closer to testing. As mentioned above, other improvements could be made to this demonstration through the use of a sturdier material for the trebuchet’s frame, but care must be taken to ensure that it will actually behave correctly before sending out to schools.

Links to National Curriculum:

- **Key Stage 2 – Forces and Motion**
  - Friction, including air resistance, as a force that slows moving objects and may prevent objects from starting to move
  - To measure forces and identify the direction in which they act
- **Key Stage 3 – Forces and Rotation/Forces and Motion**
  - Forces can cause objects to turn about a pivot

- Principle of moments and its application to situations involving one pivot
- The weight of an object on Earth is the result of the gravitational attraction between its mass and that of the Earth
- Unbalanced forces change the speed or direction of movement of objects and that balanced forces produce no change in the movement of an object
- Ways in which frictional forces, including air resistance, affect motion

Appendix B7: Coloured Shadows

Photo By: www.exo.net

Materials

- White Surface
- Red, Green, and Blue Light bulbs / Flood lamps
- 3 Light Sockets
- Any Solid Object

Setup and Procedure:

1. Set up the bulbs and the screen in such a way that the light from all three of the bulbs falls onto the same area.
2. Assure that all bulbs are approximately the same distance form the screen, preferably with the green bulb in between the red and blue ones.

What Worked?

This is a very helpful demonstration for teachers when they are trying to explain the principles of light. It engages children’s attention while at the same time associate scientific principles with fun.

Problems Encountered:

- The placement of the lamps must be precise in order to get white light

Ways to Improve:

- Once the colored shadow appears it can be traced onto a white paper and then coloured in with the same colours as it appears onto the screen.

Recommendations:

One can repeat the demonstration with one light turned off while the other two remain on. One can also vary the size of the object and the distance from the screen. The variety of objects the can be used as well as the combination of light make this demonstration very interactive and fun.

Links to National Curriculum:

- **Key Stage 2 – Light and Sound**
    - Light cannot pass through some materials, and how this leads to the formation of shadows
- **Key Stage 3 – Light and Sound**
    - White light can be dispersed to give a range of colours
    - Effect of colour filters on white light and how coloured objects appear in white light and other colours of light

Appendix B8: Collapsing Can

Photo By: Evan Graziano and Klementina Gerova

Materials:

- 1 Gallon Metal Can with Screw Cap
- Hot Plate
- Oven Mitts

Setup and Procedure:

1. Put approximately 100 mL water in can.
2. Place the can onto the hot plate.
3. Turn on the hot plate, and allow the can to heat up until steam begins to release from the top.
4. Using the oven mitts, remove the can from the hot plate.
5. Carefully screw the cap onto the can and allow it to sit.
6. Due to differences in pressure, the can should begin to be crushed.

What Worked?

This demonstration shows how strong air pressure can be, as it causes the can to collapse in on itself without the use of external force by the presenter or audience. It is also an appropriate demonstration for a teacher to perform in front of the class followed by an activity that the student s can perform with smaller cans.

Problems Encountered:

- Although the experiment was successful, finding an effective way to speed up the collapsing process can be timely

Ways to Improve:

- For a more dramatic effect, run cold water over the can as soon as it is sealed
- Pour the boiling water out of the can before screwing on the cap for a faster implosion

Recommendations:

This experiment should be performed in a controlled environment where the demonstrator can keep the public away from the hotplate and the hot can. It would be ideal to use it as a class long demonstration where the teacher would put in on the hotplate in the beginning of class, take it off midway throughout and by the end of the class the can would have crushed by itself.

Links to National Curriculum:

- **Key Stage 3 – Force and Pressure**
  - Quantitative relationship between force, area and pressure, and its application

Appendix B9: Electromagnetic Can Crusher

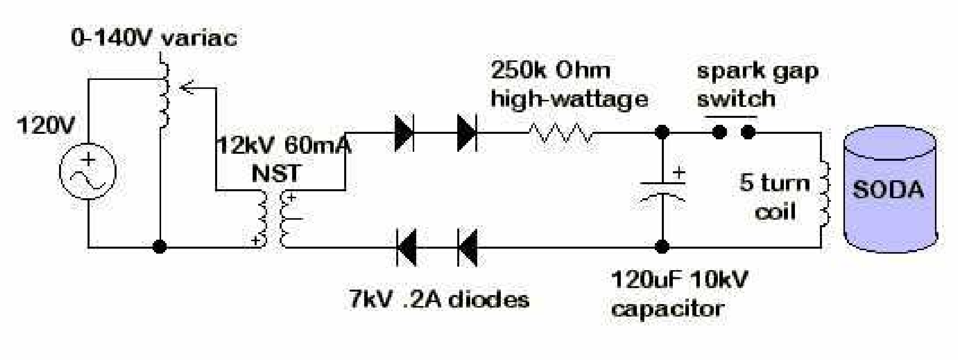
Photo and Setup By: http://members.tripod.com/extreme_skier/cancrusher/

Materials:

- #12 Wire
- Capacitor
- Resistor
- Spark Gap Switch
- Aluminum Can

Setup and Procedure:

1. Set up a circuit similar to the one shown here:



2. Charge the capacitor to a high voltage (The more voltage, the more crushing force)
3. Once the desired voltage is attained, slip the switch to the spark gap.
4. If done correctly, an enormous amount of current should be fired through the coil, creating a magnetic field that opposed the magnetic field generated by the current. This will result in a force that will push inward on the can, crushing it.

What Worked?

This particular "quick and dirty" idea was approved for continuation of its development, but was deemed impractical for continuation due to availability, cost of materials, and complexity of set up.

Problems Encountered:

- A basic knowledge of electrical engineering is required when creating this experiment.
- For a split-second during its operation, the solenoid used to crush the can is lethal, and can kill anyone who may come into contact with it.

Ways to Improve:

- Find a simpler set up that requires little to no knowledge of circuits.
- Find a way to isolate the solenoid during operation.

Recommendations:

Although the idea was viewed as having a "WOW" factor and overall very intriguing, the availability of its materials, as well as the complexity of the circuit, left the demonstration untouched the group. If you could find a readily available source for the materials, as well as someone with a good knowledge of electrical engineering, it is suggested that you perhaps find a way to redesign the circuit and make it safer for use.

