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Museum Education Materials: The design and implementation of demonstrations and activities for Science Museum and classroom use

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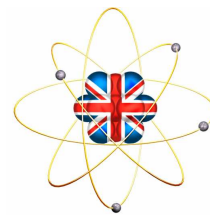
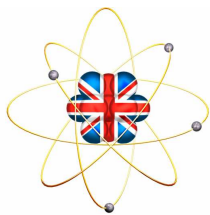
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Museum Education Materials

The design and implementation of demonstrations and activities for Science Museum and classroom use

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

Project Number: GFS-0721

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April 26, 2007

Abstract

Bringing the essence of the Launch Pad Gallery in the London Science Museum into British classrooms is an ongoing challenge. This has been partially overcome by the design, development and testing of various fun and interactive scientific demonstrations and classroom activities. These activities have been specified in plans for the construction and operation of demonstrations, as well as in plans for future development. In addition to teaching children about scientific concepts, this project will inspire and excite students about science.

Executive Summary

While many museums consist only of collections of unusual or interesting items, the London Science Museum has long sought to develop the most engaging and entertaining methods for educating the public about science and technology. This has been achieved throughout the museum, but particularly in the Launch Pad Gallery, a gallery designed specifically for children between the ages of eight and fourteen. In an effort to reach out to the community, and to educate beyond the confines of the museum, an extensive outreach program has been developed. This includes classroom visits and internet resources. The classroom visits, available for schools all over the United Kingdom, have been developed by museum staff and are an excellent, but expensive, option. The website, while easily accessible, is lacking hands-on demonstrations and activities. While the resources that the Science Museum offers to those who are unable to visit the museum itself are extensive, they can be improved.

This project assisted the Science Museum in further developing the outreach program and educating the community. The primary objective was the development of a number of new and interesting ideas and the creation of demonstrations and activities to convey a scientific concept in an engaging way. This was accomplished by brainstorming, prototyping and testing a variety of demonstrations, as well as developing, testing and refining a series of activities with the team, the museum staff, and the public.

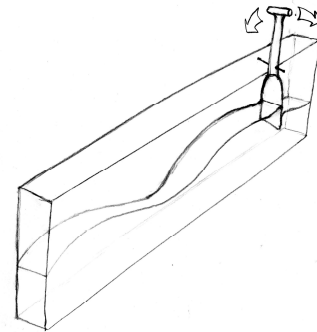
The ideas for the demonstrations were dubbed “Quick and Dirty” (QAD) for their rapid development and crude prototyping before the testing stage. The final result was 26 QAD ideas for potential demonstrations, 14 of which had been built and tested. Those that were developed beyond the concept stage were chosen for their potential to excite and entertain children about the scientific concept presented. If a demonstration seemed appropriately engaging, it was then examined further for other factors, such as feasibility, safety, and cost-effectiveness. If it met all of the appropriate criteria, a prototype was constructed and tested. This testing phase was used to determine if the demonstration was appropriate for classrooms.

The activities were designed to stimulate inquiry-based learning using a style of teaching that allows students to learn through discovery. The student is encouraged to ask questions and determine the answer using experimentation. These Inquiry-Based Learning Activities (IBLAs) each begin with a challenge that the student must overcome, with little to no input from the teacher, by investigating a scientific principle. In addition to supplementing the curriculum and helping the student explore a scientific concept, these are



intended to encourage creativity. They must then demonstrate the solution to the instructor and their peers, providing evidence for that solution. The development of these activities began with the selection of a scientific principle that the student should better understand. With an objective in mind, materials were gathered for the activity, and it was tested within the team, with staff, and with the public. After each test phase, improvements were made to the activity based on the observations made by the team and suggestions made by museum staff.

To supplement the large number of ideas that were created and tested during the seven weeks onsite, recommendation sheets were written for each of the QADs and IBLAs. These recommendation sheets include materials lists, instructions, ideas for improvement or scaling up, general recommendations, and assessments. They also include pictures of the demonstration, or sketches when pictures are not available. For demonstrations that were extensively tested, tips are offered that indicate what was effective and what might be done to address any problems that were encountered. For the IBLAs, lesson plans, tips for instructors, and worksheets are also included.



Each activity and demonstration was also analyzed and scored on a set of criteria based on a predefined rubric. These assessments allow anyone interested in the demonstrations to look through the extensive materials provided and quickly determine whether a demonstration is appropriate for the intended purpose. More importantly, information relating each demonstration and IBLA to the appropriate stage and unit in the national curriculum is provided. This provides teachers with information regarding how each demonstration might fit into their classroom and lesson plans. The work done at the London Science Museum has further developed the idea of education through fun and excitement. It assists the museum in sparking curiosity and enthusiasm regarding scientific discovery and creating unforgettable memories for children throughout the United Kingdom, specifically those that may not have access to the facilities at the museum. The demonstrations and activities created and tested will undoubtedly have an immensely positive impact on all that have the opportunity to experience them.

Authorship Page

Each member of the team contributed equally to the completion of both the project and this report. All team members provided input in the areas of writing, editing, idea creation, research, and design. Depending on skill, one or more members worked on one these areas more extensively than others. A brief synopsis of each member's specific contribution is shown below.

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Acknowledgements

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1.0 Introduction

The London Science Museum is one of the most well-known museums in the world. It offers over 300,000 objects in its prestigious collection, spanning the entire history of western science, technology and medicine. An essential part of the London Science Museum is the Launch Pad Gallery, a children's exhibit that offers an opportunity for children to experience scientific concepts. This is the most popular part of the museum, attracting over one million visitors per year. Not only can children learn about science, but they can also be entertained by the interactive nature of the exhibits. This is often accomplished through outreach programs that focus on school groups. Not everyone in the United Kingdom is able to experience the Launch Pad, however, because some British schools can be as far as 350-400 miles away. There are some alternatives to visiting the gallery, but first-hand interaction with the gallery is difficult for many schools to achieve.

One of these alternatives is to present the concepts taught in these exhibits via virtual demonstrations on the internet. The London Science Museum has a website where children can learn online, using a variety of interactive games and activities. Learning how something works by holding, touching, and playing with it, however, is much more enjoyable, exciting, and therefore educational than seeing it virtually. The museum also offers an outreach program to classrooms all over the United Kingdom that brings the Launch Pad experience to children, as another alternative. Trained staff members travel throughout the UK to provide entertaining demonstrations of scientific concepts. It is an appealing solution, but it is an expensive one. To bring the experience to a classroom in Wales or Scotland, it costs between £700 and £800 per demonstration show. To further complicate the outreach program, it is also difficult to schedule. The London Science Museum recommends that schools that are further away should coordinate their visits so the staff does not have to travel back and forth. This forces other schools to introduce certain concepts before the show, limiting the flexibility in school lesson plans. These alternatives are neither ideal nor practical for experiencing the Launch Pad. Because of the unique and effective approach that the museum takes on education, experiencing the gallery should be available in a way that is interactive, cost-effective, and practical.

The newest approach to solving this problem is a developing outreach program which does not require trained staff members to travel. Instead of hiring people to perform a demonstration or using online exhibits with fewer interactive components, the London Science Museum is currently developing a kit that may be sent to educators throughout the United Kingdom. This kit contains demonstration materials corresponding to a variety of exhibits, as well as instructions explaining how these demonstrations should be executed. A kit is an easier, more cost effective means for spreading the Launch Pad's approach to scientific understanding across the United Kingdom. These kits provide scientific knowledge in a very interactive way and they are inexpensive to manufacture and ship. They also allow increased flexibility in scheduling as schools are no longer required to coordinate with other schools for a visit and may use the materials and lesson plans at their convenience.

A group of students have already completed an Interdisciplinary Qualifying Project (IQP) at the London Science Museum, developing demonstrations based upon

some of the exhibits in the current Launch Pad Gallery. The Launch Pad is in the process of redevelopment, however, so while the demonstrations developed by the previous group of students have merit, they will be irrelevant to the Launch Pad in a matter of months. As a result, the Science Museum was in need of new demonstrations with respect to the new Launch Pad Gallery to further develop the outreach program.

The main goal of this project was to design a variety of demonstrations, create and assess demonstration kits, and further develop and assess outreach activities. Each demonstration needed to be interactive, educational, cost-effective, easy to assemble and use, and fun. Recommendations were also included for the museum to expand on each idea. Then, a variety of outreach activities known as Inquiry Based Learning Activities (IBLA) were assessed and developed, complete with lesson plans and teaching materials. These IBLAs consisted of small projects that encourage children to ask questions and discover the answer through experimentation. Prior to building the demonstration kits and assessing the outreach activities, an understanding of both demonstrations and the basis for outreach programs was vital. It was also important to determine whether each demonstration was appropriate to be used in the classroom, in that it was easy to set up and safe to use, or to be used by a professional in an outreach demonstration, having a bigger “wow” effect and less stringent safety requirements. Research was therefore completed in advance to expedite the development process with regard to these demonstrations as well as the development and assessment of the outreach activities. This research included educational psychology, conducting interviews/surveys, and holding a child’s attention and allowed for a faster, more efficient development of inexpensive and interactive kits and IBLAs that will teach scientific concepts, not only in the UK, but potentially worldwide.

2.0 Background

The opportunity to enjoy the unforgettable experience of the Launch Pad Gallery is something that every child in the United Kingdom should have. The gallery, as an integral part of the London Science Museum, aims to inspire and educate children in a way that a classroom environment cannot. It is impractical to expect that school groups would travel hundreds of miles to the Science Museum or coordinate and fund a visit from a member of the museum staff because for many schools, this would be beyond their means. By developing demonstrations that may be integrated into classrooms nationwide, the Science Museum has the opportunity to reach a wider range of students than was originally possible. Taking into consideration the history of the Science Museum, specifically with regard to their interactive galleries, demonstrations may be optimized to best fit the mission of the Museum, as well as the goals of the British educators and the National Curriculum. A better understanding of the principles of education and the integration of demonstrations into the classroom will also further this end. In addition, it is important to develop methods by which these demonstrations will be assessed, so that they may be improved upon to make them more interesting, more effective, or more appropriate for a specific age group, for example. These ideas have been researched in depth to allow for the development of the best possible set of demonstrations, and the findings of this team will be discussed in the following chapter.

2.1 Museum

2.1.1 History of the London Science Museum

Founded primarily by Prince Albert in 1857, the London Science Museum, like many others, is the result of profits from the Great Exhibition in 1851 at South Kensington, London. The Great Exhibition, or the Great Exhibition of the Works of Industry of All Nations, was a celebration of what was, at the time, the most modern of industrial design and technology. This event increased awareness of culture and industry and was economically very successful, drawing a profit of almost £200,000. With the extra revenue the Great Exhibition brought in, Prince Albert was able to develop not only the Science Museum, but the three other British museums that make up the National Museum of Science & Industry, including the National Railway Museum, the Locomotion Museum, and the National Media Museum (NMSI) (McDonald, 2002).

Today, the museum has developed beyond an exhibition of the history of science and technology and has become a place in which people of all ages and from all backgrounds are encouraged to come and explore science in terms of its history, its future, and the way that it impacts the lives of people everywhere. The galleries range from traditional to contemporary, some even introducing an interactive component, but all are designed “to promote the public's understanding of the history and contemporary practice of science, medicine, technology and industry”, as expressed in the mission statement of the museum.

2.1.2 The Implementation of Interactive Galleries

In general, children tend to seek out material based on its entertainment value, rather than on its educational promise. In order to make learning more appealing to children, the Science Museum developed a Children's Gallery in 1931. At first, the Children's Gallery only contained a few models of scientific concepts and lacked the excitement factor children desired. Over the years, the gallery developed new styles in order to convey more 'context' by making it more interactive. One method used to accomplish this was the use of dioramas (MacDonald, 2002).

"It's so refreshing to see something where people can interact with the exhibits, take part and actually touch things" (Science Museum visitors, 1990). This is just one example of the feedback that visitors provide to the museum. The Science Museum has always sought to not only teach their visitors about the educational and practical value of science, but do so in the most enjoyable way possible. Many years ago, in an effort to enhance the learning experience and make displays more enjoyable, the Science Museum hired a team of specialists, the Gallery Planning Group (GPG), to help redesign their exhibits. The GPG eventually developed a list of 11 objectives that would help raise awareness of the Science Museum. They proposed that "the museum cannot (and should not) attempt to be encyclopedic, but should aim to be synoptic and cover all aspects of science, technology, industry and medicine... or Major themes should be arranged logically in the building to enable visitors to select an area of interest from informative points to follow it through." (McDonald, 2002) This list eventually led to a more interactive and entertaining museum that was easier to learn from. The galleries have since been updated whenever necessary to contain consistently entertaining and educational activities. The Launch Pad Gallery, which opened in 1986, was designed around the idea of an interactive gallery that would provide entertainment as well as enhancing scientific understanding. These new styles of presentations and demonstrations ultimately lead to the opening of the Launch Pad—an area containing only "hands on" interactive exhibits. This special gallery contains no models from any collection.

2.2 Education

2.2.1 Educational Psychology Theory

Much research has been conducted in the field of educational psychology in an attempt to answer the question: "how does one learn?" This relatively new field, beginning with the work of Edward L. Thorndike in the early 1900's quickly evolved into a distinct and intricate discipline within the broad scope of psychology with the additional work of prominent figures such as John Dewey, Jean Piaget, and Granville Hall.

Leading child educational theories revolve around the work of Jean Piaget. His work is the basis for interactive instruction in schools, museums, and any center where modern learning takes place. Simply stated, for a child to effectively learn, he needs to interact with his environment (Caulton, 1998). The developing child is actively thinking and working out for himself how the world and his environment operate. Rather than being told the outcome of an experiment or demonstration, they should be expected to predict and observe it for themselves. It is therefore the role of the teacher to create an environment where each child can experiment and explore, rather than simply imparting knowledge as undisputed truth.

The conventional teaching method based on repetition and rehearsal, termed the law of exercise, has been the primary approach in school systems for most of their existence. Charles Skinner indicates that this process is not “a potent factor in learning” (Skinner 1945). While the pupil will be able to recall the studied material, Skinner argues that the pupil does not truly learn it. The thought process is disorderly and based upon trial and error on behalf of the pupil. A student needs to be an active participant in the conclusion to a problem to fully realize and comprehend the material presented. Remembering a concept and being able to apply it are two very different things. Repetitive drill does not often amount to the pupil being able to apply their newfound knowledge in ways and situations other than that in which it was originally presented. It supersedes the most important part of the educational process: the child coming to the conclusion himself.

In addition to direct involvement in their learning, the student’s curriculum must constantly be building on previously taught material. It is essential that the child not only uncover for themselves the workings of a system or problem, but when presented with new problems later in an educational program, they need to build on the principles and ideas learned in previous work (Lind, 1997).

The latest research in the field of educational psychology includes the work of many individuals who have presented many theories. There is, however, a common theme with regard to child development in the sciences. The role of the educator is not to lecture the pupil with the expectation that anything other than memorization is taking place. Rather it is the purpose of the instructor to question, encourage curiosity, and design and support an environment where the student is expected to discover concepts for themselves. Only then, is the student truly becoming educated.

2.2.2 Creating Interest

There is little dispute in the field of educational psychology with regard to the value of a child’s immediate interest in the subject at hand. “If any learning is to occur from the teaching, the teacher must sustain cooperation of the student in an activity. To ignore this is to ignore the essence of teaching” (Doyle, 1979).

Unless the material appeals to the student’s natural curiosity, it will not be found interesting. Inciting this emotion is not a simple task: the level of curiosity a student feels is directly proportional to the novelty of the subject material. Many science courses are based on traditional lecturing methods, however, and fail to create this atmosphere.

It is the job of the educator to spark inquiry into the subject matter. “The driving force behind problem solving is curiosity, an interest in finding out” (Lind, 1997). A lesson plan designed as a step by step experiment which the student must follow is an example of a hands-on interactive approach. It does, however, fail in promoting curiosity in the child. A more effective strategy involves presenting the pupil with the necessary equipment and asking them to answer a question or solve a problem that will involve thinking, experimenting, and trial and error. The role of the teacher should be to merely guide the students in their activity, asking questions designed to further challenge the student in achieving the original goal.

In a study conducted by John A. Zahorik, data from 65 elementary and secondary school teachers was collected and analyzed in the form of four separate essays dealing

with creating interest in their students. Not surprisingly, the overwhelming majority of the teachers relied primarily on hands-on learning to establish and maintain a child's interest. Another method teachers frequently used was to personalize the presented material (Zahorik, 1996). By relating the information to something the student is familiar with, the teachers were often successful in sparking interest in the subject matter. Classroom demonstrations should then inherently have the novelty factor. They should be designed in such a way to relate a foreign concept to something the pupil is already familiar with. Several other techniques were used in the study, some of which may be valuable when developing classroom demonstrations. These are included in Table 1.

TABLE 1. Actions Teachers Take to Generate Student Interest

| Actions | Teachers Reporting | |
|-----------------------|--------------------|------------|
| | Number | Percentage |
| Hands-on activities | 65 | 100 |
| Personalized content | 42 | 65 |
| Student trust | 42 | 65 |
| Group tasks | 36 | 55 |
| Variety of materials | 19 | 29 |
| Teacher enthusiasm | 18 | 28 |
| Practical tasks | 11 | 17 |
| Variety of activities | 7 | 11 |

Table 1 Zahorik, John A; Elementary and Secondary Teachers' Reports of How They Make Learning Interesting; Vol. 96, No. 9; pg. 556

As important as creating interest is, avoiding disinterest is just as essential. A predominant finding in Zahorik's study was the avoidance of teaching unsuitable material in trying to maintain student interest. Material that was too difficult, easy, redundant, or extensive caused the students to lose interest (Zahorik, 1996). It is of utmost importance that interactive demonstrations do not take on any of these deterring qualities.

It should be noted that there is a danger in creating hands-on demonstrations that are intended to be fun or entertaining. Many figures in the field such as Duckworth, Easley, Hawkins, Hendriques, Flick, Roth and others maintain that lesson plans that rely predominantly on the child having fun result in the child having learned nothing after it has been completed (Zahorik, 1996). The difficulty in designing demonstrations is striking this delicate balance between entertainment and education.

2.3 National Curriculum

In addition to understanding the psychology of a child for the purposes of this project, it is imperative to know and abide by the national curriculum. Schools in the United Kingdom must follow a very strict and laid out curriculum standardized for the entire nation. If a private organization, such as the London Science Museum is to present any educational material in British schools, they must adhere to it.

According to the National Curriculum website (<http://www.nc.uk.net>, Jan 2007), the goal of the National Curriculum in the United Kingdom is to set a standard for the subjects to be taught in schools, and the "knowledge, skills and understanding required in each subject". It also helps to standardize assessments and designate goals that children

should be achieving at particular ages or by a specific stage in their education. It provides flexibility for the creativity and ideas of educators, although many make use of resources from the Qualifications and Curriculum Authority (QCA), a public body interested in developing and regulating applications of the National Curriculum. At the same time, the National Curriculum ensures that students that receive a public education in the United Kingdom will understand concepts necessary to go on to a higher education if desired, and to be fully prepared for life as a British citizen.

The British National Curriculum for children from ages eight to fourteen is broken down into two stages: Key Stage 2 (KS2) and Key Stage 3 (KS3). Students are required to take national exams between each Key Stage. This indicates that the students, who have entered KS2 and KS3, are expected to have certain knowledge that has been obtained in Key Stage 1 (KS1) between the ages of five and seven. The exam required to move on from KS1 only covers material regarding math and English. KS2 and KS3, however, begin the British student's scientific education. The examinations that conclude KS2 in a child's education, at age eleven, include only basic English, science and math, while those indicating the completion of KS3 at age fourteen include math, including mental mathematics, science, design and technology and information and communication technology. These national examinations are accompanied by an assessment by an instructor, but as these assessments will vary over the wide range of British schools and instructors. The national standard is an essential tool that is used to focus efforts toward a uniform interactive solution for demonstrating scientific concepts to a large number of students.

The National Curriculum is represented by a series of eight levels, and after each key stage, it is expected that a student will have advanced to a corresponding level. For example, after KS2, at age eleven, a student should achieve level four, and at age fourteen, upon completion of KS3, a student is expected to be at level five. The education section of the United Kingdom government website explains the different levels succinctly. KS2 and KS3 require that students learn about scientific inquiry, life processes and living things, materials and their properties, and physical processes, with regard to science. Broken down into subcategories, scientific inquiry includes understanding "ideas and evidence in science and investigative skills", according to the QCA website, found at <http://www.qca.org.uk/>. The section representing life processes and living things includes "cells and cell functions, humans as organisms, green plants as organisms, variation, classification and inheritance and living things in their environment". "Materials and their properties" includes knowledge about "classifying materials, changing materials, and patterns of behavior". The time spent on physical processes, perhaps the subcategory most relevant to this proposal, is dedicated to "electricity and magnetism, forces and motion, light and sound, the Earth and beyond, and energy resources and energy transfer".

These subcategories have been the focus of the demonstrations developed as discussed in the following chapters. All materials developed should assist students in reaching the objectives laid out in the National Curriculum, and enhance their understanding of the aforementioned subjects. It is important to remember, however, that these interactive activities should link these subjects to the Launch Pad gallery in the London Science Museum and that they must maintain their entertainment value while

remaining useful to instructors and educators across the nation as they teach in accordance with the National Curriculum.

2.4 *Inquiry-Based Learning Activities (IBLAs)*

One method that may be used in the classroom to encourage students to learn through experience and interaction is the Inquiry-Based Learning Activity (IBLA), a classroom technique that is being expounded by the Science Museum, although similar approaches have been used across the world. The goal of these activities is to teach children scientific concepts in a fun and exciting way. A list of inquiry-based learning activities can be seen in Appendix D.

The initial idea behind these activities may be explained in three steps. First, the teacher or educator will designate a challenge or a goal for the students to achieve, either individually or in small groups. This will build anticipation and inspire curiosity in the children. The children will then investigate different ways to implement a solution to the problem. This will include brainstorming and taking notes or drawing ideas. Each student or group of students will then build their favorite design and present it to the rest of the class. Finally, the students will connect and reflect on each idea and try to relate them to things they have seen, heard, or studied. In doing this, the children will gain a better understanding of scientific phenomena and relate it to their lives in an entertaining and creative way.

These activities, when coupled with a complete lesson plan, are enormously efficient in not only teaching scientific concepts, but in bringing out and fostering the students creative side; a result favorable for obvious reasons.

2.5 *Integrating Demonstrations into the Classroom*

Demonstrations are an essential part of learning in a classroom environment. Having students see physical objects move and obey the laws of nature, keeps the students interested in scientific concepts being conveyed. Not all students can easily learn from a verbal explanation and most children have trouble sitting and listening to lectures for long periods of time. This is where demonstrations can come in to aid teaching plans and illustrate concepts that an instructor is trying to explain. This section goes into detail about how familiarity has been used to illustrate science and how interaction has also been used successfully.

2.5.1 *Toys and Familiarity*

The use of toys in education is sometimes faux pas to the education community, but when an educator uses the right approach, “fun” props can have a very positive impact on the learning process. As previously discussed, overuse of fun can distract from educational objectives, but toys have the unique ability to maintain the interest of everyone, especially young children. One successful example of the implementation of toys in demonstrations took place at the Houston Museum of Natural Science where Rob Schuller, a 12 year old boy, was able to teach physics to visitors using toys. The toys enabled Rob to show visitors a wide variety of scientific concepts in a very concrete way, while entertaining them. Since most children are very comfortable with toys, and have

played with them enough to understand how the toys react to various stimuli, it is reasonable to say that they have a thorough familiarity with those toys. What Rob accomplished was to take the familiarity of the toys and the experience children have with toys, and use those ideas to form a link between the experiences and the science concepts. Fundamentally, toys have mass, are affected by gravity and momentum, and obey the laws of physics. Because of this, their entertainment value may be exploited to explain science to children. (Summers, 1984)

2.5.2 The Importance of Interaction in the Classroom

One important thing that traditional instruction methods overlook, is the difference in learning styles among members of an audience, or in this instance, students in a classroom. Most people fall into the category of visual, audio, or kinesthetic learners. When learning something, the visual learners need to see it, the auditory learners need to hear it, and the kinesthetic learners need to feel it. If an instruction or lecture is not sympathetic to all of these then someone may fail to understand the concept being introduced. Interactive demonstrations can effectively tender to each learning style while insuring all necessary material is covered. An interactive demonstration can best be described by a demonstration that incorporates the audience using not only audio and visual methods, but by allowing them to touch and experience the demonstration themselves.

A perfect example of functional and effective interactive classroom demonstration is Keil Hileman and his classes at Monticello Trails Middle School in Shawnee Kansas. Mr. Hileman teaches his sixth, seventh, and eighth grade classes almost exclusively with museum artifacts he has collected and artifacts that have been donated to the school. In the collection there is everything from a 1796 flintlock musket to Japanese lanterns. And unlike traditional museums, all the items in this class are meant to be touched. This interactive style has sparked the interest of his students and they absolutely love his classes. As Pierpont mentions, "...his hands on approach to teaching has students itching to get into his classroom." Hileman's students are excited and actively engaged in classroom activities merely because they get to interact with the artifacts spread around them. Is this method of teaching appropriate for the students? Are they learning? In one of Hileman's lessons he asks for volunteers to come up and hold a very heavy ball for one minute. The ball is special because it came from the ball and chain once used on slaves. When the students finish their one minute the look of exhaustion on their faces shows they have a better understanding of how awful slavery was. Every one of the artifacts in this museum classroom is able to have the same effect on the children as the ball and chain, and the learning that is possible is nearly infinite. (Peirpont, viewed 2007)

2.5.3 San Francisco Exploratorium

"Snacks at the San Francisco Exploratorium" is a web site that contains links to instructions and resources that allow teachers (or anyone for that matter) to build demonstrations of different science principles. This is a very useful resource that may be considered a model for the demonstrations in this project. The success of the Exploratorium's snacks is apparent, as their published book of demonstrations has reached people and organizations throughout see the United States and across the globe. The web address to the Snacks page is <http://www.exploratorium.edu/snacks/index.html>.

2.6 Assessment

Learning to assess a demonstration or a classroom activity was another essential component of the preparation for this project. When developing anything at all, the work must be evaluated appropriately to continue to change and improve it. In this instance, the most notable aspects to assess were how much students enjoyed an activity and how educational it was. Enjoyment should be examined in terms of student engagement; if a child is enjoying something they will likely be visibly engaged. Education must be assessed in terms of knowledge retained, both in the short term and the long term. For such a qualitative evaluation, where numbers can not simply be recorded from instruments, key techniques include observation, surveys and interviews, all of which will be discussed in greater detail in this section.

2.6.1 Student Engagement

Another important thing to consider when conducting demonstrations is whether the students, or listeners, are really engaged. In Chapman's article, "Assessing Student Engagement Rates," she lists both the signs of engagement and signs of unaffected students, as seen in Table 2.

| Engaged | Disengaged |
|--|--|
| Students select tasks that challenge their abilities | Passiveness |
| Students take action when they are given the opportunity | Failure to make an effort |
| Students show intense effort and concentration during the learning process | Give up easily |
| They show positive emotions | Students can be |
| <ul style="list-style-type: none"> • Enthusiasm • Optimism • Curiosity • Interest | <ul style="list-style-type: none"> • Bored • Depressed • Anxious • Angry |
| Say things Like | Withdrawn |
| <ul style="list-style-type: none"> • “I went back over the things I didn’t understand” • “I tried to figure out how today’s work fit with what I had learned before” | Rebellious |

Table 2: Signs of Engagement and Disengagement

These signs should be considered during a lesson or demonstration to confirm that students are actually paying attention and developing an understanding of the material. If students are not engaged then the presentation method is ineffective.

Chapman goes on to discuss methods for conducting an assessment. She lists four main types of assessment: Student Self Reports, where students fill out questionnaires that indirectly assess engagement, Checklists and Rating Scales, in which a teacher or instructor makes assessments using a series number scales to rate the above signs, Direct Observations, where a teacher or instructor observes one student at a time while making

written observations regarding their level of engagement, and Focus Case Studies, where small groups are investigated, allowing detailed descriptive accounts to be collected.

The Student Self Reports are used to illustrate how students felt about their own engagement; this is, of course, handled in an indirect manner. By asking certain questions the assessor can determine a student's attention level and span, how much thought students put into an experience, and how hard they worked regardless of difficulties faced. A very important outcome of Student Reports is that they are more than capable of indicating "why" there may or may not have been a lack of engagement. Teachers may not notice this attitude during a lesson. A problem with Student Reports is students, especially the younger variety, may not have a well developed sense of self evaluation. Students account of their experience maybe incorrect, inconclusive, or vague.

Checklists and Rating Scales allow observers to quickly record levels of engagement among students. The ability to quickly quantify data may simplify data analysis, but checklists do have flaws. They do not tell in what instance a particular observation occurred. The recorded data will not distinguish between a student that is not interested because of complicated material or lack of engaging material. Checklists and Scales really only see the bigger picture or the presentation as a whole. Direct observations are used to record what a single student is doing during a lesson or demonstration. Here the instructor or observer takes a certain time period to watch a particular student to see if that student is engaged and what it is they are doing that suggests this. After a given time period the observer moves on to another student and repeats the process. This is beneficial because the observations are much more detailed than a number rating system, and the observer is able to record in context what happened. Conversely, the direct observations method is restricted by limited time periods for every student observed. Only one student is captured in one short moment in time, which leaves much to be desired in terms of completeness. Direct observations can, however, be used to confirm the data taken from Student Self Reports.

Focused Case Studies can also be used to assess student engagement. Here, the observer takes note of student behaviors, signs of engagement, and the environment in which they occur. This is especially good for small groups, where large amounts of data would prove redundant and complicated to record. Observers should note the interaction between students participating and their peers, something other assessment methods intentionally do not consider. The only trouble with focus studies is their inability to effectively account for every student and their level of engagement. While the number of students is small, the observer (probably a single person or teacher) will struggle to note every student's reaction to the material.

2.6.2 Assessing Children's Knowledge Retention

Demonstrations may be very visually appealing but does the demonstration itself teach a child a scientific concept? In order to fully understand how much children learn from demonstrations, they must take some sort of assessment. However, the traditional paper and pencil tests should not be the only mean of seeing how a child learns. It has been demonstrated by McNair, Thomson, and Williams that "these kinds of tests rarely assess children's development of mathematical and scientific concepts validly". To really discover how much a student knows about a concept, other methods of analyzing should

be taken into effect, such as anecdotal notes, drawings, surveys, paintings, and field notes (McNair, Thomson, Margaret, 1998).

Anecdotal notes are recorded observations of what a child says and does before, during, and after a demonstration. These kinds of notes can reveal significant amounts of information on how a child can develop scientific concepts. It is important to keep in mind that these notes must be taken immediately or shortly after the child's actions. Recording exactly what the child does will reduce the amount of bias or summations.

Drawings are a creative way of analyzing how a child develops concepts. In the study shown by McNair, Thomson, and Williams they had a group of students draw what they thought of a scientist looks like. Most of the children drew the scientists as a "geeky" kind of person including white lab coats, big glasses, and messy hair. However, after camp, the children had done all sorts of scientific experiments and were then told to draw another picture of what a scientist looks like. This time, the students did not draw the stereotypical "geeky" scientist but rather themselves doing one of their favorite science experiments.

Using just one assessment to judge whether or not a child has learned a concept is not valid. In order to fully grasp how a student can develop concepts, a combination of assessments, anecdotal notes, and drawings are essential.

2.6.3 Surveys

The purpose of this section is to gain a basic understanding of surveys so that they can be created to gather information from professionals, information that can be used to improve the demonstrations. A survey is described as being "a method of collecting information from people about their ideas, feelings, plans, beliefs, and social, educational, and financial background. (Fink, 1985)" While we do not desire anyone's social, educational, or financial background, we would like to know what professionals (teachers and museum staff) that use the demonstrations, have for ideas of improvement, or how they feel about the current designs. A well constructed survey can help gather useful data on how professionals (teachers, museum staff) feel about the demonstrations. By surveying each professional that implements the demonstration trends can be discovered and analyzed to make further revisions of the demonstration design more successful. The next parts of this section will look at some critical things to consider when using a survey to gather information, and specifically how those concerns apply to this project.

The reason for doing a survey could be because, a policy needs to be implemented, a program's effectiveness needs to be evaluated, or a researcher needs the data from a survey (Fink, 1985). For this project we are both evaluating the effectiveness of our demonstrations and are in effect researchers. Therefore we are within reason to use a survey to gather the information we seek, mainly feedback, on our demonstrations used in the field.

When creating a survey it would be unwise to devise a series of questions and then proceed to ask them to any and every person you come across, you have to be sure that your survey is going to yield useful data. For a survey to be both valid and reliable you need to be sure instructions are very clear, know who will be asked the questions, know when and how often the survey will be conducted, and know how the data will be processed, analyzed, and interpreted (Fink, 1985). Take care to follow these steps when

creating the survey, taking extra caution to complete each one correctly. This diligence will ensure you have a solid survey.

Also something to consider is what type of survey you will conduct. For example it could be a written questionnaire or it could be a face-to-face interview. Here we will focus on the questionnaire. With a questionnaire, it is possible to send it to any professional in any location; it can even go with the demonstration. Also, it is not unreasonable to believe that teaching professionals can provide clear and detailed answers to the open-ended questions that will be explained shortly. The assumption being made here is that the targets of the survey, teaching professionals, have the educational background, skill, and desire to help with the improvement of education. If in the event that this assumption is proved incorrect, the survey can be re-examined and then modified to compensate for any problems.

The steps to take to create a survey are straight forward but the creators need to make sure that all of the steps are completed in order to have a successful survey. The process starts with deciding on the type of survey to be conducted, followed by creating the survey's content, writing the questions, and pilot testing the form. After the survey is created, decide who your target for the survey is (all people from a group or just a sample, etc.) and what is your timeline (when and how often). Lastly, issues of administering the survey should be addressed. For example, "Who should conduct the interview?" or "By when must the questionnaire be returned?" In conjunction, special attention should be given to the question development portion. This is the phase where much of the bias, which is to be avoided, can happen. (Fink, 1985)

Generally speaking a survey has two types of questions, open-ended and closed-ended. Open-ended questions allow for survey takers to provide their own, and potentially creative answers. This creates a problem when you have a large variety of answers over a series of surveys and are unable to compare them to each other. Also, there is a level of complexity with open-ended questions. What happens when if you have a survey taker that has limited writing ability, or is unable to spell the proper words? Or perhaps they fail to remember all aspects of the answers? You can see where their might be problems in collecting the amounts of data desired. Alternately, there are closed-ended questions. These questions are similar to open-ended questions in structure, except the survey taker is give a series of multiple choice answers for that particular question. The definite degree of answers for these questions allows those analyzing the surveys to come to conclusions quickly and efficiently.