Links to National Curriculum

- **Key Stage 2 – Electricity**
    - Construct circuits, incorporating a battery or power supply and a range of switches, to make electrical devices work
    - Represent series circuits by drawing and conventional symbols, and how to construct series circuits on the basis of drawings and diagrams using conventional symbols
- **Key Stage 3 – Electricity and Magnetism**
    - Design and construct series and parallel circuits, and how to measure current and voltage
    - Energy is transferred from batteries and other sources to other components in electrical circuits
    - Magnetic fields as regions of space where magnetic materials experience forces, and that like magnetic poles repel and unlike poles attract
    - A current in a coil produces a magnetic field pattern similar to that of a bar magnet

Appendix B10: Oobleck

Photo By: www.exploscience.com

Materials:

- Water
- Corn Starch
- Vibrating Pad
- Bowl

Setup and Procedure:

1. Create a mixture in the bowl consisting of 1 cup of water and 1 cup of cornstarch.
2. Mix until the resulting substance is a thick combination of the two.
3. Place the bowl on the vibrating pad, allowing the substance to come to rest.
4. Turn on the vibrating pad and, using your finger, break the surface of the mixture.
5. The result should be a series of finger-like growths that will appear and begin to multiply along the mixture’s surface.

What Worked?

This particular “quick and dirty” idea was approved for continuation of its development, but was discontinued due to the unavailability of a vibration pad.

Problems Encountered:

- The substance tends to react differently when vibrating at different levels. This could result in an unreliable demonstration.
- Creating the mixture sometimes takes patience, as even if proper amounts are used, the way that it is mixed can result in an unfit substance.

Ways to Improve:

- Find other means of vibration that will work as vibrating pads are not all too common.
- Scale the demonstration up, using a much larger portion of oobleck.

Recommendations:

As a stand-alone demonstration, oobleck is still able to provide a great deal of interest and entertainment. However, when accompanied by the vibrating pad, it reacts in such an unexpected way, that a “WOW” factor is unavoidable. For the sake of this, it is suggested that another means of vibration is found, as a vibrating pad is relatively difficult to obtain. Also, by perhaps using larger amounts of the substance, the presenter may be able to demonstrate some of its other characteristics, such as the ability to support great weights while in its solid form, but how quickly it can change back to liquid while doing so.

Links to National Curriculum

- **Key Stage 2 – Changing Materials**
    - Describe changes that occur when materials are mixed
    - Non-reversible changes result in the formation of new materials that may be useful
- **Key Stage 3 – Changing Materials**
    - When physical changes take place, mass is conserved
    - Relate changes of state to energy transfer

Appendix B11: Balloon Rocket

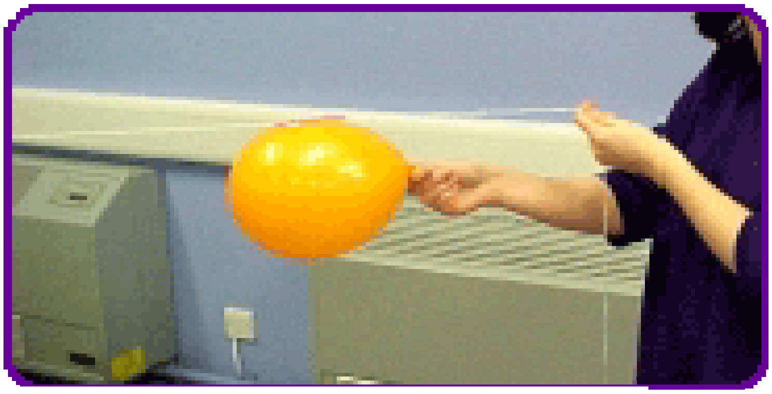


Photo By: http://www.at-bristol.org.uk/Newton/1st_law

Materials:

- Balloons of different shapes
- Drinking straw cut into 5cm lengths
- Sticky tape
- Scissors
- 2 chairs or 2 friends
- Thin card
- Long piece of smooth string (5m) to act as a track for your rocket

Setup and Procedure:

1. Thread the string through the straw, and attach both ends of the string to the chairs, making sure it is taught and level.
2. Blow up a balloon and hold it closed so the air does not escape - do not tie it shut.
3. Attach the balloon to the straw with sticky tape.
4. Move your balloon rocket to one end of the string
5. Let go.

What Worked?

The materials for this demonstration are easily sourced, and there are no serious health or safety hazards. Due to its straightforwardness, teachers will be able to easily construct the demonstration, as well as have plenty of time to explain the principles behind it.

Problems Encountered:

- Not Applicable

Ways to Improve:

- Try the same experiment with different shaped balloons
- You can decorate your rocket using the card to make fins and a nose cone

Recommendations:

This is a very simple, yet very effective demonstration. The use of different shapes of the balloons and additional attachments will enable children to discover scientific principles by themselves, and would be suitable for a classroom follow-up activity.

Links to National Curriculum:

- **Key Stage 2 – Forces and Motion**
    - Friction, including air resistance, as a force that slows moving objects and may prevent objects from starting to move
    - When objects are pushed or pulled, an opposing pull or push can be felt
    - To measure forces and identify the direction in which they act
- **Key Stage 3 – Forces and Motion/Forces and Pressure**
    - To determine the speed of a moving object and to use the quantitative relationship between speed, distance, and time
    - Ways in which frictional forces, including air resistance, affect motion
    - Quantitative relationship between force, area, and pressure and its application

Appendix B12: Hovercraft

Photo and Setup By: http://amasci.com/amateur/hovercft.html

Materials:

- Battery Powered Leaf Blower
- Plywood – 3 or 4 ft., 3/8 or ½ in. thick
- Plastic Sheet, 1ft. Larger than the Plywood
- Small Plastic Disk
- Bolt, 2 in., ¼-20, Nut, ¼-20, Fender Washers (2)
- Smooth Floor
- Electric Saber Saw
- Drill
- Razor Knife
- Staple Gun
- Duct Tape

Setup and Procedure:

1. Cut out your plywood disk.
2. Drill a 5/16 in. hole in the exact centre, and be sure that that the 2 in. bolt is able to easily pass through it.
3. Make a hole in the plywood that exactly fits the end of the leaf blower or vacuum cleaner hose. This hole must be placed halfway between the centre of the disk and the edge.
4. Lay the plywood disk on the centre of the large plastic sheet.
5. Fold the edges of the sheet up over the plywood, and then, using the staple gun, staple it to the top of the plywood disk, placing a staple about every 4 in.
6. Cut off any excess plastic.
7. Use duct tape to tape the edge of the plastic down to make it look nice.