In the spirit of time, our focus will lie on closed-ended questions. To help prevent potential problems with closed-ended questions here are a series of criteria to consider when creating questions.

1. Each question should be meaningful to respondents.
2. Standard English should be used.
3. Questions should be concrete.
4. Biased words and phrases must not be used.
5. The instructor should be aware of his own biases.
6. Questions should not be too personal.
7. Each question should represent just one thought (Fink, 1985)

As long as these steps are followed, the survey is capable of being valid and reliable, void of bias.

2.6.4 Conducting Qualitative Interviews

Interviews with student groups and professionals are also extremely useful when conducting educational research. A properly organized interview not only reveals particulars such as past events, their outcomes and immediate effects, it also reveals how the subject feels towards a specific event or result, and how they would like to proceed. This is very difficult to obtain from books and scientific journals. For this reason, it is important to learn how to properly conduct interviews and extract as much useable information as possible. It is also essential to focus on obtaining qualitative data from interviews, specifically information that may only be acquired through direct observation of an event. Kvale, the author of Interviews: An Introduction to Qualitative Research, defines a qualitative interview as having seven parts: thematizing, designing, interviewing, transcribing, analyzing, verifying and reporting.

Thematizing is the pre-interview stage in which the interviewer decides exactly what information they wish to obtain from the subject. Other factors are also discussed during this stage, such as whether or not the interview will supplement another form of data collection and in what way that data will affect what the interviewer is looking for during the interview itself. The interviewer also considers what information may be obtained exclusively from this particular source.

The design of an interview is crucial for its success. In the design stage the interviewer, in addition to constructing the primary questions that are established by the objectives of the interview, must construct the framework of the interview. This defines how the interview will proceed and involves creating follow up questions, as well as having transitions planned between them, to make for a smooth conversation. They must also be ready to deviate from the plan if the flow of the interview warrants it.

There are three main functions of the interviewer during the interview itself. They must establish a good rapport with the subject, make them feel at ease, and most importantly smoothly guide them from question to question. Flexibility, patience, and active listening are required characteristics of a good interviewer.

While interviewing, the information obtained must also be transcribed. This is the physical data the interviewer will have collected after the interview. It must contain the questions asked verbatim and their responses. A thorough transcription will also utilize audio or visual recording devices.

In the analysis phase the interviewer searches for themes, patterns, and repeating topics the subject brings up. In some cases it is determined that a follow-up interview is necessary to clarify a point or concept. It is important to make note of the subject's attitude toward a subject, as well as the information imparted.

After the analysis phase is completed, the interviewer must ensure the creditability and validity of the information collected and analyzed. A typical method of verification is conducting interviews with multiple people regarding a subject or event. In the instance of this project, verification required interviewing more than one student, teacher, or museum staff member.

The final step in the interview process is simply to report the findings. This report contains findings from interviews in the Results section, for the reference of the reader.

Qualitative interviews play a vital role in data collection; not everything can be learned by direct observation and examination. A vital aspect of the work done was a result of knowledge and evaluation by professionals. To obtain this information, it was necessary to fully understand and conduct qualitative interviews.

3.0 Methodology

This project focused on expanding and improving the current outreach program of the London Science Museum. The team produced a set of 26 different “Quick and Dirty” ideas based upon exhibits in the Launch Pad Gallery that were being developed. Twelve of these were further developed into prototypes of classroom demonstrations, complete with lesson plans, educational materials and specifications for production and educational use. This report contains precise design criteria, assessment tools for use with these demonstrations, and explanations of possible modifications educators or professionals may make to personalize or adapt the learning experience provided to their particular classroom setting. In addition to the research conducted prior to the development of these demonstrations, a water rocket demonstration was developed, tested with children, and evaluated in Worcester, MA. This has greatly impacted the work done at the London Science Museum, as the information gained was invaluable and prevented a variety of mistakes during the final development process. A full description of this process may be found in Appendix A.

In addition, the team also tested the functionality of proposed Inquiry Based Learning Activities (IBLAs), creating lesson plans for each, including objectives, a materials list, a strategy, a set of steering tips for educators, and conclusions to be drawn as a result of the activity. The team also discovered and developed new and different ways to approach each Inquiry Based Activity.

3.1 Objectives

There were three main objectives which were achieved over a period of seven weeks. The team first came up with approximately eight quick and dirty ideas for week one, week three, and week five. Half of these quick and dirty ideas were then developed into demonstrations either for the classroom or the museums outreach program. The team also tested and developed three inquiry based learning activities. For each of these objectives, the team compiled recommendation sheets for each idea, demonstration, and Inquiry Based Learning Activity for the sponsors’ reference.

Each demonstration developed from a quick and dirty idea must adhere to a certain set of criteria. All demonstrations must be fun, exciting, safe, and cost effective, and as such, all were designed to have a significant “wow” factor. Each demonstration was required to pass the rigorous tests of the Health and Safety Team at the London Science Museum. The risk assessment forms used are available in Appendix E. The demonstrations had to be cost-effective, as well. The materials used were required to be both inexpensive and readily available to make the demonstrations accessible to teachers and instructors across the United Kingdom. All of the materials used in the final demonstrations were readily available, and may be found either as a part of a school’s facilities or purchased at a local store.

Each IBLA must also follow a certain list of criteria. They must build anticipation, encourage self-learning, and fit into a one-hour time slot. Just like the demonstrations built, they also must be fun, safe, and cost-effective.

Figure 1 demonstrates the set of tasks that the team worked to complete the demonstration kits. The team researched potential ideas, designed, built, tested, analyzed, and refined each demonstration, leaving recommendations for the staff at the London

Science Museum to repeat the process. Afterwards, conclusions were drawn from each demonstration, with regard to its value and usefulness, as well as to potential improvements that might be made. Due to the time constraints of this particular project, repeating this cycle for each of the demonstrations was impossible, but the project was concluded with the understanding that the Science Museum staff will continue to develop the demonstrations and IBLAs for classroom use.

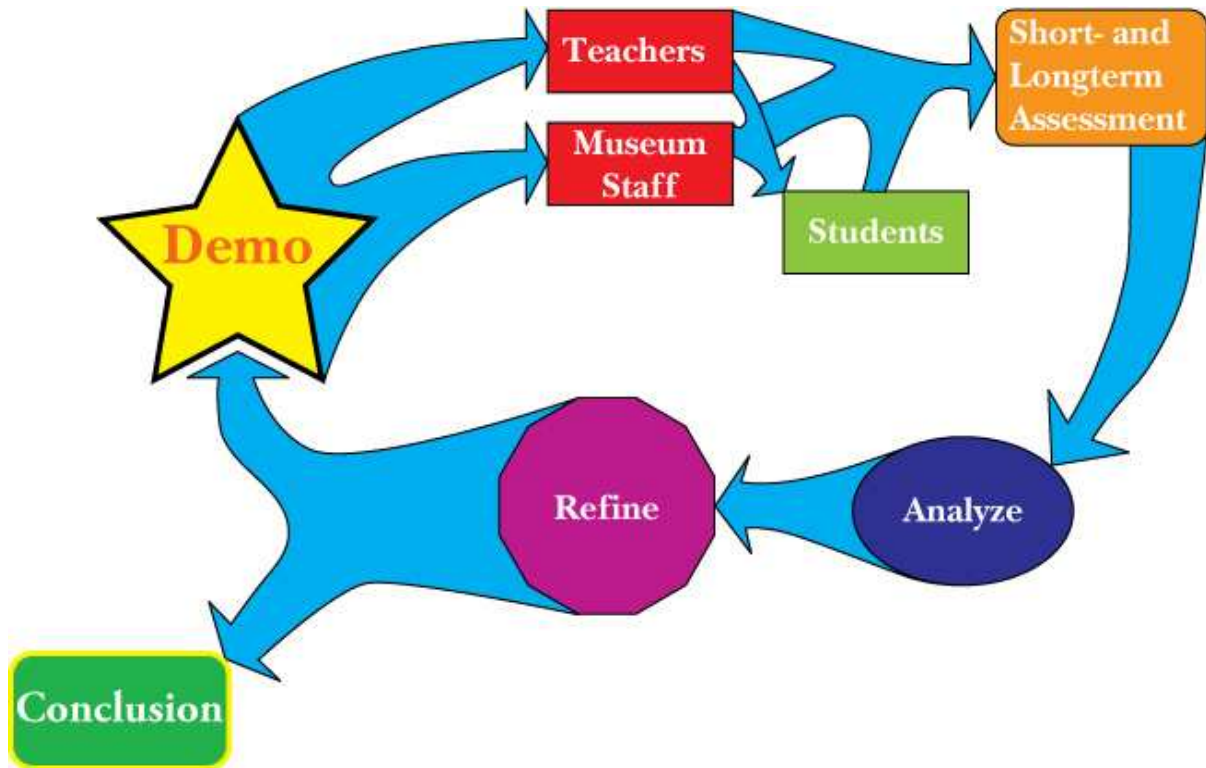


Figure 1: Demonstration Cycle

Figure 5 shows a timeline, indicating the blocks of time that were dedicated to each step in the development process. Weeks one, three, and five were spent conducting research and brainstorming ideas for each of the demonstrations. The team created eight “quick and dirty ideas”, developed these ideas and produced blueprints or plans for each demonstration. Once the demonstrations were completed, the team tested and analyzed them to see if further improvements could be made. The team also tested and developed the inquiry-based activities in the odd numbered weeks. In weeks two, four, and six it was important to focus on the construction of a set of prototypes. These were tested on museum staff, family groups in the museum, and in classrooms. After making as many refinements as time would allow, a final recommendation was documented and presented to the London Science Museum. By adhering to the timeline, these demonstration kits were made efficiently during the allotted seven weeks.

| | Week | | | | | | |
|--|------|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| Demonstration Ideas | | | | | | | |
| Develop Inquiry-based learning activity | | | | | | | |
| Build Demonstrations | | | | | | | |
| Test and Analyze | | | | | | | |
| Refine | | | | | | | |
| Complete Recommendations to LSM | | | | | | | |

Figure 2. Timeline of proposed methodology

3.2 *Creating Quick and Dirty Ideas*

As seen in the timeline shown in Figure 2, weeks one, three and five were used to formulate a list of quick and dirty ideas. To start this process, the team made use of very basic brainstorming techniques, coming up with a list of ideas and then discussing their merit and practicality. The objective was to list as many ideas as possible, regardless of how improbable or impractical it may sound. Documenting these ideas may not have directly benefited the project itself, but it may be useful in the future to the staff of the Science Museum. For example, some ideas were very expensive or complicated and highly impractical for the team to develop during the seven week period allotted, but it was essential that these ideas be documented to provide the staff of the Science Museum with the opportunity to develop them in the future.

In order to document these ideas properly, the team has composed a list of each idea from the brainstorming session. Hand-drawn sketches were then developed to visually demonstrate how these ideas could work. The team also produced a tentative materials list and brief explanation of the educational goals for each idea. Each of these components was then included in a recommendation sheet, along with a set of improvements that may be made to further develop the demonstrations. By the end of the fifth week, the team had developed 14 quick and dirty ideas, and by the seventh week, the recommendation sheets were complete.

3.3 *Building/Testing Prototypes from Q&Ds*

After the end of weeks one, three, and five the team began developing blueprints for four of the proposed eight quick and dirty ideas. The decision of which quick and dirty ideas the team built was based upon input from the sponsors, as well as the general requirements for a demonstration. It was also a priority to determine and recommend

which demonstrations would be best suited for a classroom, where the demonstration would be presented by the teacher, versus an outreach program, where it would be presented by museum staff.

Once these objectives and requirements were established, the team began to develop the materials list for each of the demonstrations the team decided to pursue. Afterwards, the team spent an average of a half-day shopping for the materials required for the demonstrations, usually at Homebase, the hardware store, and local grocery stores. It was important to consider that if these demonstrations were to be used in classrooms, the materials needed to be easy for teachers and instructors to obtain.

Also, developing these ideas was based on availability of materials and limitations of tools. Some of the QADs would be easy to develop only if the materials were easy to source. For instance, one of the QADs was called “Flammable Methane Bubble Column” (further detail can be seen in Appendix C) in which one fills a bubble with methane and lights it on fire. The process is very simple and easy to do but sourcing the methane gas was not convenient. Also, the limitation of tools has somewhat hindered some of the QADs from being developed. One example is the “Paper Airplane Launcher” QAD (further detail can be seen in Appendix C). Again, the idea is very simple and easy to make. However, assembling it would have been difficult due to health and safety regulations at the Science Museum. Building the “Paper Airplane Launcher” still could have been done but it would have to be built by machinists in the workshop at their convenience. Therefore, this would have taken too much time to be a working demonstration.

After sourcing all the materials, the team constructed a prototype of the demonstrations. Depending on the demonstration, the time spent developing each varied. Some demonstrations took one day to develop, while others took an entire week. Usually, if the demonstration had a major flaw in functioning, the team decided to not further develop it since it would take a significant amount of time to make it work. For example, the Lemon Battery idea worked in theory, but during the development phase, there were some unforeseen variables. A full description of this idea can be found in Appendix C. In theory; it should have taken only two lemons in series to make a small climbing robot move since this particular robot required two volts and each lemon produced one volt. However, each lemon did not source enough current and the robot was still not functional. It would have taken well over twenty lemons to make the robot move. Therefore, the team decided that this idea was not practical and laid the demonstration to rest, but developed a set of recommendations for the Science Museum if the staff were particularly interested in the idea.



Figure 3 Lemon Battery Demonstration

There were, however, many successful demonstrations the team built. For the demonstrations that did work, the team decided to further improve upon it until the week was over. One example of this was the Pulley System, which is discussed further in Appendix C. After sourcing the materials and building the first prototype of the Pulley System, it was declared a success. The team decided it would be appropriate to make further improvements. More modifications were made to the Pulley System. More pulleys were added, as well as a wooden base that a person could sit on, as if on a child's swing. In the final prototype of the Pulley System a person can lift himself with relative ease by sitting on the wooden base and pulling on the rope.

Proper testing of the demonstrations was a critical step in the evaluation of the project, and provided important insight as to what was required to improve each one. There were a variety of tests conducted throughout the project to gain this insight. As shown in the project flow chart (figure 4), the team began assessing demonstrations by presenting the demonstrations to the staff at the London Science Museum, such as explainers, who are specifically trained to explain museum exhibits and science to children in a fun way. We took note of their criticisms of both the demonstrations and the lesson plans we created to accompany them.

Testing progressed from working with the museum staff to working with children in schools. The staff of the London Science Museum currently has an outreach program in which staff travel to schools presenting various scientific concepts from assorted exhibits. The team accompanied the outreach staff to observe demonstration methods and the children's reactions to determine the demonstrations effectiveness. The team observed the outreach team by taking notes and recording observations regarding the level of engagement of the children involved, as well as their level of understanding of the material presented. This included the attention span of the children when they were interacting with each demonstration, levels of engagement, and whether they exhibited signs of comprehension. The accompanying staff provided further criticism, allowing for further development of each demonstration.

3.4 *Developing Inquiry-based Learning Activities*

Not only has the team created quick and dirty ideas, but during weeks of one, three, and five the team evaluated inquiry-based activities (IBLA). Detailed information for each of these IBLAs is available in Appendix D. In order to fully develop and test these IBLAs, it was necessary to gather all of the appropriate materials, define the objectives, and conduct the actual activities, determining appropriate guidelines for how much time should be spent in each process (brainstorming, construction, etc.). Afterwards, the team evaluated the activity to determine whether or not it would fit into a typical class time span of 50 minutes, explain the scientific concept required, and be appropriate for children, and if so, of what age or school year. The team created a lesson plan for teachers to follow, which included objectives, a list of materials, a user-friendly outline/strategy, steering tips, and the conclusions that should be drawn from the activity. The teachers were also be provided with a homework assignment for the children to do prior to the demonstration to help them begin thinking about the concepts that will be taught so they can work with those concepts in mind. An instruction sheet was developed as well to assist the children during the activity if they prefer to read rather than hear instructions. This included questions to assist the teacher in evaluating their understanding, and to reinforce that understanding.

3.5 *Assessing and Obtaining Professional Feedback*

Testing of the Inquiry Based Learning Activities follows a similar design of the water rocket demonstration that the team conducted in the United States, prior to arrival at the London Science Museum. The water rocket demonstration significantly helped the team develop lesson plans for these IBLAs. A full description of what has been accomplished with regard to teaching materials is available in Appendix D. Testing also had to be conducted on the demonstrations based off the quick and dirty ideas. In addition to the experience gained during the water rocket demonstration pretest, the team had access to staff members, like Glen Murphy, who work exclusively with interactive galleries and inquiry based learning activities. Their input on the lesson plans and demonstrations was essential to conducting appropriate and comprehensive testing. Also, there have been other sources of professional feedback from the London Science Museum staff. Visitor researchers, Rachel Church and Sofie Davis, have helped develop and test IBLAs. They have actually performed each activity as if they were students to obtain a better idea of how a child would react to the activity, and what he would take away from it. Their professional background on studying children's behaviors has made their contribution invaluable when developing the IBLAs, helping the team obtain a better understanding of how to improve the questions asked of students and teachers, and how to better conduct the lesson plan.

One other member of the Science Museum staff, Jin Nirwal, has been extremely helpful with assessing any safety concerns in demonstrations and IBLAs. Due to the nature of these demonstrations, the team must be aware of any and all safety concerns so as to not put any children in harm. For this reason she has provided a risk assessment sheet, which may be found in Appendix E. The team has completed this form for each demonstration, prior to testing with the public. The tests that were conducted with the

public were the most important when determining whether or not the demonstration had a significant “wow factor”. With the feedback from the combination of staff, professionals, Explainers, and the public the team has completely assessed both the demonstrations and IBLAs effectively.

3.6 Complete Recommendations to the LSM

The final result of this project consists of twelve demonstration kits and three Inquiry-Based Learning Activities. The demonstration kits contain materials lists, parts that are difficult for teachers to source, instructions for construction, a lesson plan, and techniques for assessing their effectiveness. The inquiry based learning activities were produced and distributed in a similar manner, with an emphasis placed on the lesson plan and assessment techniques. The recommendations provided to the museum contained information that will allow staff to further develop each demonstration and IBLA, and include information regarding the reproducible procedures used to create them originally. While they were not the main goal of the project, the procedure followed was highly regarded by the museum staff, so that future attempts at developing demonstrations and IBLAs may be easier and better structured than past attempts.

4.0 Results and Analysis

This chapter shows the designs developed for both the demonstrations and the IBLAs described earlier. The first section will detail two of the demonstration designs, the steps that were taken to obtain the current result, and how it was evaluated. The second section will describe one of the three IBLAs tested and a short summary of their outcomes and further recommendations for each of the three will be issued in later sections.

Demonstrations

This section will describe two of the demonstrations created, and refer the reader to the demonstration appendix for the remaining demonstrations. Each demonstration started with a brainstorming session that involved coming up with eight ideas. The eight ideas were then drawn up in their most basic form for illustration and presentation purposes. After the ideas were formed they were presented to the Liaison, who decided which would be best to pursue in the form of a working model. The descriptive term designated to these demos was “Quick and Dirty,” thus each demo is given alphanumeric designation QAD # XX where XX is the number of the demo. These numbers were used to refer to the demos since there were a large number of ideas during the project. A complete list of QAD ideas is listed in Appendix C.

QAD # 02 Electrolysis of Water

The main goal of this demonstration is to use electricity to separate water into its two basic components, hydrogen and oxygen. Based on fundamental chemistry concepts, the electrolysis of water demonstrates vividly the concept of compounds being composed of atoms and molecules which can, and often do, have very different chemical and physical properties than the compound itself. In this experiment, students will synthesize hydrogen and oxygen gas from common water. Once the gasses are collected, they will relight an extinguished match in the pure oxygen, and will ignite the hydrogen gas to create a loud “pop” noise. This will conclusively demonstrate to the students that they did in fact produce these two gasses from water.

While rich in scientific information and pantomime, the demonstration itself is simple to carry out. A complete list of materials can be found in Appendix C, and an image of the demonstration may be viewed in Figure 4.



Figure 4. The electrolysis demonstration in action.

The demonstration should be set up as follows:

- 1) Pour the water in to the beaker and mix in salt with a ratio of approximately 10:1.
- 2) Connect the battery terminals to the graphite rods using the crocodile (aka alligator) clips and leads.
- 3) Fill both test tubes with water and submerge them upside down in the beaker, this is done so that the students will see the gas forming in the test tubes and force the water level in them down.
- 4) Insert the graphite rods in the beaker and position each in its own test tube. Bubbles will begin to form from both graphite rods. Hydrogen from the – and oxygen from the +.
- 5) After approximately 10 minutes once half of the hydrogen test tube is filled, the battery is to be disconnected and the test tubes pulled out. Care must be taken to not lose any of the collected gas. This is achieved by using a stopper or one's hand to cap the test tube as soon as it's taken out of the water.
- 6) Light and extinguish an extra long match, while it is still smoldering quickly insert it into the test tube containing oxygen. It will relight itself due to the high concentration of the gas.
- 7) Light and insert an extra long match into the test tube containing hydrogen; it will create a small explosion resulting in a loud popping noise.

Students performing this experiment should be exposed to a brief chemistry lesson where they are presented basic principles such as atoms, molecules, compounds, and bonds. While there is an enormous amount of information accompanying this demonstration, it is simply designed to show how a compound's building blocks can be very different from the original compound.

While it is not necessary to explain in detail the process of electrolysis, it is worth noting that the electrodes merely attract ions that are the opposite charge when submerged in a liquid that conducts electricity. The formula for the reaction is as follows: $2\text{H}_2\text{O}_{(l)} \rightarrow 2\text{H}_{2(g)} + \text{O}_{2(g)}$. It is for this reason that twice as much hydrogen as oxygen is collected.

Once the gasses are collected, students should be asked what they believe will happen by inserting smoldering match in the oxygen test tube and a burning one in the hydrogen test tube. A discussion should ensue for several minutes as the finale itself is very short. The teacher may present points such as "objects only burn in the presence of oxygen" or "hydrogen is combustible" if the students are not sure where to begin.

After the demonstration is complete and the hydrogen combusted, the teacher should reinforce the fact that the class was able to obtain hydrogen, a highly combustible substance from plain water, a non combustible substance. Discussion can ensue about various implications of producing hydrogen through electrolysis such as powering cars. Students may be apt to view this process as obtaining free energy, if the discussion is headed in this direction the teacher should bring up the use of a battery, and how the process requires current to be sent through the water.

While the demonstration is perfectly safe, there are several points to consider. The demonstration utilizes both fire and creates a small explosion. For this reason it may be necessary for the teacher to ignite the gasses if children are not of age to be dealing with such an experiment. It should also be noted that using salt as the electrolyte creates small quantities of chlorine gas once the mixture becomes saturated. For this reason the voltage must be kept below 9 and no one should be standing directly above the demonstration as the electrolysis is being performed. This can be avoided by using washing soda instead of salt as the electrolyte.

After developing the lesson plan and knowing the details of how the demonstration works, further evaluation was made by professional staff of the Science Museum. Team testing has found a couple of unsafe issues such as forming the chlorine gas and creating small explosions. After finding these issues the team has presented them to other staff such as Jin Nirwal and Glenn Murphy for further evaluation.

After presenting the demonstration to Jin, member of the health and safety department, she instructed the team to fill out Risk Assessment Forms for each demonstration that will potentially be tested with the public. These forms quantify the amount of risk associated with the demonstration. An example of this sheet may be found in Appendix E. After filling out the form, it was presented to Jin again for final approval, determining whether or not the demonstration is considered safe to test with the public.

This demonstration meets all of the criteria for an effective classroom experiment. It is simple, cheap, quick, entertaining, and leaves much room for thought, discussion, and further research. It was completed by one of the team members in school when he was of this age and certainly left a lasting impression about the fun and relevance of science.

QAD #08 Pulley System (Wall Pulley)

The main goal of this demonstration is to use a set of pulleys to show mechanical advantage by having a student lift an otherwise impossible weight with relative ease. Students will use an assembly of pulleys known as a block and tackle to raise either themselves or fellow classmate several feet in the air. Based on basic principles of physics, this demonstration illustrates the theory of work and how to manipulate applied force using simple machines to obtain a mechanical advantage.

Materials for this experiment are readily available at any DIY shop and are outlined in Appendix C. We were able to obtain everything from Homebase™. The assembly can be constructed from two long blocks of wood for supports and one flat block of wood for a seat, a variable number of pulleys and rope. The team constructed a prototype of this system using six pulleys, as seen in Figure 5. In general, it may be assembled as follows:

- 1) Position and mount half of the pulleys in the center of one of the 2" x 2"s so that they are next to each other.
- 2) Position and mount the other half of the pulleys in the center of the other 2" x 2" so they are next to each other.
- 3) Attach an eye screw in each corner of the 1.5 ft long 2" x 2" on the side without the pulleys.
- 4) Position the 2' long 2" x 2" above the 1.5' and thread the rope through the pulleys with the last length being tied to the 2' long 2" x 2"
- 5) Drill a hole in each corner of the 1" x 6" big enough to fit the rope through
- 6) Position the seat below the 1.5' long 2" x 2" and attach to the eye screws using rope threaded through the 4 drilled holes. (Leave enough space for child to be able to sit upright and not hit head on lower pulley assembly).

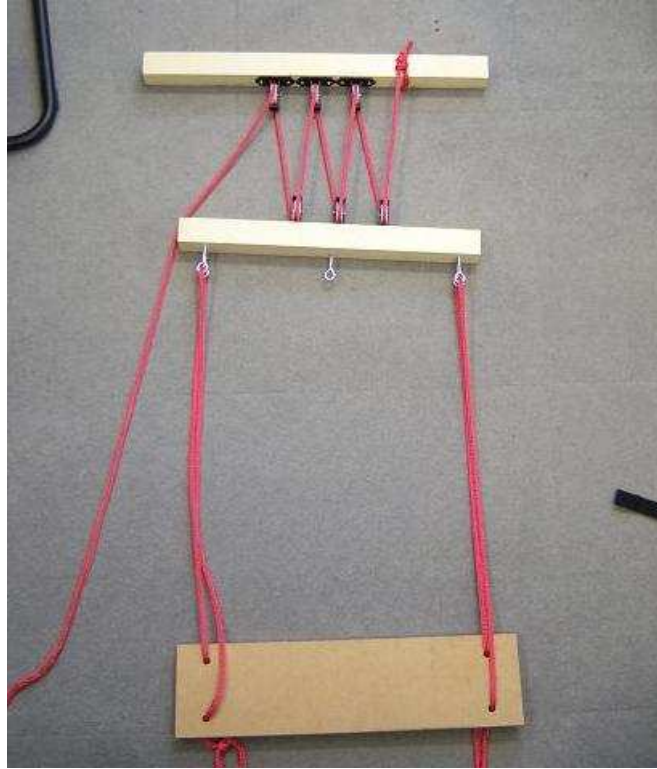


Figure 5. The completed pulley assembly.

Students performing this demonstration should be exposed to a brief physics lesson prior to attempting the experiment. The lesson should cover basic topics such as forces and work. Students should be made aware that the amount of work they do is constant; if they decrease the applied force, they increase the distance they must exert on the force, and vice versa. This point may be emphasized with the operation of the pulley assembly as a simple machine.

The assembly should be propped up between two high, stable surfaces such as file cabinets or lockers as shown in Figure 6. With the assembly secure, a student can sit on the seat and be hoisted by anyone in the class, including themselves, with minimal effort. For a more dramatic effect the heaviest student can be asked to sit and the smallest asked to lift them. Depending on the number of pulleys used, the smallest student will be able to lift virtually any load. An assembly using 4 pulleys will decrease the applied force by a factor of 4; using 6 will decrease it by a factor of 6 and so on.



Figure 6. Erik lifting himself in Pulley System

Variations on this demonstration can be made at the discretion of the teacher. Modifications include using pulleys of various diameters to emphasize gear reduction. Mounting the 2' long 2" x 2" on a solid surface such a wall is also possible to create a "tug of war" scenario in which one student pulls on the rope and several students simultaneously pull on the 1.5' 2" x 2".

Depending on the number of students and pulleys, the single student should be able to easily win.

It should be noted that while this demonstration involves lifting students several feet in the air, it poses virtually no safety hazard. In our prototype we used Eliza Tinsley™ brand wall pulleys designed to hoist flower pots. With three of them sharing the load we were safely able to lift a 155lb team member.

After the demonstration is completed, discussion should ensue about the practical aspects of this simple machine. Students should realize that there is a trade off between applying minimal force and covering minimal distance. Other simple machines, such as gears and levers can be discussed.

While the assembly requires a fair amount of construction, it only needs to be done once as it is reusable in every way. It is quick to set up and dramatically emphasizes the principle of work using simple machines.

After developing the pulley system, the demonstration was presented to education professionals for more feedback. As with the electrolysis demonstration it has also been presented to Jin and a Risk Assessment Form was completed pointing out potential dangers associated with the Pulley System.

Not only has this demonstration been shown to Jin but it has also been shown to a pair of Explainers, Melissa and Matt. Their feedback as to how lesson plans and overall design of the demonstration might be improved has been very helpful. During the discussion it has been found that this Pulley System has great potential for an outreach demonstration with a much bigger “wow” effect. Some of these possibilities include increasing the size of the baseboard so that the pulley system can lift up multiple children and adding a slide track to increase or decrease the number of pulleys to demonstrate how pulleys can reduce force. It would also be possible to create a “tug-of-war”, in which a stronger person or an adult pulls one end of the pulley system while a smaller person or a child pulls on the other end. This would then show the mechanical advantage the child has, and he should be able to beat the stronger person with relative ease.

Performing these demonstrations for professionals has provided a great deal of insight on how to improve overall quality of demonstrations. The team has discovered many ways to make the pulley system stronger and ways to make it more fun to use. Though not all demonstrations are as developed as this pulley system, the same process is taken with as many demonstrations as time allotted.

Inquiry-Based Learning Activities

Inquiry-Based Learning Activities (IBLAs) are investigative lesson plans where students use materials and skills available to better understand a certain concept by solving a problem. In this section one of the three IBLAs will be described in detail. The process used to initially investigate the IBLA will also be discussed, including the results achieved. A full explanation of all the IBLAs can be found in Appendix D.

IBLA #01 Sound

For this IBLA, the objective is to teach children about the science of amplifying and propagating sound. The team set up an activity in the theme of spies and detectives. The setting is “a place” where there is a secret meeting of criminals plotting to contaminate a water supply. The goal is for the detectives/spies (the students) to figure out what the criminals are saying and therefore can find where the contaminated substances are (the recording). The students only have common household

objects to help hear what the message is.

Also, the students have to be a certain distance away from the source of the sound

or else the criminals will find out they are there. The team developed a lesson plan, a homework sheet, and a worksheet for this IBLA, which can be found in the IBLA #01 section of Appendix D.

The team compiled a materials list including metal bowls of varying sizes, PVC piping, funnels, etc. Items that are not useful were also included, such as packaging material and cup coasters. These types of items are called red herring items. The sound recording is placed in some corner of the room, which acts as the location where criminals develop their plan. The “contaminated substance” can be a household substance placed in a plastic bag, which should be hidden in the location designated in the recording.

Prior to the actual activity the teacher must hand out a “homework sheet” for the students to complete. Some of the questions include, “Write down three materials that you think sound would travel well through and three things you think would not carry sound well”, and “Look up the definition of a vacuum (not the one you clean the floor with!). Do you think sound would travel well through a vacuum? Why or why not?” The homework sheet can be found in Appendix D. By asking these types of questions, it creates a better understanding of sound, increases curiosity, and raises anticipation. Asking questions for children can be a very difficult task. The team had previous experience with asking questions based on the Water Rocket demonstration conducted in



Figure 8: The materials used in the initial test run of the IBLA.

the United States, and the team has gone over this with multiple professionals at the Science Museum.

In theory, the children should be performing the actual activity in three steps: Brainstorming ideas, building the product, and testing the machine. It should take about 10 minutes to brainstorm, 20 minutes to build, 15 minutes for testing, and the rest of the time should be used for discussion and stating conclusions. A worksheet has been developed for the children to follow during the activity which can be found in Appendix D. This worksheet is a guide for children to help organize their thoughts when doing this activity.



Figure 9. Example of possible sound project.

To stimulate originality and ingenuity, this activity can be set up competitively. There is a rubric included in the lesson plan which the teacher can judge each product based on ingenuity, originality, aesthetics, applied knowledge, team work, and success of the machine. This rubric can be seen in the lesson plan in Appendix D. Each criterion has a certain weight to it and the teacher can then give out a prize for the team who builds the best device.

The team has also developed many prototypes that represent a variety of ideas that children could have. There is a list of these possible projects listed in the lesson plan. These possibilities are a way of demonstrating to teachers what the children could be building, providing the teacher with some indication of how to guide the children.

After fully developing the IBLA with the team, it was presented to professionals of the Science Museum, just as the demonstrations were. After gathering general feedback from the Liaisons, the team then further evaluated the IBLA by bringing it to visitor researchers in the Science Museum, Rachel Church and Sofie Davis.

During the meeting time with Rachel and Sofie the team had one hour to show them the IBLA. Therefore, it seemed appropriate to let Rachel and Sofie perform the actual IBLA. While they performed the IBLA, one of the team members took observational notes while other members observed and answered any questions that they had.

It was interesting to find a different view of how to approach this IBLA. As the team is comprised up of four engineers, there are certain approaches that may seem more immediately obvious than others. However, when Rachel and Sofie performed the demonstration it was evident that they approached the challenge differently than expected. Instead of using the nails to create sound vibrations with the metal bowls, they used the nails in a different manner. Eventually, they came up with an idea that was similar to one of the projected ideas presented in Appendix D. This was the tubing idea in which PVC piping and poster board tubing was connected together to propagate the sound.

After performing the IBLA it was clearly evident that they enjoyed themselves and used good team work to find different ways of propagating the sound. Their

constructive criticisms on the developed lesson plan, worksheets, and homework sheets have greatly improved the IBLA. Though this particular IBLA has not gone through public testing, due to time constraints, it is ready to do so in the future.

All three of the IBLAs have been fully developed and have been tested differently to obtain different perspectives. The Sound IBLA has been tested with Rachel and Sofie, the Mystery Powder IBLA has been tested with the Explainers and the public, while as the Solar Power Toy IBLA has been tested with the team, as there were difficulties with the power of the light being used. Evaluating these IBLAs with professionals has proven to be a significant way of improving the overall quality of how they work.