8. Poke a hole in the centre of the coffee can lid and attach it to the bottom of the hovercraft.
9. Using the razor knife cut six vent holes in the plastic, about 2 in. diameter. They must be placed within a few inches of the coffee can lid. Space them out so that there is plenty of plastic between each of them.
10. To reinforce the thin necks of plastic between the holes, use a coupld of layers of duct tape.
11. Flip the hovercraft over so that the plastic sheet is on the bottom and place it on a smooth floor.
12. Place the vacuum cleaner hose into the hole and turn it on.

What Worked?

This is a very effective demonstration as the hovercraft will be able to support the weight of a child. Due to the materials required, as well as the sheer size, we were unable to create a working prototype, however.

Problems Encountered:

- Many of the materials may be relatively difficult for a teacher to source
- The surface where the hovercraft will be operated needs to be very smooth for it work properly

Ways to Improve:

- When making the wooden disk, one can avoid using a big bolt. Instead, fasten down the small plastic disk with several short wood screws.
- Avoid using 1 mil thickness garbage bags. Instead, use a heavy 4 mil, or 6 mil, plastic drop cloth from a paint store or an old plastic shower curtain.

Recommendations:

This would be an appropriate class demonstration that teachers could prepare prior to their lesson. The set up time is a bit long therefore they should set it up the day before and during class just use the principles from the large demonstration and let students build smaller prototypes using hairdryers instead of leaf blower.

Links to National Curriculum:

- **Key Stage 2 – Forces and Motion**
    - Friction, including air resistance, as a force that slows moving objects and may prevent objects from starting to move
    - When objects are pushed or pulled, an opposing pull or push can be felt
- **Key Stage 3 – Forces and Motion**
    - Quantitative relationship between force, area, and pressure, and its application
    - Ways in which frictional forces, including air resistance, affect motion

Appendix B13: Supercooling Water

Photo By: www.cynical-c.com

Materials:

- Purified Water
- Completely Smooth Container or Water Bottle
- Freezer

Setup and Procedure:

1. Begin by taking a container or bottle of pure or purified water and placing it into a freezer.
2. Assure that the water will remain undisturbed and allow it to sit overnight as though you were trying to freeze it.
3. Take the water out of the freezer and gently shake it. The water should begin to quickly freeze in front of your eyes.

What Worked?

This particular “quick and dirty” idea was approved for continuation, but was unable to be completed. Although the instructions were carefully followed, there were other factors, such as use of a public freezer and inability to test the purity of water that resulted in a series of unsuccessful attempts.

Problems Encountered:

- The freezer that is to be used must remain completely undisturbed during the process. The use of a public freezer prevented this.

- Manually purifying water tends to be unreliable, with no actual way of testing how clean it is.

Ways to Improve:

- Not Applicable

Recommendations:

As a stand-alone experiment, supercooling of water provides a great “WOW” factor. However, due to its specifications and little room for error, it can be very difficult to perform and cause more frustration than anything. If attempting this experiment, it is vital that the freezer will remain untouched and that the water is guaranteed to be pure. It is also a necessity that the container is as smooth as possible, so that there are no good nucleation points for the water to begin crystallizing.

Links to National Curriculum

- **Key Stage 2 – Changing Materials**
    - Describe changes that occur when materials are heated or cooled
    - Temperature is a measure of how hot or cold things are
    - Reversible changes, including dissolving, melting, boiling, condensing, freezing, and evaporating
- **Key Stage 3 – Changing Materials**
    - When physical changes take place, mass is conserved
    - Relate changes of state to energy transfers

Appendix B14: Lissajous Figures

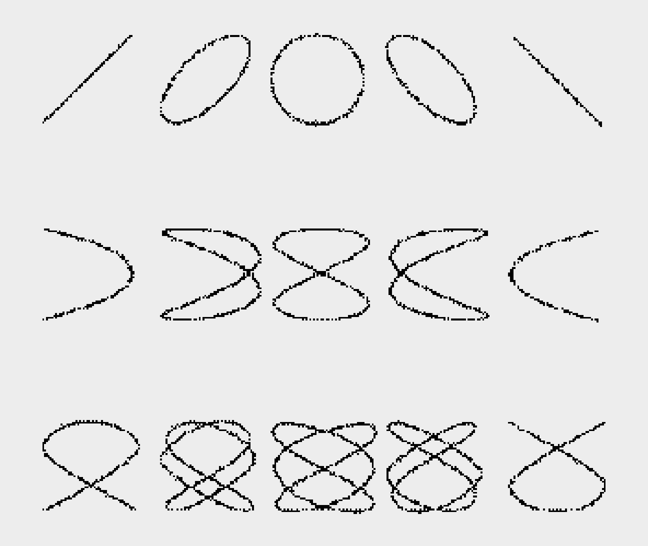


Photo and Setup By: http://www.sfu.ca/physics/outreach/activities/pendulumpictures.htm

Materials:

- Black Sheet of Construction Paper
- Styrofoam Cup
- Salt
- String
- Nail

Setup and Procedure:

1. Tie a long piece of string between two chairs, so that it hangs a few feet above the floor.
2. Then tie another piece of string into a loop around the first piece (your new pendulum should look like a Y).
3. Now attach your pendulum bob, which will be the cup and salt.
4. Attach the cup using anything, such as a paper clip poked through each side or a thin piece of twine (try to make the cup balanced).
5. Now, fill the cup with salt.
6. Poke a small hole in the bottom of the cup with the nail. Salt should begin to flow freely.
7. Pull the cup a bit in any direction and let it go. You will watch as a Lissajous pattern is formed.