5.0 Recommendations

For each QAD and demonstration developed, a complete set of recommendation sheets were created. These recommendation sheets were produced to demonstrate to the staff of the Science Museum, in detail, how each idea should work. Each recommendation sheet includes: required materials, how to build, how it works, further development needed, pictures, etc. It was also useful to develop a quantitative rating system for assessing the demonstrations based upon the observations of team members and input from the museum staff. A rating system was added in the recommendation sheet, as shown in figure 7, to exemplify how each demonstration obtained certain objectives.

| | |
|----------------|----------|
| WOW Factor | ☀☀☀☀☀☀☀☀ |
| Risk | ☀☀☀ |
| Cost Effective | ☀☀☀☀ |
| Find Materials | ☀☀☀☀☀☀ |
| Ease of Use | ☀☀☀☀☀☀☀☀ |
| Building Time | ☀☀☀☀ |

Figure 10. Rating System Chart

The rating system was applied to each demonstration and QAD and each objective was evaluated based on a controlled set of specific rules to avoid bias, as seen below.

WOW Factor – Perceived based on the experience of both the project team and museum staff.

- ☀ = No excitement, not fun, boring
- ☀☀ = Little bit of fun but not very exciting
- ☀☀☀ = Fun and little bit exciting
- ☀☀☀☀ = Very fun and exciting
- ☀☀☀☀☀☀ = The most fun and exciting

Risk – Based on average risk assessment or perceived risk

- ☀ = Fatally Dangerous, needs heavy development
- ☀☀ = Serious Injury may occur, needs development
- ☀☀☀ = Somewhat dangerous, needs some development
- ☀☀☀☀ = Little risk or minor injury, just about ready for testing
- ☀☀☀☀☀☀ = Safe, ready for testing

Cost Effective

- ☼ = >100£
- ☼☼ = 41£ - 100£
- ☼☼☼ = 21£ - 40£
- ☼☼☼☼ = 11£ - 20£
- ☼☼☼☼☼ = <10£

Find Materials

- ☼ = Unique items required, extremely hard to find
- ☼☼ = Not very common items to find
- ☼☼☼ = Everything can be found within reason
- ☼☼☼☼ = Everything can be found with local shopping
- ☼☼☼☼☼ = Classroom/Science lab items

Ease of Use

- ☼ = Very hard to use, hard to make it work
- ☼☼ = Hard to use
- ☼☼☼ = Not very user-friendly to use
- ☼☼☼☼ = Easy to use
- ☼☼☼☼☼ = Easy, simple, user-friendly

Building Time

- ☼ = >2 hours
- ☼☼ = 1 hour – 2 hours
- ☼☼☼ = 31 minutes – 1 hour
- ☼☼☼☼ = 10 minutes – 30 minutes
- ☼☼☼☼☼ = <10 minutes

A full detailed list of recommendation sheets and their rating system can be found in Appendix C.

6.0 Conclusions

The goal of this project, bringing interactive learning, hands on discovery, and having fun, into British classrooms has led to much, not only on the part of the students, but of the team members themselves. The objective of the project is to generate interest within the student, to make them aware of the science around them, to make them question and explore. For all this to happen, the student must be presented with an activity that stimulates their curiosity; something original, fun, and exciting.

With this premise, the team set about developing classroom demonstrations and inquiry based learning activities to be sent to schools spanning all of the UK. The purpose of these demonstrations and activities being to stimulate interest and awareness from the student, who will not only have fun performing these activities, but will be inspired to continue to feed their desire for knowledge. It is for this reason that both the inquiry based learning activities and demonstrations were to be developed with a tremendous fun factor built in, to generate curiosity within the student in regards to the subject matter.

Development of the demonstrations and activities occurred at a tremendous rate. By the end of the project, 26 demonstration ideas were presented, with 14 being developed with some being brought to the prototype stage. In addition, two of the three inquiry based learning activities were fully developed. Each pursued idea went through a rigorous testing phase being presented to museum staff, team members, and the public. Modifications were made; improved prototypes and lesson plans were represented and reported, with the entire collection of work done presented in Appendix C and D.

While the project ends with the culmination of the term, the implication of the work lasts forever. Direct testing with staff members and especially children has demonstrated just how much fun can be had with scientific learning when it is presented in a certain way. Genuine smiles and joyful expressions filled students who made use of the demonstrations and activities completed by the team. While there are considerable advances to make to the prototypes outlined in the appendices, there is no doubt that our work has, and will continue to inspire and excite children about science and the unknown.

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Appendix A

Water Rocket Demonstration Pre-Test

Appendix A: Water Rocket Demonstration Pre-Test

In preparation for the work that will be done on site in London the team developed a demonstration that was tested on a group of children very close to the required age range (ages 8-14). The idea is to get a feel for children's reactions to demonstrations, to know what it takes to build a demonstration, and to experience first hand what keeps children engaged. For our demonstration we constructed a water bottle rocket launcher (see Appendix C for pictures and materials list) and used small water bottles as rockets. The motivation for this water rocket demonstration was to experience first hand how children will react. However, this demonstration will not be used in the UK as it only serves as a sample of what it will be like while working in the London Science Museum. The team has learned a great deal of information such as the attention span of children, developing interesting demonstrations, and the feasibility of teaching concepts to children.

To begin the demonstration, one of our group members introduced the lesson with background materials and science concepts behind how this rocket system worked. She presented ideas about velocity, mass, pressure, force, and momentum. In order for the children to be actively engaged for the introduction the team needed to spark their curiosity. The team did this by letting the children roam around while the team prepared for one rocket firing. As soon as the rocket blasted off, all the children were instantly intrigued and came near the rocket and wondered what happened. This made it easier for the background lesson since the children were interested in how they could do this. Afterwards the group of 12 children was split up into pairs of two. Each pair was given a rocket and told to line up so they could perform their first launch. The first set of launches was performed with no water to set a bench mark for the children, without it they would not see how the addition of mass affects flight. For the next set of launches the children were asked to apply what they learned earlier by telling the

supervising demonstrators how much water they wanted to add to the bottle. If there was extra time, more launches were conducted within the remaining time.

Immediately after the demonstration the students were asked to complete a written assessment of their experience. The assessment included both questions to target technical knowledge achieved and engagement during the demonstration.

Observations

Overall, most of the children were very excited to perform the water rocket demonstration. Observations and notes were documented by using cameras and video recorders. It was set up, so that one person pumps up the water rocket to 30psi and the other releases the rocket by pulling on the release valve. In theory, the children were suppose to switch roles during the second water rocket trial but that was not the case for each pair. It seemed that pumping the rocket was more entertaining than releasing the valve and therefore the teams fought over who got to pump. The more assertive students usually pumped while the more passive one seems to release the valve.

In terms of engagement, the students did pay attention for the first few rocket rounds but after the third or fourth trial the children seem to lose interest, especially those who already blasted their rocket first. They would show disengagement by running around the gym, not watching the actual demonstration, or arguing about who would pump the rocket next.

During the introduction of giving the students background information of how the water rocket works was rather successful. By setting of a sample rocket demonstration in front of the kids, it really seemed to get their attention. The introduction was fairly simple and it seemed that most of the children understood the basic scientific concepts behind the water rocket.



Figure 11: Interaction with Water Rocket

Survey Analysis

A short survey was given to the students after they performed the demonstration. The survey consisted of general questions (age), whether they had fun or not, and whether or not they understood the scientific concept. See Appendix B for the actual survey that was conducted.

After analyzing all the surveys, it was noted that every single child wrote that they had fun performing the water rocket demonstration. Some of the responses were “Yes, I had fun doing this project.”, “YES!!”, “Of course, extremely fun”. It was apparent, that this water rocket demonstration had succeeded in covering the exciting and fun aspect.

Another one of the questions on the survey was “What was the best way of getting the rocket in the air? (How much water and pumps of air did you use?). This question was to assess whether or not the children understood the science behind how a water rocket goes up. Unfortunately, all the answers varied, including “...pumping it as hard as you can. I used an inch of water”, “I used some water and a few pumps”, “Use a lot of water”, and “Only a little amount of water”. After looking at all the surveys it cannot be concluded that the students as a whole learned the theory of how a rocket goes in the air. Perhaps, this could have been different if the children had more time to play around with the

rocket by having more water rocket runs. Due to time constraints, the students could only perform two runs per pair. Also, it seems that the question itself was a bit confusing for the children to answer. Some of the answers did not make sense and some of the answers were not related to the question. For future reference, the questions have to be clearer and possibly word the question into a multiple choice format.

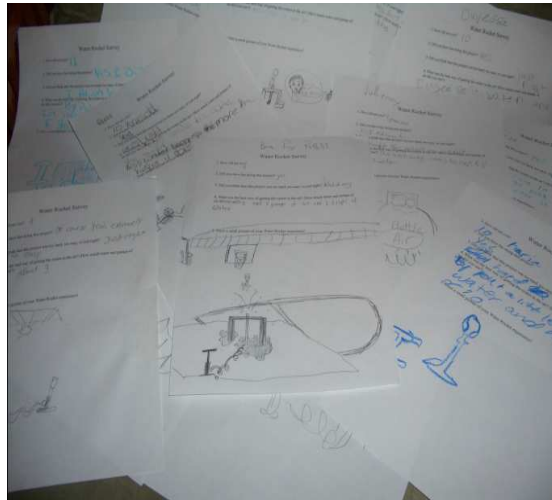


Figure 12: Student Surveys on Water Rocket Experience

What the Team has Learned

By doing this water rocket demonstration first hand with an actual group of children, provided us valuable insight on a sample of what the team will be doing in London. During the team's stay in London, it will be very difficult to actually assess these demonstrations to kids because the main goal of this project is to develop the prototypes strictly. Also, even if the team builds a fully functional demonstration that is ready to use, it can be rather difficult to actually use in a classroom since there are numerous things to consider. Some of these dilemmas include: scheduling a time to set up these demonstrations, whether or not teachers are explaining these concepts at the time, or simply if the teachers have different plans. However, conducting this demonstration in Worcester gives the team a good taste of what demonstrations should include.

Having the children interacting with the demonstration is essential to keep them engaged, excited, and entertained. This was clearly shown not only by the responses from the surveys but also clearly shown during observation using a camera and video recorder to document.



Figure 13: Rocket Launch

The team has learned that each demonstration has to be shorter than five minutes long. Based on the water rocket demonstration, kids lose interest after the third or fourth rocket run. By keeping the demonstrations shorter, kids will be more engaged since they will notice that their turn to perform the demonstration is soon. It was shown in our demonstration that down-time in between rocket runs proved to be a problem. During the down-time the children were not as engaged and rowdiness was a concern. So, the team has learned that having a side activity between rocket demonstrations may be necessary to keep them occupied. Some of these side activities could include: planning and preparing for the next water rocket launch, conducting another survey, talking with an instructor of how their demonstration could be improved on, etc.

Another point that was learned from this experiment was that in order to convey the science behind the water rocket more trial runs were needed. Although, this may seem contraindicating to the last point, more time is needed to

learn. If more time was given, each pair of students could have fiddled with the water rockets more and learned to see that using 1/3 water and a good amount of pressure will blast the rocket at a maximum. However, time was a constraint and this may have been a factor in the learning process. On the other hand, if more time was given, the attention span and excitement factor may have gone down. A good balance between fun, control, and learning is very difficult to achieve.

| Positives | Negatives |
|---|--|
| <ul style="list-style-type: none"> • First hand experience • Teaches valuable information about what demonstrations needs • A sample of what the team will be doing • Can compare this demonstration to future demonstrations built in London • This provides information we cannot have in London. • Found ways to make demonstrations, in general, exciting and entertaining • Took limited resources/materials to build the water rocket (cheap and reproducible) | <ul style="list-style-type: none"> • Difficult to plan • Giving proper background information for children to retain is difficult • This actual demonstration cannot be used in a classroom (outside or high ceiling places only) • Hard to keep students under orderly fashion • May not be possible to set up this kind of arrangement in London. |

Table 3 Summary of Outcomes

What could be Improved

During the pre-test there could have been many ways to improve the overall experience for everyone (children, mentors, and instructors). First, there were too many children with one water rocket. In an ideal situation, a rocket per

four or five children would have resulted in less down-time and more engagement to how it works. This could have increased a child's learning experience and increased interaction with the water rocket. For each water rocket, however, there should be at least one instructor and one mentor to keep the students in orderly fashion. Having the mentor will keep the kids under control, and the instructor can go step by step with each team to show the science of the water rocket. Also, this gives a chance for the students to ask questions about any confusion they might have.

The surveys could also be improved upon quite significantly. This was an excellent opportunity to gather first hand experience of what to expect from children surveys. After conducting this survey, it seems that the major problem was that the questions were not clear enough. Other than the general questions, asking about how the water rocket got in the air was challenging for the kids to answer. Therefore, by breaking down the question, "What was the best way of getting the rocket in the air?" could make it easier for kids to understand. Some of the questions that may result from that include "How much water did you use during the experiment?" A following question could say, "Did using more water or less water get the rocket higher in the air?" The same kind of patter could be asked about pressure.

Lastly, if the team had time, another survey would be given out to the same students a couple weeks later to see if they had retain any knowledge about the water rocket experience. By doing this, the team can decipher if the demonstration had any sort of impact on the children. If a child remembers the information, then the team would know that they enjoyed the demonstration and perhaps spark more of their curiosity about the subject matter.

Worcester Pre-test Water Rocket Demonstration Survey

Water Rocket Survey

1. How old are you?
2. Did you have fun doing this project?
3. Did you think that this project was too hard, too easy, or just right?
4. What was the best way of getting the rocket in the air? (How much water and pumps of air did you use?)
5. Draw a small picture of your Water Rocket experience!

Pictures and Material List of Water Rocket



Material List:

- Bicycle pump
- Plastic Tubing
- Pressure Gauge
- Water Rocket Stand
- O-rings
- Release Valve

Appendix B

Exhibits Considered for
Possible Demonstrations

Appendix B: Exhibits Considered for Possible Demonstrations

Big Machine - is a machine that consists of many other smaller machines and is loosely based on the current Launch Pad's *Grain Pit*. Visitors control the movement of grain by altering the use and design of the smaller machines (e.g. pulley, lever, wheel and axle) and the speed at which they operate.

Electro Magnetic Induction Man - is a multi station exhibit which controls the actions of large and humorous sculpture/automata (e.g. a person) placed clearly in the middle of the exhibit. Visitors will build electro- magnetic devices to trigger some movement in the sculpture e.g. eyes opening or trousers falling down.

Electrolysing water to produce Hydrogen – using a battery wired to two graphite rods (or pencils) to split water into Hydrogen and Oxygen. This supports the 'Hydrogen Rocket' exhibit in Launchpad.

Energy Store – where visitors pump a large volume of water from a low tank to a higher one. When released, the water drives a water turbine which in turn powers a generator. The electricity produced by the generator then powers a colour TV which presents a live shot of the visitors at the exhibit.

Image relay – where visitors use lenses to magnify, reduce, invert or sharpen images.

Inefficient Machine – which is an illustration of energy transfer and the principal of the conservation of energy. Visitors will start the machine e.g. a ball rolling down a marble run, with some large forceful motion and as the ball travels down the run, energy is transferred in different ways e.g. sound, motion, light, gravity, meaning that at the end of the run the ball has only enough energy for a tiny, humorous motion.

Invisible Visible – where visitors alter the frequency of sound and see how this changes the jumping patterns in a liquid-filled tube.

Vibration Station - where the visitors put electronic 'clickers' on a range of everyday boxes and tubs e.g. pizza boxes to make music.

Wave tank – which consists of a large water tank which visitors can interact with to produce waves. The focus of this exhibit is the energy transfer involved within the tank.

Yacht Racer – where visitors control air blowers and the angle of the sail to move wheeled yachts to a destination.

Appendix C

“Quick and Dirty”
Demonstrations

Appendix C: “Quick and Dirty” Demonstrations

Contents

| | Title | Description |
|---------|----------------------------------|--|
| QAD# 01 | Water Rocket | A combination of water and pressure is used to propel a plastic soda bottle high into the air. |
| QAD# 02 | Electrolysis of Water | Electricity is used to separate water into Oxygen and Hydrogen gas. |
| QAD# 03 | Hot Air Balloon | A heat source is combined with a thin and light bag to create a miniature hot-air balloon. |
| QAD# 04 | Convection Propeller | A light propeller is turned using a concentrated heat source. |
| QAD# 05 | Deflecting Laser | A laser beam is deflected using the refractive properties of heated air. |
| QAD# 06 | Wave Tank | A clear plastic tank is partially filled with water and used with a paddle to create and visualize waves. |
| QAD# 07 | Lemon Battery | Two different type metal electrodes are inserted into a lemon and used to create a voltage. |
| QAD# 08 | Pulley System | A series of pulleys are used with rope to create a system that can be used to lift heavy weight with ease. |
| QAD# 09 | Crazy Machine | Interesting machines are used to transfer energy into different types. |
| QAD# 10 | Floating on CO ₂ | Bubbles are floated on CO ₂ gas, seemingly floating in mid-air. |
| QAD# 11 | Mentos and Soda Rocket | The highly energetic reaction of soda and mentos candies is used to propel a bottle rocket into the air. |
| QAD# 12 | Creating a Vacuum or Candle Boat | Two experiments designed to demonstrate the effects of a vacuum. |
| QAD# 13 | Paper Airplane Launcher | Counter rotating disks are used to launch paper airplanes. |
| QAD# 14 | Heat Boat | A candle and a metal coil are used to create a heat differential in the water, propelling the boat. |
| QAD# 15 | Breaking Glass | Glass is tempered along a certain line, and then quenched and broken along that line. |
| QAD# 16 | Imploding Can | Steam is superheated inside the can, then sealed and cooled rapidly causing the can to collapse |
| QAD# 17 | Water into Wine | A magic trick, a hidden pH indicator is revealed when a magic powder is added to water. |

| | | |
|---------|---------------------------------|--|
| QAD# 18 | Electromagnetic Accelerator | A capacitor is discharged through a wire coil which is wrapped around a tube containing a metal projectile. The instant magnetic field propels the projectile out of the tube. |
| QAD# 19 | Gaussian Launcher | The principles of momentum are combined with magnets and steel ball bearings to launch the steel ball bearings. |
| QAD# 20 | Flammable Methane Bubble Column | Methane gas is pumped into a bubble column and ignited. |
| QAD# 21 | Liquid Nitrogen Bubbles | Liquid nitrogen is added to a mixture of warm soapy water, which rapidly creates many bubbles. |
| QAD# 22 | Match Rocket | A single match is used to create a miniature rocket, launching the match. |
| QAD# 23 | Bed of Nails | A bed of nails is used to show how weight distribution can keep a force from destroying an object. |
| QAD# 24 | “Walking on Water” | Corn flour and water mixture is used to show non-Newtonian fluid properties. |
| QAD# 25 | Water Explosion | Elements in the first column of the periodic table are put into water to create explosions. |
| QAD# 26 | Discharging a Capacitor | A charged capacitor is shorted with a small wire, which in turn vaporizes the small wire. |

Each QAD is rated and each objective was based on a controlled set of criteria, illustrated below. Rating boxes can be found in the upper right corner of the each QAD recommendation page.