What Worked?

This demonstration is very easy to set up and perform, and allows bystanders to create their own works of art. It also links to one of the exhibits currently in the museum.

Problems Encountered:

- It can be somewhat difficult to properly balance the cup of salt
- If the hole in the cup is too large, and the salt may flow out too quickly

Ways to Improve:

- Use “sticky” paper to allow the children to keep their designs
- Use a dark background for the salt to land on
- Use lasers and mirrors rather than salt

Recommendations:

This demonstration links to the math exhibition in the Science Museum. Children can compare the Lissajous figures they have created with the ones that are displayed at the museum. The demonstration is easy to set up and could be even preformed at home by parents planning to visit the museum with their children. It is ideal for a do-it-yourself experiment for the Launch Pad webpage.

Links to National Curriculum:

- **Key Stage 2 – Forces and Motion**
  - Objects are pulled downwards because of the gravitational attraction between them and the Earth
  - Friction, including air resistance, as a force that slows moving objects and may prevent objects from starting to move
- **Key Stage 3 – Forces and Motion/Force and Rotation**
  - Unbalanced forces change the speed or direction of movement of objects and that balanced forces produce no change in the movement of an object
  - Ways in which frictional forces, including air resistance, affect motion
  - The principle of moments and its application to situations involving one pivot

Appendix B15: Air Cannon

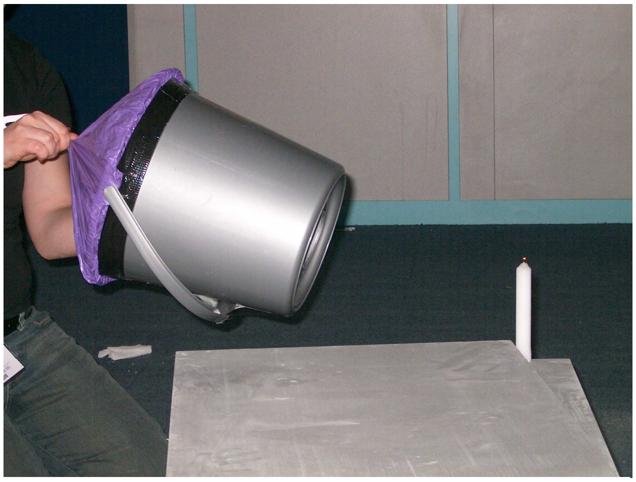


Photo By: Evan Graziano and Klementina Gerova

Materials:

- Waste Bucket
- Knife
- Shower Cap
- Duct Tape
- Safety Pin

Setup and Procedure:

1. Begin by cutting a hole in the bottom of the bucket, about 3 inches in diameter.
2. Next, place the shower cap around the larger end of the bucket, ensuring that it hangs off the end slightly.
3. Tape around the bottom of the shower cap, securing it to the waste bucket.
4. Take the safety pin, and stick it through the center of the shower cap.
5. Once this is done, you should be able to pull back on the pin, and then push it forward, forcing a ball of air out of the smaller hole.

What Worked?

The experiment itself is relatively easy to set-up, yet still provides a great deal of entertainment, as well as a “WOW” factor, providing it is accompanied by proper materials. In our presentation, we used it to blow out a candle, shoot perfume across the room, and to knock over series of cups in a mini-competition.

Problems Encountered:

- Determining proper material to cover the larger end of the waste bucket as well as proper tension to be used
- Finding an effective way to shoot smoke across the room

Ways to Improve:

- Find some type of elastic material that maybe be used in conjunction with the shower cap as to ease the operation of the experiment, as well as to provide a much stronger ball of air
- Create some type of handle that could be attached to the cannon, making it easy to hold and providing better aim
- Find an effective way to shoot smoke balls/rings out of the air cannon

Recommendations:

Overall, the demonstration can be viewed as a success. We were able to test with both staff and public, and, based on our feedback from both, found that the demonstration was both interesting and exciting. It is suggested that work is continued on the prototype's actual structure (handle, elasticity, etc.), but in regards to presentation there is little that would need to be changed.

Links to National Curriculum:

- **Key Stage 2 – Forces and Motion**
    - Friction, including air resistance, as a force that slows moving objects and may prevent objects from starting to move
    - To measure forces and identify the direction in which they act
    - When objects are pushed or pulled, an opposing pull or push can be felt
- **Key Stage 3 – Forces and Motion**
    - Ways in which frictional forces, including air resistance, affect motion
    - Quantitative relationship between force, area and pressure, and its application

Appendix B16: Burning Money

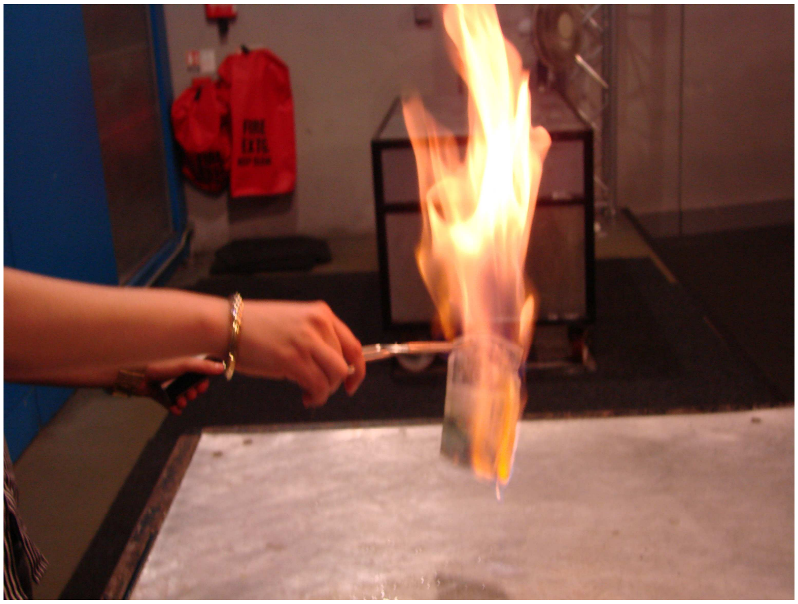


Photo By: Klementina Gerova

Materials:

- Money Note
- Matches
- Isopropyl Alcohol
- Water
- Tongs
- Cup
- Salt Packet

Setup and Procedure:

1. Begin by mixing the water and alcohol together in the cup at a ratio of 1:1
2. Mix in the packet of salt and stir until it is dissolved
3. Place the note into the mixture and allow to soak for a few seconds
4. Take the note out with the tongs and move away from your body
5. Using a match, light the bill on fire
6. The fire should eventually die down as the alcohol burns off, leaving the bill unaffected by the flame

What Worked?