WOW Factor – Perceived based on the experience of both the project team and museum staff.

- ☼ = No excitement, not fun, boring
- ☼☼ = Little bit of fun but not very exciting
- ☼☼☼ = Fun and little bit exciting
- ☼☼☼☼ = Very fun and exciting
- ☼☼☼☼☼ = The most fun and exciting

Risk – Based on average risk assessment or perceived risk

- ☼ = Fatally Dangerous, needs heavy development
- ☼☼ = Serious Injury may occur, needs development
- ☼☼☼ = Somewhat dangerous, needs some development
- ☼☼☼☼ = Little risk or minor injury, just about ready for testing
- ☼☼☼☼☼ = Safe, ready for testing

Cost Effective

- ☼ = >100£
- ☼☼ = 41£ - 100£
- ☼☼☼ = 21£ - 40£
- ☼☼☼☼ = 11£ - 20£
- ☼☼☼☼☼ = <10£

Find Materials

- ☼ = Unique items required, extremely hard to find
- ☼☼ = Not very common items to find
- ☼☼☼ = Everything can be found within reason
- ☼☼☼☼ = Everything can be found with local shopping
- ☼☼☼☼☼ = Classroom/Science lab items

Ease of Use

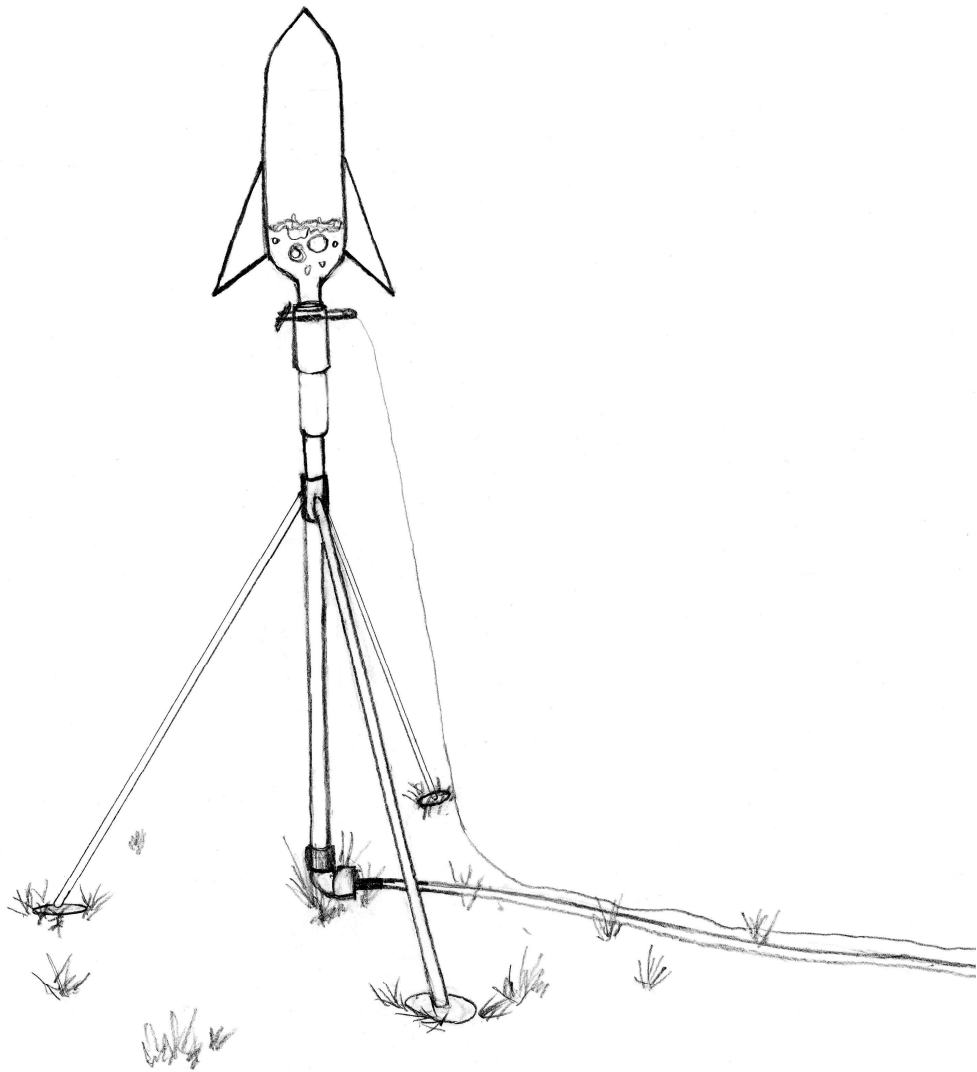
- ☼ = Very hard to use, hard to make it work
- ☼☼ = Hard to use
- ☼☼☼ = Not very user-friendly to use
- ☼☼☼☼ = Easy to use
- ☼☼☼☼☼ = Easy, simple, user-friendly

Building Time

- ☼ = >2 hours
- ☼☼ = 1 hour – 2 hours
- ☼☼☼ = 31 minutes – 1 hour
- ☼☼☼☼ = 10 minutes – 30 minutes
- ☼☼☼☼☼ = <10 minutes

QAD# 1

Water Rocket



Water Rocket

| | |
|----------------|--------|
| WOW Factor | ☼☼☼☼☼☼ |
| Risk | ☼☼☼☼ |
| Cost Effective | ☼☼ |
| Find Materials | ☼☼☼☼ |
| Ease of Use | ☼☼☼☼☼ |
| Building Time | ☼ |

| | |
|-------------------|------------------|
| Team Name: | Science Museum 1 |
| Activity: | Water Rocket |

| Material | Specific Use |
|------------------|-------------------|
| Bicycle pump | Pumps Rocket |
| Pressure gage | Measures Pressure |
| Plastic Tubing | Directs Air |
| 0.5" PVC Pipe | General Support |
| PVC Fittings | Attaches Piping |
| PVC Glue | Attaches Piping |
| Stem Valve | Connects Rocket |
| O-rings | Holds Rocket |
| 0.125" Steel Rod | Launch Pin |
| Bottle | Rocket |
| Tent Stakes | Supports Rocket |
| Twine | Release Valve |
| Eye Screws | Holds Rocket |

| |
|--|
| Setup Required: |
| Extensive set-up procedure can be found in IQP report under Appendix A |

| |
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| Problems Encountered: |
| When children tried to pull on the string to release the rocket it usually did not work without a little assistance from one of the team members. |
| Also, the general support of the rocket could have been sturdier. |

| | | |
|-------------------------|-----------|-------------------------|
| Category: | IBLA | Demonstration |
| End Use: | Classroom | Outreach (Professional) |
| Tested: | Yes | No |
| Effect achieved? | Yes | No |

| | | |
|----------------|------------|-------------------|
| Tested: | Untested | Team Tested |
| | Explainers | Sophie and Rachel |
| | Teachers | Classrooms |
| | Families | Staff: |
| Other: | | U.S. Pre-test |

| |
|---|
| Further development options: |
| <ul style="list-style-type: none"> Needs risk assessment form completed Was not one of the chosen QAD to be developed |

| |
|--|
| Performing the demonstration: |
| <ol style="list-style-type: none"> Fill up the bottle with some amount of water Place bottle over the PVC piping and secure it over the o-ring. Pump bicycle pump to pressurize the bottle (30 psi is plenty) Pull on string to release the rocket |

| |
|---|
| How could this be improved? |
| <ul style="list-style-type: none"> Design better release valve Stronger base to keep launcher from tipping over |

| |
|--|
| How could this be scaled up? |
| <ul style="list-style-type: none"> Use 2 liter bottles and more water Build up bigger pressure using automated pump instead of bicycle pump. |

National Curriculum:

KS2

Investigative skills

- ask questions that can be investigated scientifically and decide how to find answers
- consider what sources of information, including first-hand experience and a range of other sources, they will use to answer questions
- 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

Obtaining and presenting evidence

- check observations and measurements by repeating them where appropriate

Considering evidence and evaluating

- use observations, measurements or other data to draw conclusions
- decide whether these conclusions agree with any prediction made and/or whether they enable further predictions to be made
- use their scientific knowledge and understanding to explain observations, measurements or other data or conclusions
- review their work and the work of others and describe its significance and limitations.

KS3

Ideas and evidence in science

- that it is important to test explanations by using them to make predictions and by seeing if evidence matches the predictions

Investigative skills

- use scientific knowledge and understanding to turn ideas into a form that can be investigated, and to decide on an appropriate approach
- decide whether to use evidence from first-hand experience or secondary sources
- carry out preliminary work and to make predictions, where appropriate

Considering Evidence

- use observations, measurements and other data to draw conclusions
- decide to what extent these conclusions support a prediction or enable further predictions to be made
- use their scientific knowledge and understanding to explain and interpret observations, measurements or other data, and conclusions

Evaluating

- consider anomalies in observations or measurements and try to explain them
- consider whether the evidence is sufficient to support any conclusions or interpretations made
- suggest improvements to the methods used, where appropriate.

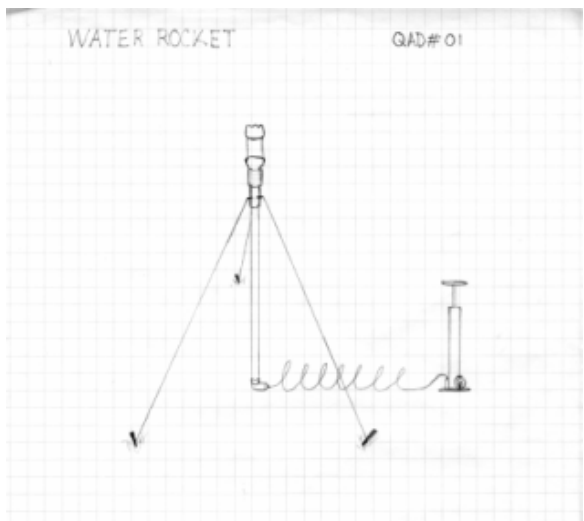
Forces and Motion

- how to determine the speed of a moving object and to use the quantitative relationship between speed, distance and time
- that the weight of an object on Earth is the result of the gravitational attraction between its mass and that of the Earth
- 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

- ways in which frictional forces, including air resistance, affect motion [for example, streamlining cars, friction between tyre and road]

General Recommendations: There has been a lot of development with this demonstration. The team has spent an entire term devoted on this prior to coming to London. It has been tested with the team and on groups of kids. Many observations were made and the children were thoroughly “Wowed”.

Pictures:



QAD# 2

Electrolysis of Water



Electrolysis

| | |
|----------------|------------|
| WOW Factor | ☀️☀️☀️☀️☀️ |
| Risk | ☀️☀️☀️ |
| Cost Effective | ☀️☀️☀️☀️ |
| Find Materials | ☀️☀️☀️☀️ |
| Ease of Use | ☀️☀️☀️ |
| Building Time | ☀️☀️☀️ |

| | |
|-------------------|------------------|
| Team Name: | Science Museum 1 |
| Activity: | Electrolysis |

| Material | Specific Use |
|---------------------|----------------------|
| Beaker | Holds Solution |
| Test tube | Collects Hydrogen |
| Matches | Initiates Pop |
| 9V Battery | Power Source |
| 2 X Graphite Rods | Release Gases |
| 2 X Alligator Clips | Conducts Electricity |
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| Setup Required: |
| <ol style="list-style-type: none"> 1. Pour the water in to the beaker and mix in salt with a ratio of approximately 10:1. 2. Connect the battery terminals to the graphite rods using the crocodile clips and leads. 3. Fill both test tubes with water and submerge then upside down in the beaker, this is done so that the students will see the gas forming in the test tubes and force the water level in them down. |

| |
|---|
| Problems Encountered: |
| Graphite rods are difficult to source |
| Putting the graphite rod in the test tube was sometimes challenging |

| | | |
|-------------------------|-----------|-------------------------|
| Category: | IBLA | Demonstration |
| End Use: | Classroom | Outreach (Professional) |
| Tested: | Yes | No |
| Effect achieved? | Yes | No |

| | | |
|----------------|------------|-------------------------|
| Tested: | Untested | Team Tested |
| | Explainers | Sophie and Rachel |
| | Teachers | Classrooms |
| | Families | Staff: Sam, Maria, Alex |
| | Other: | |

| |
|---|
| Further development options: |
| Combine the oxygen and hydrogen to make an explosion versus just burning the hydrogen |

| |
|--|
| Performing the demonstration: |
| <ol style="list-style-type: none"> 1. Insert the graphite rods in the beaker and position each in its own test tube. Bubbles will begin to form from both graphite rods. Hydrogen from the - and oxygen from the +. 2. After approximately 10 minutes once half of the hydrogen test tube is filled, the battery is to be disconnected and the test tubes pulled out. Care must be taken to not lose any of the collected gas. This is achieved by using a stopper or ones hand to cap the test tube as soon as it's taken out of the water. 3. Light and extinguish an extra long match, while it is still smouldering quickly insert it into the test tube containing oxygen. It will relight itself due to the high concentration of the gas. 4. Light and insert an extra long match into the test tube containing hydrogen; it will create a small explosion resulting in a loud popping noise. |

| |
|---------------------------------------|
| How could this be improved? |
| Making the set up more user friendly. |

| |
|--|
| How could this be scaled up? |
| Do the experiment under very cold conditions such as dry ice. This should create snow. |

National Curriculum:

KS2

Obtaining and Presenting Evidence

- use simple equipment and materials appropriately and take action to control risks

Separating Mixtures of Materials

- to use knowledge of solids, liquids and gases to decide how mixtures might be separated.

Electricity

- to construct circuits, incorporating a battery or power supply and a range of switches, to make electrical devices work [for example, buzzers, motors]

KS3

Elements, Compounds, and Mixtures

- how elements combine through chemical reactions to form compounds [for example, water, carbon dioxide, magnesium oxide, sodium chloride, most minerals]with a definite composition
- how to separate mixtures into their constituents using distillation, chromatography and other appropriate methods.

Patterns of Behavior

- how metals react with oxygen, water, acids and oxides of other metals, and what the products of these reactions are
- about the displacement reactions that take place between metals and solutions of salts of other metals
- how a reactivity series of metals can be determined by considering these reactions, and used to make predictions about other reactions

General Recommendations:

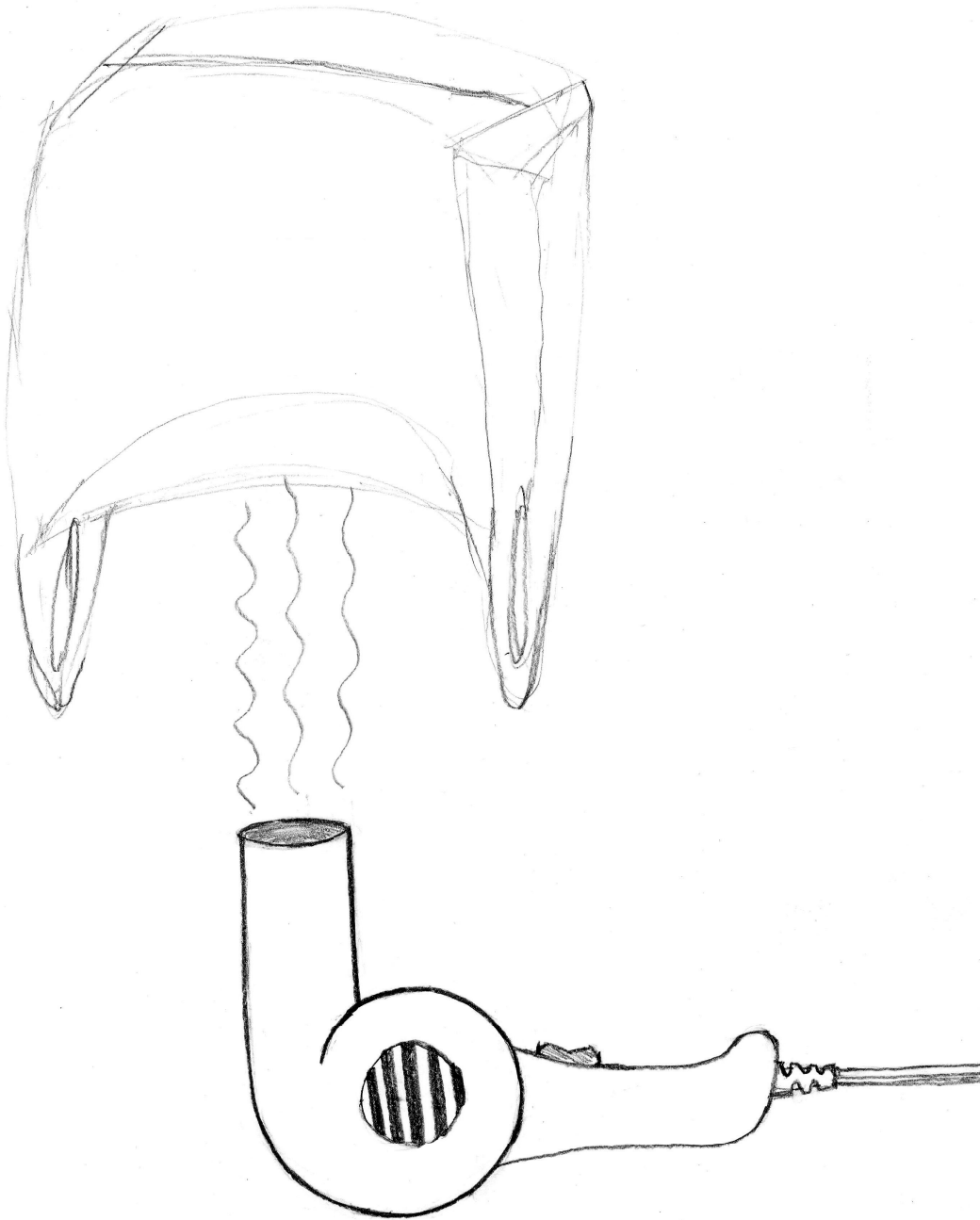
This demonstration has been highly successful and has lots of potential to be part of a classroom or outreach demonstration.

Pictures:



QAD# 3

Hot Air Balloon



Hot Air Balloon

| | |
|----------------|--------|
| WOW Factor | ☼☼☼☼☼☼ |
| Risk | ☼☼☼☼ |
| Cost Effective | ☼☼☼☼☼☼ |
| Find Materials | ☼☼☼☼☼☼ |
| Ease of Use | ☼☼☼☼ |
| Building Time | ☼☼☼☼ |

| | |
|-------------------|------------------|
| Team Name: | Science Museum 1 |
| Activity: | Hot Air Balloon |

| Material | Specific Use |
|--|--------------------|
| Heat Source (Candle, High wattage light bulb, Heat gun...) | Creates Convection |
| Plastic Grocery Bag / | Holds Air |
| Dry Cleaning Bag | Alternative Bag |
| Wooden Dowels | Holds Heat Source |
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|--|--------------------|
| Setup Required: | (In Theory) |
| <ol style="list-style-type: none"> Place candle or other heat source on wooden dowel. Attach the plastic bag or dry cleaning bag onto the wooden dowels. | |

| |
|------------------------------|
| Problems Encountered: |
| Not Applicable |

| | | |
|-------------------------|------------------|-------------------------|
| Category: | IBLA | Demonstration |
| End Use: | Classroom | Outreach (Professional) |
| Tested: | Yes | No |
| Effect achieved? | Yes | No |

| | | |
|----------------|-----------------|-------------------|
| Tested: | Untested | Team Tested |
| | Explainers | Sophie and Rachel |
| | Teachers | Classrooms |
| | Families | Staff: |
| | Other: | |

| |
|--|
| Further development options: |
| No development has been made. Strictly a QAD |

| |
|---|
| Performing the demonstration: |
| <ol style="list-style-type: none"> Hold plastic bag over the candle. Make sure that the plastic bag does not touch the candle. Light the candle and wait for bag to fill with heated air. In theory, the heat should cause the bag to lift the candle and dowels into the air. |

| |
|------------------------------------|
| How could this be improved? |
| Not Applicable |

| |
|-------------------------------------|
| How could this be scaled up? |
| |

National Curriculum:

KS2

Investigative Skills

- ask questions that can be investigated scientifically and decide how to find answers
- consider what sources of information, including first-hand experience and a range of other sources, they will use to answer questions

Obtaining and Presenting Evidence

- use simple equipment and materials appropriately and take action to control risks

Considering Evidence and Evaluating

- make comparisons and identify simple patterns or associations in their own observations and measurements or other data
- use observations, measurements or other data to draw conclusions
- decide whether these conclusions agree with any prediction made and/or whether they enable further predictions to be made
- use their scientific knowledge and understanding to explain observations, measurements or other data or conclusions
- review their work and the work of others and describe its significance and limitations.

KS3

Investigative Skills

- use scientific knowledge and understanding to turn ideas into a form that can be investigated, and to decide on an appropriate approach
- decide whether to use evidence from first-hand experience or secondary sources
- carry out preliminary work and to make predictions, where appropriate

Obtaining and Presenting Evidence

- use a range of equipment and materials appropriately and take action to control risks to themselves and to others

Considering Evidence and Evaluating

- use observations, measurements and other data to draw conclusions
- decide to what extent these conclusions support a prediction or enable further predictions to be made
- use their scientific knowledge and understanding to explain and interpret observations, measurements or other data, and conclusions

Conservation of Energy

- how energy is transferred by the movement of particles in conduction, convection and evaporation, and that energy is transferred directly by radiation

General Recommendations:

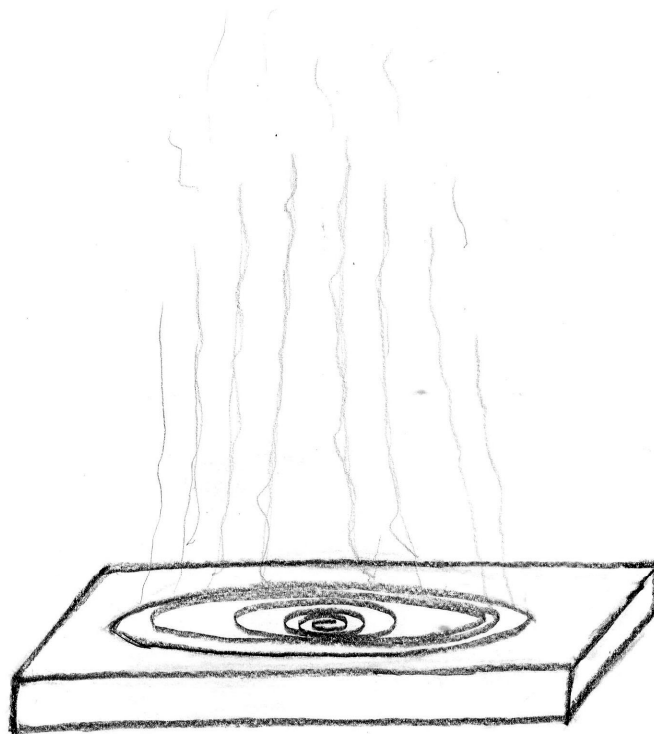
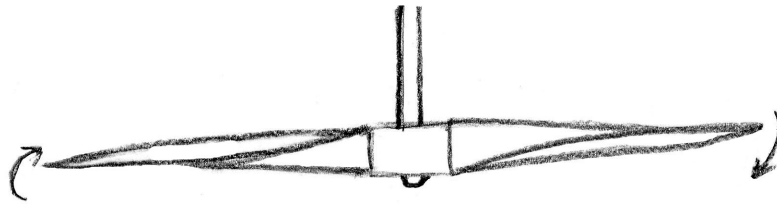
In theory, it should not take long to set up.

Lots of safety issues needs to be taken into consideration

Pictures: Not Applicable

QAD# 4

Convection Propeller



Convection Propeller

| | |
|----------------|-------|
| WOW Factor | ☼☼☼☼ |
| Risk | ☼ |
| Cost Effective | ☼ |
| Find Materials | ☼☼☼☼☼ |
| Ease of Use | ☼☼ |
| Building Time | ☼☼☼ |

| | |
|-------------------|----------------------|
| Team Name: | Science Museum 1 |
| Activity: | Convection Propeller |

| Material | Specific Use |
|-----------------|-----------------|
| Rotating Device | Spins with Heat |
| Heat Source | Spins Propeller |
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| Setup Required: |
| <ol style="list-style-type: none"> 1. Have children design a propeller using a piece of computer paper. The shape should be created in a way so that it will spin when it is blown on. |

| |
|------------------------------|
| Problems Encountered: |
| Not Applicable |

| | | |
|-------------------------|------------------|-------------------------|
| Category: | IBLA | Demonstration |
| End Use: | Classroom | Outreach (Professional) |
| Tested: | Yes | No |
| Effect achieved? | Yes | No |

| | | |
|----------------|-----------------|-------------------|
| Tested: | Untested | Team Tested |
| | Explainers | Sophie and Rachel |
| | Teachers | Classrooms |
| | Families | Staff: |
| | Other: | |

| |
|--|
| Further development options: |
| No development has been made. Strictly a QAD |
| Could be used as part of the "Inefficient Machine" |

| |
|--|
| Performing the demonstration: |
| <ol style="list-style-type: none"> 1. Mount the propeller up on the ceiling. 2. Using the heat source place directly underneath the propeller 3. The heat should cause convection and in theory, the propeller should spin. |

| |
|------------------------------------|
| How could this be improved? |
| Not Applicable |

| |
|-------------------------------------|
| How could this be scaled up? |
| Not Applicable |

National Curriculum:

KS2

Investigative Skills

- ask questions that can be investigated scientifically and decide how to find answers
- consider what sources of information, including first-hand experience and a range of other sources, they will use to answer questions

Obtaining and Presenting Evidence

- use simple equipment and materials appropriately and take action to control risks

Considering Evidence and Evaluating

- make comparisons and identify simple patterns or associations in their own observations and measurements or other data
- use observations, measurements or other data to draw conclusions
- decide whether these conclusions agree with any prediction made and/or whether they enable further predictions to be made
- use their scientific knowledge and understanding to explain observations, measurements or other data or conclusions
- review their work and the work of others and describe its significance and limitations.

KS3

Investigative Skills

- use scientific knowledge and understanding to turn ideas into a form that can be investigated, and to decide on an appropriate approach
- decide whether to use evidence from first-hand experience or secondary sources
- carry out preliminary work and to make predictions, where appropriate

Obtaining and Presenting Evidence

- use a range of equipment and materials appropriately and take action to control risks to themselves and to others

Considering Evidence and Evaluating

- use observations, measurements and other data to draw conclusions
- decide to what extent these conclusions support a prediction or enable further predictions to be made
- use their scientific knowledge and understanding to explain and interpret observations, measurements or other data, and conclusions

Conservation of Energy

- how energy is transferred by the movement of particles in conduction, convection and evaporation, and that energy is transferred directly by radiation

General Recommendations:

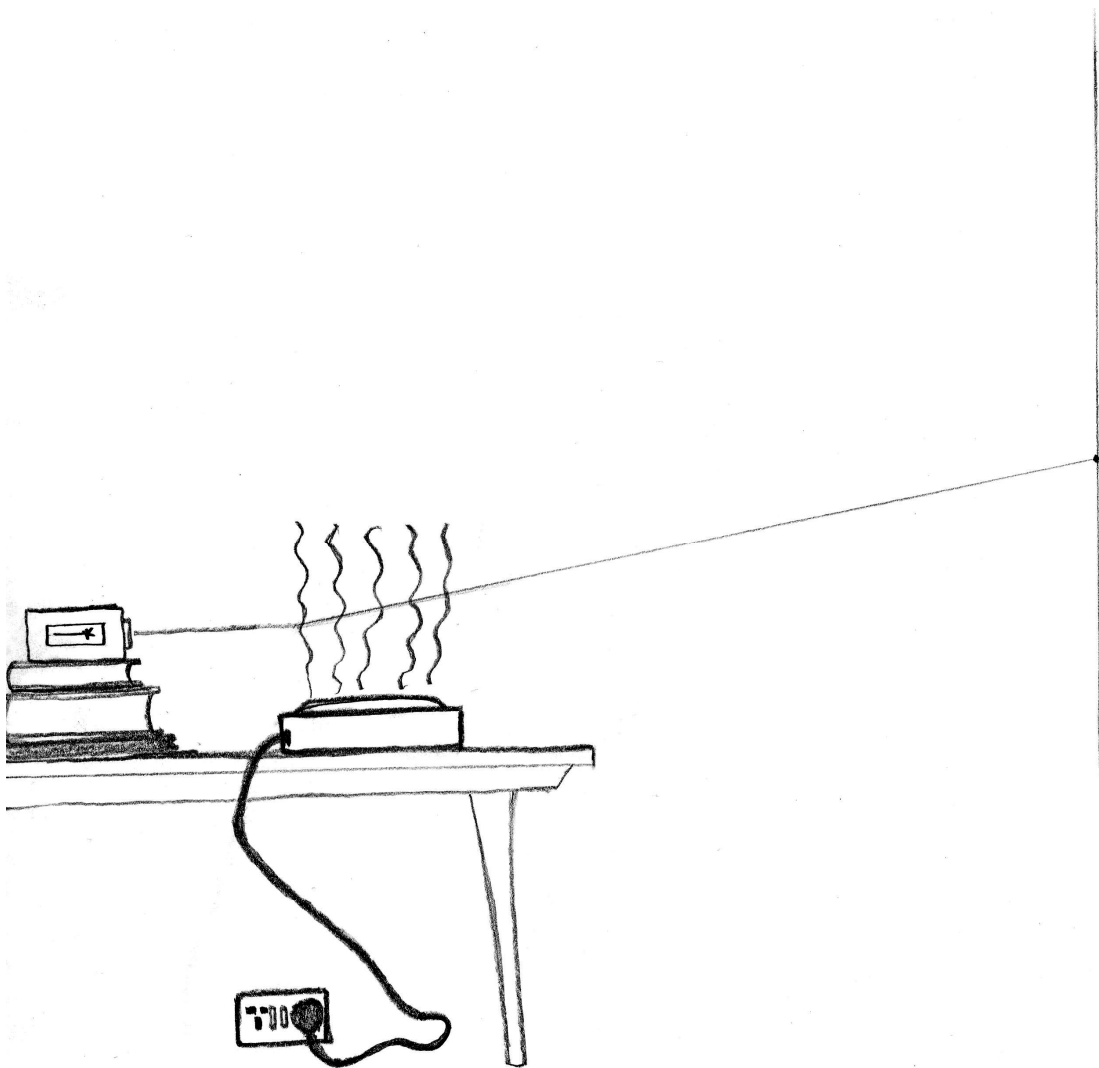
In theory, it should not take long to set up.

Does not show a lot of “wow” factor by itself. But, using this with a series of demonstrations (i.e. Inefficient Machine) would make it much better

Pictures:

QAD# 5

Deflecting Laser



Deflecting Laser

| | |
|----------------|-------|
| WOW Factor | ☼☼☼☼☼ |
| Risk | ☼ |
| Cost Effective | ☼☼☼☼ |
| Find Materials | ☼☼☼☼ |
| Ease of Use | ☼ |
| Building Time | ☼☼☼☼☼ |

| | |
|-------------------|------------------|
| Team name: | Science Museum 1 |
| Activity: | Deflecting Laser |

| Material | Specific Use |
|---------------|---------------------|
| Laser Pointer | Creates Beam |
| Heat Source | Causes Deflection |
| Tape | Holds Laser Pointer |
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| Setup Required: |
| <ol style="list-style-type: none"> 1. Mount laser pointer to a supported structure using the tape. Make sure there is no obstruction of the laser's path 2. Place heat source underneath the direction of the laser beam |

| |
|---|
| Problems Encountered: |
| <p>It takes a long time for the laser pointer to move along the wall. In about 5 minutes worth of time the laser pointer beam only moved up a few inches.</p> <p>Also, the button on the laser pointer was sometimes a hassle to push down when using tape.</p> |

| | | |
|-------------------------|-----------|-------------------------|
| Category: | IBLA | Demonstration |
| End Use: | Classroom | Outreach (Professional) |
| Tested: | Yes | No |
| Effect achieved? | Yes | No |

| | | |
|----------------|------------|-------------------|
| Tested: | Untested | Team Tested |
| | Explainers | Sophie and Rachel |
| | Teachers | Classrooms |
| | Families | Staff: |
| | Other: | |

| |
|---|
| Further development options: |
| Need to find way to make beam move faster and deflect further |
| Risk assessment still needed |

| |
|---|
| Performing the demonstration: |
| Turn on heat source and laser pointer. As it begins to heat up it creates convection. This in turn, causes the light to refract and the laser deflects. The laser point on the wall gradually moves upward. |

| |
|--|
| How could this be improved? |
| We used a toaster as our heat source and it may have not been enough heat. Therefore, use a hotter heat source (Bunsen burner) |
| Find a better way to hold down the button on the laser pointer or use a laser that can be switched on and off |

| |
|---|
| How could this be scaled up? |
| This could be used as part of a IBLA. Using the themes of "deactivating an alarm" via moving the laser upwards. |

National Curriculum:

KS2

Investigative Skills

- ask questions that can be investigated scientifically and decide how to find answers
- consider what sources of information, including first-hand experience and a range of other sources, they will use to answer questions

Obtaining and Presenting Evidence

- use simple equipment and materials appropriately and take action to control risks

Considering Evidence and Evaluating

- make comparisons and identify simple patterns or associations in their own observations and measurements or other data
- use observations, measurements or other data to draw conclusions
- decide whether these conclusions agree with any prediction made and/or whether they enable further predictions to be made
- use their scientific knowledge and understanding to explain observations, measurements or other data or conclusions
- review their work and the work of others and describe its significance and limitations.