The experiment is extremely easy to set-up, but still provides a large “WOW” factor. The initial flame when first lighting the note tends to surprise the viewers, and the idea that it remains unharmed afterwards tends to arouse a great deal of interest. We also found that the experiment may be performed relatively close to a fire alarm (about 1 meter away) without setting it off.

This is very good, as teachers will not need to worry about setting any alarms off in the classroom.

Problems Encountered:

- Determining the proper amount of water and alcohol to mix together
- Finding a way to make the flame more visible when lighting the note on fire

Ways to Improve:

- Use notes of higher value as it may arouse a greater interest from the audience
- Experiment with different alcohols or substances that may alter the color of the flame
- Find other materials that relate more to children, such as toys, that could be lit on fire

Recommendations:

Although not yet tested with the public, the demonstration proved to be a great success with the staff. However, as it is a relatively short experiment, it is suggested that you find other materials or objects to burn, as well as find substances that may alter the color of flames or their intensity. The experiment, itself, has been tested with various materials (money, plastic, rug, and paper) and in each instance has worked reliably, without causing any damage to the said materials.

Links to National Curriculum:

- **Key Stage 2 – Changing Materials**
    - Describe changes that occur when materials are mixed
    - Describe changes that occur when materials are heated or cooled
    - Temperature is a measure of how hot or cold things are
    - Burning materials results in the formation of new materials and that this change is not usually reversible

Appendix B17: Sound in a Bag

Photo By: http://www.snowandrock.com/products/images/12digits/small/MOT0003ZZ.jpg

Materials:

- Battery Powered Radio
- Plastic Garbage Bag
- Vacuum Cleaner with Hose
- Several Pillows
- 12x12 in. Wire Screen
- Duct Tape

Setup and Procedure:

1. Turn on radio and tune into a station with continuous music.
2. Put the radio in the plastic bag.
3. Tape the screen into a cylinder shape and attach to the end of the nozzle on the vacuum cleaner hose.
4. Put the nozzle and screen into the plastic bag and seal the bag so air cannot get into or out of the bag.
5. If the vacuum is to loud to hear the radio, pile pillows around the vacuum to muffle the sound.

What Worked?

Although approved by staff, we were unable to progress with this idea as our hopes of adding in a new element, for increased “WOW” factor proved to impede our progress. This idea, being that rather than using a vacuum, you use various gases to see how it affected the sound waves.

Problems Encountered:

- Need to make sure what types of gasses are available to teachers in the science departments

Ways to Improve:

- Instead of using a plastic garbage bag, one can use a vacuum bag
- The use of various gases to affect the sound waves should provide an interesting effect regarding audible sound from the radio

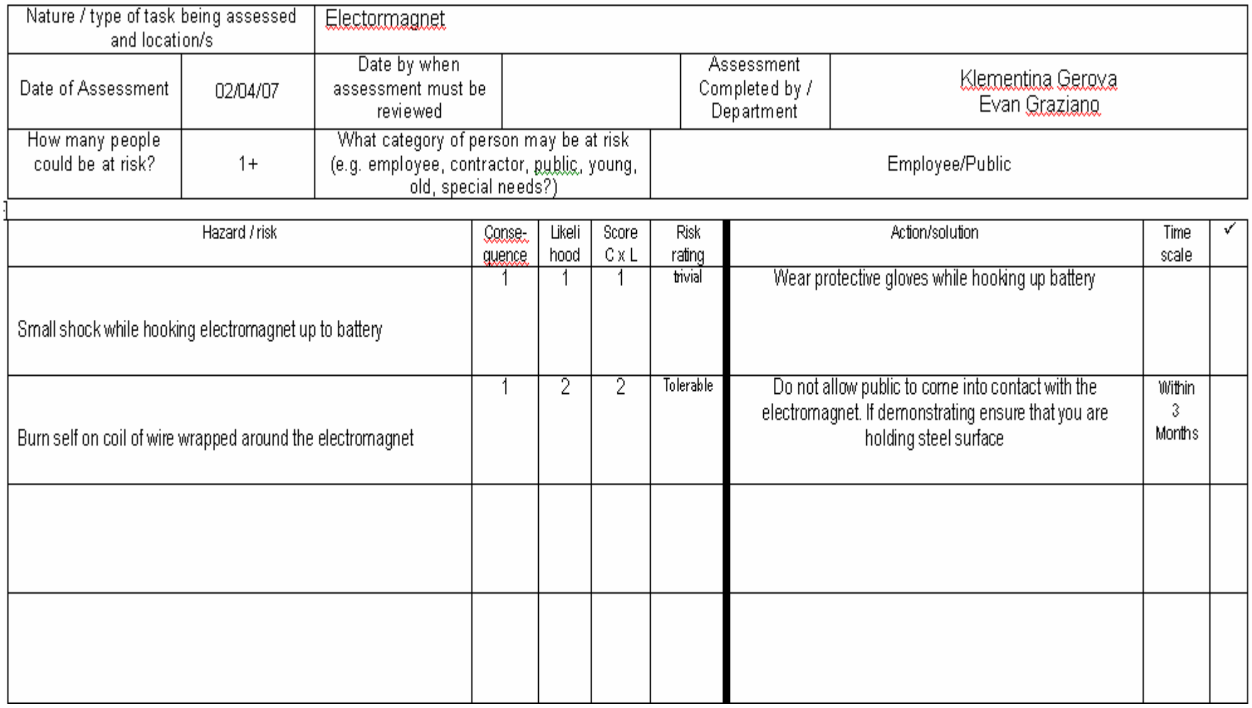
Recommendations:

There are a few improvements could be made to make this demonstration more exciting. For example, you could take a series of bags, each one containing a different gas, and place a radio that is playing the same station in each. Due to the properties of sound (it travels at different speeds thought different gasses), one will be able to hear the same radio station playing at different speeds.

Links to National Curriculum:

- **Key Stage 2 – Vibration and Sound**
    - Vibrations from sound sources require a medium
    - Sounds are made when objects vibrate but that vibrations are not always directly visible
- **Key Stage 3 – Vibration and Sound**
    - Light can travel through a vacuum but sound cannot

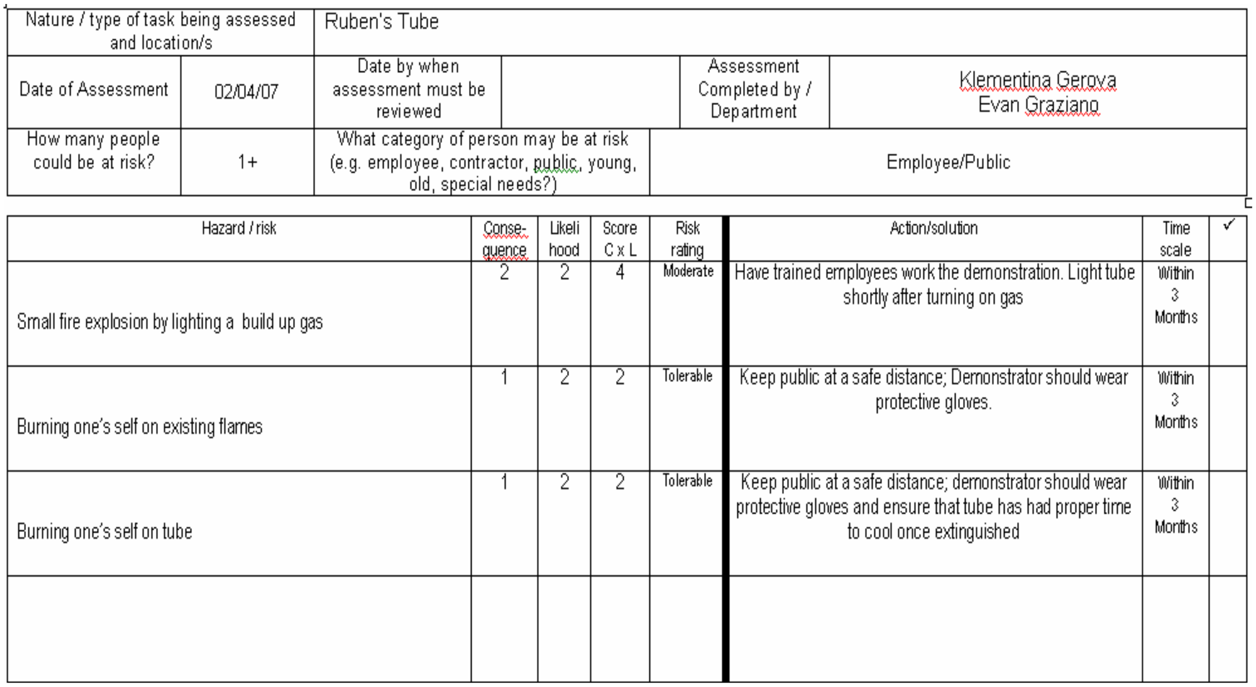
Appendix B18: Electromagnet Risk Analysis



Nature / type of task being assessed and location/s	Electormagnet				
Date of Assessment	02/04/07	Date by when assessment must be reviewed		Assessment Completed by / Department	Klementina Gerova Evan Graziano
How many people could be at risk?	1+	What category of person may be at risk (e.g. employee, contractor, public, young, old, special needs?)	Employee/Public		

Hazard / risk	Conse-quence	Likeli hood	Score C x L	Risk rating	Action/solution	Time scale	✓
Small shock while hooking electromagnet up to battery	1	1	1	trivial	Wear protective gloves while hooking up battery		
Burn self on coil of wire wrapped around the electromagnet	1	2	2	Tolerable	Do not allow public to come into contact with the electromagnet. If demonstrating ensure that you are holding steel surface	Within 3 Months	

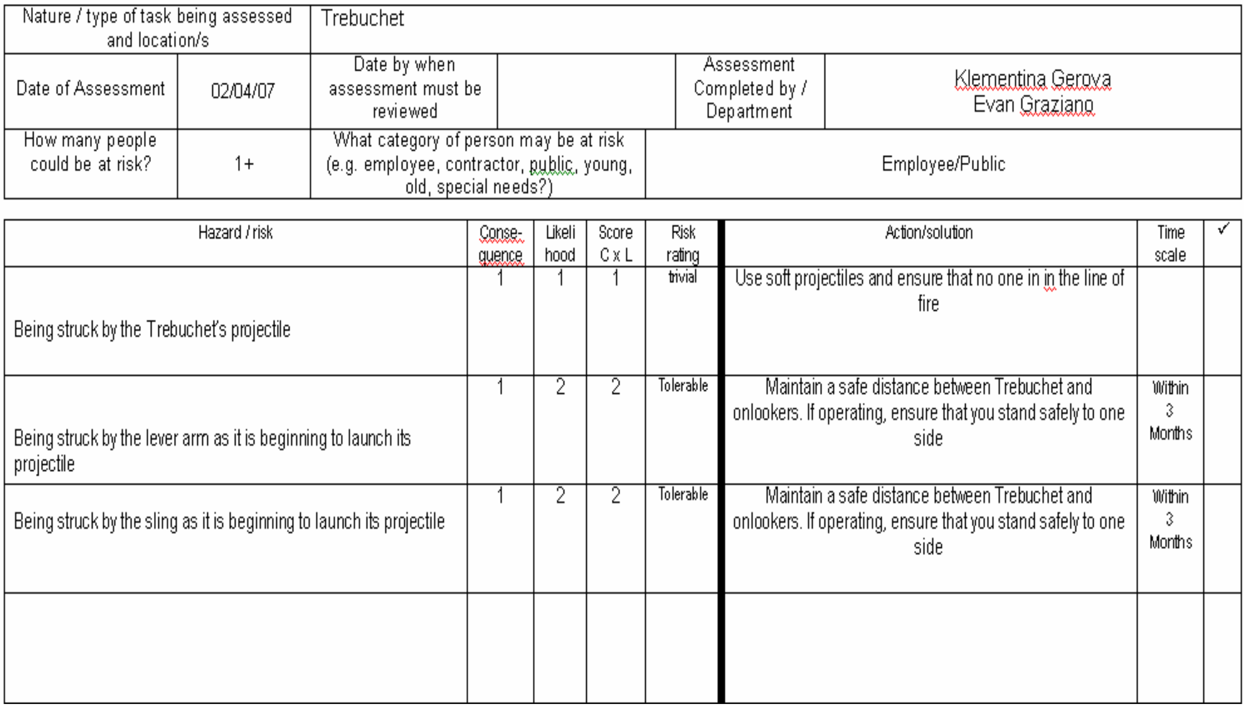
Appendix B19: Ruben's Tube Risk Analysis



Nature / type of task being assessed and location/s	Ruben's Tube				
Date of Assessment	02/04/07	Date by when assessment must be reviewed		Assessment Completed by / Department	Klementina Gerova Evan Graziano
How many people could be at risk?	1+	What category of person may be at risk (e.g. employee, contractor, public, young, old, special needs?)	Employee/Public		

Hazard / risk	Conse-quence	Likeli hood	Score C x L	Risk rating	Action/solution	Time scale	✓
Small fire explosion by lighting a build up gas	2	2	4	Moderate	Have trained employees work the demonstration. Light tube shortly after turning on gas	Within 3 Months	
Burning one's self on existing flames	1	2	2	Tolerable	Keep public at a safe distance; Demonstrator should wear protective gloves.	Within 3 Months	
Burning one's self on tube	1	2	2	Tolerable	Keep public at a safe distance; demonstrator should wear protective gloves and ensure that tube has had proper time to cool once extinguished	Within 3 Months	

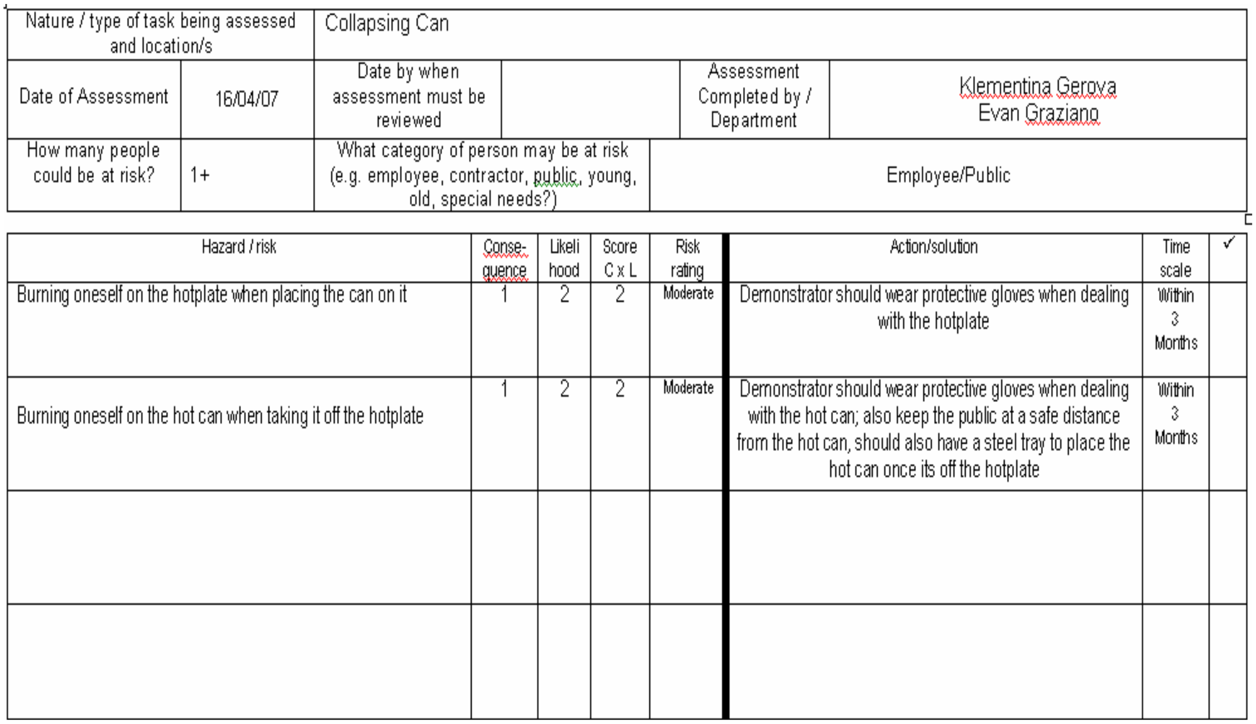
Appendix B20: Trebuchet Risk Analysis



Nature / type of task being assessed and location/s	Trebuchet				
Date of Assessment	02/04/07	Date by when assessment must be reviewed		Assessment Completed by / Department	Klementina Gerova Evan Graziano
How many people could be at risk?	1+	What category of person may be at risk (e.g. employee, contractor, public, young, old, special needs?)	Employee/Public		

Hazard / risk	Conse-quence	Likeli hood	Score C x L	Risk rating	Action/solution	Time scale	✓
Being struck by the Trebuchet's projectile	1	1	1	trivial	Use soft projectiles and ensure that no one in in the line of fire		
Being struck by the lever arm as it is beginning to launch its projectile	1	2	2	Tolerable	Maintain a safe distance between Trebuchet and onlookers. If operating, ensure that you stand safely to one side	Within 3 Months	
Being struck by the sling as it is beginning to launch its projectile	1	2	2	Tolerable	Maintain a safe distance between Trebuchet and onlookers. If operating, ensure that you stand safely to one side	Within 3 Months	

Appendix B21: Collapsing Can Risk Analysis



Nature / type of task being assessed and location/s	Collapsing Can				
Date of Assessment	16/04/07	Date by when assessment must be reviewed		Assessment Completed by / Department	Klementina Gerova Evan Graziano
How many people could be at risk?	1+	What category of person may be at risk (e.g. employee, contractor, public, young, old, special needs?)	Employee/Public		

Hazard / risk	Conse-quence	Likeli hood	Score C x L	Risk rating	Action/solution	Time scale	✓
Burning oneself on the hotplate when placing the can on it	1	2	2	Moderate	Demonstrator should wear protective gloves when dealing with the hotplate	Within 3 Months	
Burning oneself on the hot can when taking it off the hotplate	1	2	2	Moderate	Demonstrator should wear protective gloves when dealing with the hot can; also keep the public at a safe distance from the hot can, should also have a steel tray to place the hot can once its off the hotplate	Within 3 Months	

Appendix B22: Air Cannon Risk Analysis

Nature / type of task being assessed and location/s	Air cannon				
Date of Assessment	16/04/07	Date by when assessment must be reviewed		Assessment Completed by / Department	Klementina Gerova Evan Graziano
How many people could be at risk?	none	What category of person may be at risk (e.g. employee, contractor, public, young, old, special needs?)	none		

Hazard / risk	Conse-quence	Likeli hood	Score C x L	Risk rating	Action/solution	Time scale	✓
none							

Appendix B23: Burning Money Risk Analysis

Nature / type of task being assessed and location/s	Burning Money				
Date of Assessment	13/04/07	Date by when assessment must be reviewed		Assessment Completed by / Department	Evan Graziano/Klementina Gerova
How many people could be at risk?	1+	What category of person may be at risk (e.g. employee, contractor, public, young, old, special needs?)	Public,Employee		

Hazard / risk	Conse-quence	Likeli hood	Score C x L	Risk rating	Action/solution	Time scale	✓
When lighting the note on fire, there is a live flame, which may burn the performer.	1	2	2	Tolerable	The performer should wear protective gloves while lighting the fire	Within 3 Months	
When the note is lit, it is possible for the observers to burn themselves on the flame	1	2	2	Tolerable	The performer should ensure that the observers maintain a safe distance from the demonstration	Within 3 Months	
Lit note being dropped on performers	1	2	2	Tolerable	The performer should use a pair if tongs when performing the demonstration to ensure safe distance between himself/herself and the burning note; as well as have a fire extinguisher nearby in case it might be needed	Within 3 Months	
Lit note being dropped on floor	1	2	2	Tolerable	The performer should do the demonstration over a metal tray; as well as have a fire extinguisher nearby in case it might be needed	Within 3 Months	
Lit note setting on fire other substances/materials within certain parameter	1	2	2	Tolerable	The performer should clear the demonstration space of flammable substances/,materials and have a fire extinguisher nearby in case it might be needed	Within 3 Months	
Lit note doesn't extinguish by itself	1	2	2	Tolerable	The performer should have a bucket of water on standby	Within 3 Months	

Appendix B24: Air Cannon Presentation

AIR CANNON

PRINCIPLES

- CHANGES IN AIR PRESSURE
  - When firing the Air Cannon, the amount of air particles begins to multiply. The particles also begin to travel more quickly, resulting in an increased number of collisions amongst them. This leads to a greater pressure in the air.
- ATMOSPHERIC VORTEXES
  - When you fire the Air Cannon, a high-pressure shockwave leaves the bucket first, quickly followed by an air ball. This shockwave creates a vortex of swirling air, which keeps the air ball intact and in place.

MATERIALS

WASTE BUCKET

SHOWER CAP

DUCT TAPE

KNIFE

WHAT'S THAT SMELL?

TARGET PRACTICE

Appendix B25: Sample "Quick and Dirty" Staff Feedback Form

Staff Activity Assessment

1. **On a scale of 1-10, (1 being the lowest and 10 being the highest) how interesting/exciting do you find this demonstration?**

   1 2 3 4 5 6 7 8 9 10

2. **On a scale of 1-10, (1 being the lowest and 10 being the highest) how interesting/exciting do you think that a child aged 8-14 will find this demonstration?**

   1 2 3 4 5 6 7 8 9 10

3. **In what ways do you feel that the demonstration may be improved upon to make it more interesting/exciting?**

4. **Where do you feel that this demonstration would best fit into a teacher's curriculum (what scientific principles does it best demonstrate/where would it best fit in to outreach/launch pad)?**

5. **Do you feel that the demonstration should be accompanied by any other deliverables (i.e. lesson plan, worksheets, etc)? If so, please specify.**

6. **Should the demonstration be modified in any way so that it is more beneficial to the students? Explain.**

7. **Do you feel that the demonstration's set-up will take too much time or be too complicated for the teacher? Explain.**

Appendix B26: Completed "Quick and Dirty" Staff Feedback Form

Burning Bill Assessment

1. **On a scale of 1-10, (1 being the lowest and 10 being the highest) how interesting/exciting do you find this demonstration?**

   1 2 3 4 5 6 [✓ 7] [✓ 8] 9 10

2. **On a scale of 1-10, (1 being the lowest and 10 being the highest) how interesting/exciting do you think that a child aged 8-14 will find this demonstration?**

   1 2 3 4 5 6 7 8 [✓ 9] 10

3. **In what ways do you feel that the demonstration may be improved upon to make it more interesting/exciting?**

   build it up with kids – get them excited about it before you do it

4. **Where do you feel that this demonstration would best fit into a teacher's curriculum (what scientific principles does it best demonstrate/where would it best fit in to outreach/launchpad)?**

   ? Not sure!

5. **Do you feel that the demonstration should be accompanied by any other deliverables (i.e. lesson plan, worksheets, etc)? If so, please specify.**

   yes – need to have a structure for it to fit into – so the trick has a point to it and teacher can develop ideas.

6. **Should the demonstration be modified in any way so that it is more beneficial to the students? Explain.**

   Needs to be in a structure – so it lasts longer + clear learning takes place

7. **Do you feel that the demonstration's set-up will take too much time or be too complicated for the teacher? Explain.**

   No