KS3

Investigative Skills

- use scientific knowledge and understanding to turn ideas into a form that can be investigated, and to decide on an appropriate approach
- decide whether to use evidence from first-hand experience or secondary sources
- carry out preliminary work and to make predictions, where appropriate

Obtaining and Presenting Evidence

- use a range of equipment and materials appropriately and take action to control risks to themselves and to others

Considering Evidence and Evaluating

- use observations, measurements and other data to draw conclusions
- decide to what extent these conclusions support a prediction or enable further predictions to be made
- use their scientific knowledge and understanding to explain and interpret observations, measurements or other data, and conclusions

Conservation of Energy

- how energy is transferred by the movement of particles in conduction, convection and evaporation, and that energy is transferred directly by radiation

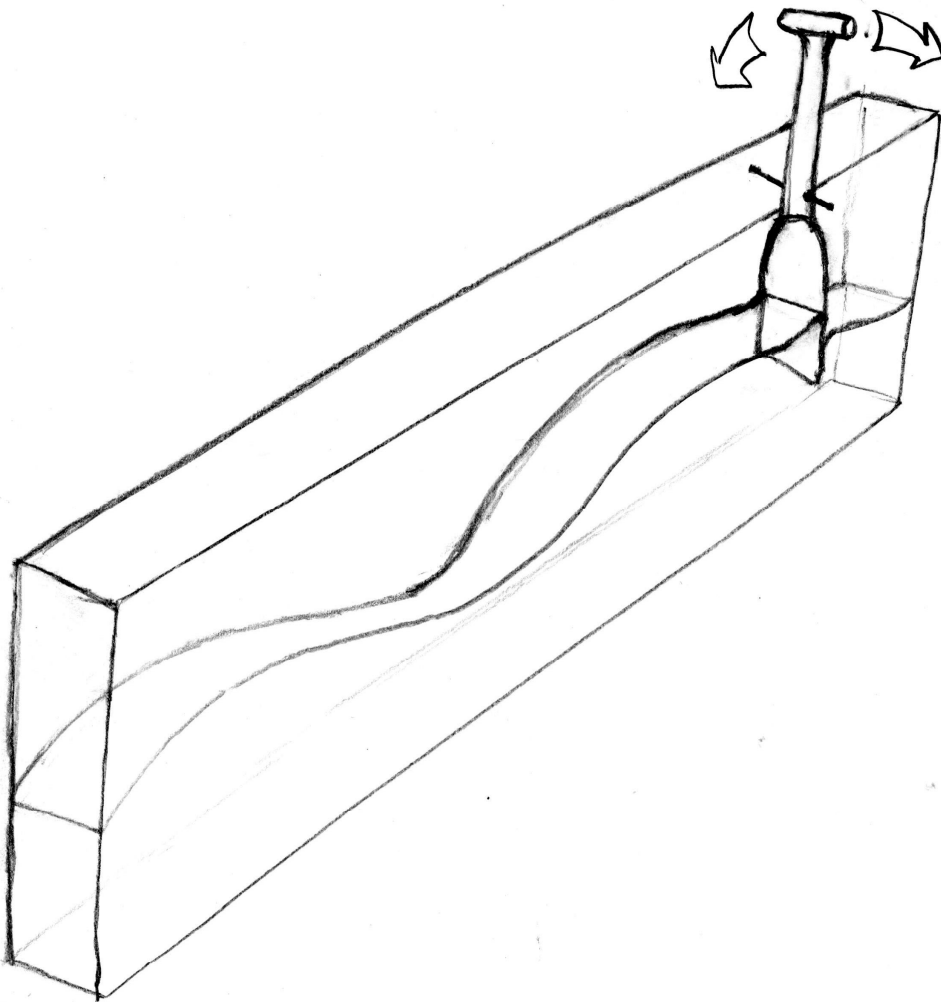
General Recommendations:

The team strongly recommends the use of this demonstration as part of a theme based IBLA. Doing this demonstration by itself does not prove to have a big “wow” factor.

Pictures:

QAD# 6

Wave Tank



Wave Tank

| | |
|----------------|-------|
| WOW Factor | ☼☼☼☼☼ |
| Risk | ☼☼☼☼☼ |
| Cost Effective | ☼☼ |
| Find Materials | ☼☼ |
| Ease of Use | ☼☼ |
| Building Time | ☼ |

| | |
|-------------------|------------------|
| Team Name: | Science Museum 1 |
| Activity: | Wave Tank |

| Material | Specific Use |
|---|-----------------------|
| Clear, Thin Tank (Approx. 3' x 1' x 2") | Holds Water |
| Food Coloring | Differentiates Layers |
| Water | Different Medium |
| Paddle | Creates Waves |
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| Setup Required: |
| <ol style="list-style-type: none"> 1. Fill tank approximately halfway with water 2. Mount paddle in the tank so that one can move paddle and create waves. |

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| Problems Encountered: |
| Not Applicable |

| | | |
|-------------------------|-----------|-------------------------|
| Category: | IBLA | Demonstration |
| End Use: | Classroom | Outreach (Professional) |
| Tested: | Yes | No |
| Effect achieved? | Yes | No |

| | | |
|----------------|------------|-------------------|
| Tested: | Untested | Team Tested |
| | Explainers | Sophie and Rachel |
| | Teachers | Classrooms |
| | Families | Staff: |
| | Other: | |

| |
|-------------------------------------|
| Further development options: |
| Not Applicable |

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| Performing the demonstration: |
| Have a person push the paddle back in forth to create waves. Because the tank is skinny, the person should be able to watch the frequency of the waves. In theory, faster paddling will cause higher frequencies and vice versa. |

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| How could this be improved? |
| Not Applicable |

| |
|-------------------------------------|
| How could this be scaled up? |
| Not Applicable |

National Curriculum:

KS2

Investigative Skills

- ask questions that can be investigated scientifically and decide how to find answers
- consider what sources of information, including first-hand experience and a range of other sources, they will use to answer questions

Obtaining and Presenting Evidence

- use simple equipment and materials appropriately and take action to control risks

Considering Evidence and Evaluating

- decide whether these conclusions agree with any prediction made and/or whether they enable further predictions to be made
- use their scientific knowledge and understanding to explain observations, measurements or other data or conclusions

Forces and Motion

- that when objects [for example, a spring, a table] are pushed or pulled, an opposing pull or push can be felt
- how to measure forces and identify the direction in which they act.

KS3

Investigative Skills

- use scientific knowledge and understanding to turn ideas into a form that can be investigated, and to decide on an appropriate approach
- decide whether to use evidence from first-hand experience or secondary sources
- carry out preliminary work and to make predictions, where appropriate

Obtaining and Presenting Evidence

- use a range of equipment and materials appropriately and take action to control risks to themselves and to others

Considering Evidence and Evaluating

- use observations, measurements and other data to draw conclusions
- decide to what extent these conclusions support a prediction or enable further predictions to be made
- use their scientific knowledge and understanding to explain and interpret observations, measurements or other data, and conclusions

Energy Transfer

- about the variety of energy resources, including oil, gas, coal, biomass, food, wind, waves and batteries, and the distinction between renewable and non-renewable resources

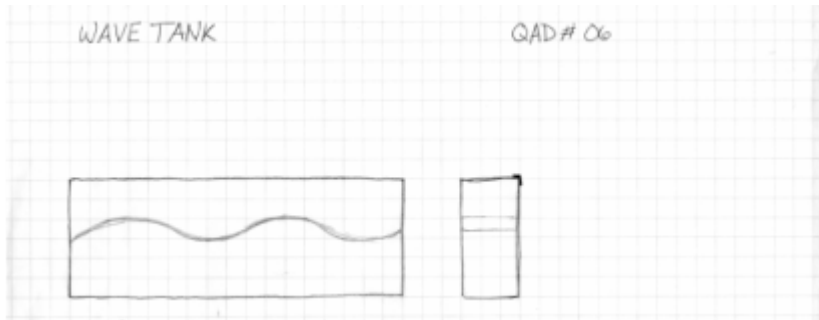
Conservation of Energy

- how energy is transferred by the movement of particles in conduction, convection and evaporation, and that energy is transferred directly by radiation

General Recommendations:

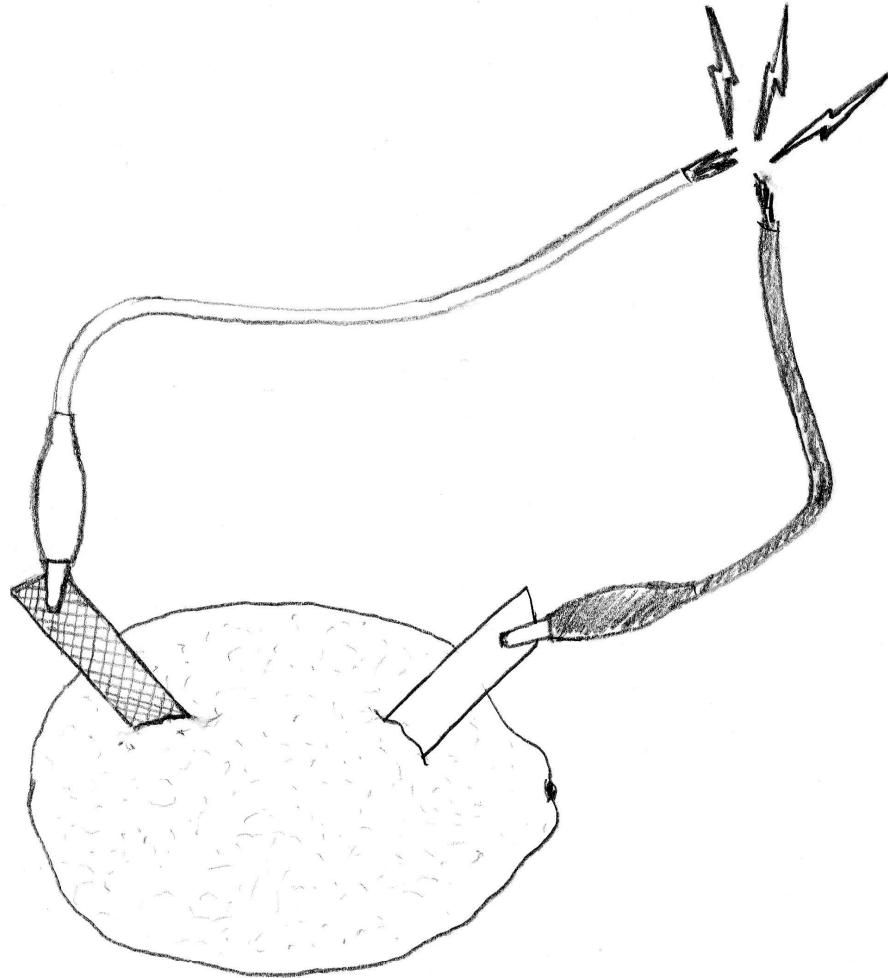
Decided not to pursue the idea since this idea has already been developed by the Science Museum.

Pictures:



QAD# 7

Lemon Battery



Lemon Battery

| | |
|----------------|--------|
| WOW Factor | ☼☼☼☼☼☼ |
| Risk | ☼☼☼☼ |
| Cost Effective | ☼☼☼☼☼ |
| Find Materials | ☼☼☼☼☼ |
| Ease of Use | ☼☼☼☼☼ |
| Building Time | ☼☼☼☼☼ |

| | |
|-------------------|------------------|
| Team Name: | Science Museum 1 |
| Activity: | Lemon Battery |

| Material | Specific Use |
|----------------------|------------------|
| 5 X Lemons | Power Source |
| Toy with low voltage | The Wow Factor |
| Copper Wire | Combining Power |
| Zinc Nails | Combining Power |
| Multimeter | Measures Voltage |
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| Setup Required: |
| <ol style="list-style-type: none"> 1. Place zinc nail into a lemon and attach copper wire around it 2. Do the same with other lemons and set them up in series 3. Connect final leads from one lemon into the toy. The toy used was the "Climbing Robot" which was bought from the Science Museum gift shop. |

| |
|---|
| Problems Encountered: |
| <p>Though there were enough lemons (two) to gather enough voltage, there was not enough current. Therefore, the toy remained inactive.</p> <p>If this were to work, more lemons would be needed (perhaps over ten) and thus make this more impractical.</p> |

| | | |
|-------------------------|-----------|-------------------------|
| Category: | IBLA | Demonstration |
| End Use: | Classroom | Outreach (Professional) |
| Tested: | Yes | No |
| Effect achieved? | Yes | No |

| | | |
|----------------|------------|-------------------|
| Tested: | Untested | Team Tested |
| | Explainers | Sophie and Rachel |
| | Teachers | Classrooms |
| | Families | Staff: |
| | Other: | |

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|---|
| Further development options: |
| Use vinegar instead of lemons. Vinegar has been tested to produce more voltage. |

| |
|---|
| Performing the demonstration: |
| <ol style="list-style-type: none"> 1. After setting up the lemons place the toy in necessary position. In this case, the climbing toy was mounted on a window surface. 2. Using a multimeter, measure the amount of voltage coming out of the lemons. Two lemons should produce approximately two volts. 2. Turn on the toy and the lemons should source enough power to make the toy climb on the window. |

| |
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| How could this be improved? |
| Instead of setting the lemons up in series, they should be set up in a combination of series and parallel. Doing so, will increase both voltage and current. |

| |
|--|
| How could this be scaled up? |
| Though it is highly impractical, the lemons can power things up. To scale up, use a lot of lemons to power up a bigger toy requiring more voltage/current. |

National Curriculum:

KS2

Investigative Skills

- ask questions that can be investigated scientifically and decide how to find answers
- consider what sources of information, including first-hand experience and a range of other sources, they will use to answer questions

Obtaining and Presenting Evidence

- use simple equipment and materials appropriately and take action to control risks

Considering Evidence and Evaluating

- make comparisons and identify simple patterns or associations in their own observations and measurements or other data
- use observations, measurements or other data to draw conclusions
- decide whether these conclusions agree with any prediction made and/or whether they enable further predictions to be made
- use their scientific knowledge and understanding to explain observations, measurements or other data or conclusions
- review their work and the work of others and describe its significance and limitations.

KS3

Investigative Skills

- use scientific knowledge and understanding to turn ideas into a form that can be investigated, and to decide on an appropriate approach
- decide whether to use evidence from first-hand experience or secondary sources
- carry out preliminary work and to make predictions, where appropriate

Obtaining and Presenting Evidence

- use a range of equipment and materials appropriately and take action to control risks to themselves and to others

Considering Evidence and Evaluating

- use observations, measurements and other data to draw conclusions
- decide to what extent these conclusions support a prediction or enable further predictions to be made
- use their scientific knowledge and understanding to explain and interpret observations, measurements or other data, and conclusions

Conservation of Energy

- how energy is transferred by the movement of particles in conduction, convection and evaporation, and that energy is transferred directly by radiation

General Recommendations:

Though 2 lemons were not enough to power the toy, the team did find out that this idea still works. We tested the idea using one lemon to power up a Hallmark Christmas card which played music.

Pictures:



QAD# 8

Pulley System



Pulley System

| | |
|----------------|----------|
| WOW Factor | ☼☼☼☼☼☼☼☼ |
| Risk | ☼☼☼☼ |
| Cost Effective | ☼☼☼☼ |
| Find Materials | ☼☼☼☼ |
| Ease of Use | ☼☼☼☼☼☼ |
| Building Time | ☼☼☼☼ |

| | |
|-------------------|------------------|
| Team Name: | Science Museum 1 |
| Activity: | Pulley System |

| Material | Specific Use |
|-------------|-------------------|
| Wood Screws | Attaching Pulleys |
| Eye Screws | Support Weight |
| 6mm Rope | Controls Movement |
| Wood | General Support |
| 6 X Pulleys | Force Reduction |
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|-------------------------|-----------|-------------------------|
| Category: | IBLA | Demonstration |
| End Use: | Classroom | Outreach (Professional) |
| Tested: | Yes | No |
| Effect achieved? | Yes | No |

| | | |
|----------------|------------|-------------------|
| Tested: | Untested | Team Tested |
| | Explainers | Sophie and Rachel |
| | Teachers | Classrooms |
| | Families | Staff: |
| | Other: | |

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| Further development options: |
| To show the phenomenon of pulleys have a sliding piece where one can add more pulleys. Test out with one pulley vs. six pulleys. |

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| Setup Required: |
| <ol style="list-style-type: none"> 1. Position and mount half of the pulleys in the centre of one of the 2" x 2"s so that they are next to each other. 2. Position and mount the other half of the pulleys in the centre of the other 2" x 2" so they are next to each other. 3. Attach an eye screw in each corner of the 1.5 ft long 2" x 2" on the side without the pulleys. 4. Position the 2' long 2" x 2" above the 1.5' and thread the rope through the pulleys with the last length being tied to the 2' long 2" x 2" 5. Drill a hole in each corner of the 1" x 6" big enough to fit the rope through 6. Position the seat below the 1.5' long 2" x 2" and attach to the eye screws using rope threaded through the 4 drilled holes. (Leave enough space for child to be able to sit upright and not hit head on lower pulley assembly). |

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| Performing the demonstration: |
| <ol style="list-style-type: none"> 1. Set up the pulley system by placing the top support bar on top of two filing cabinets 2. Have someone sit on the base 3. Using the rope a peer or the person sitting on the base can lift oneself up 4. When lifted up the desired height make sure the person does not let go of the rope. Gradually let rope down to slowly lower the person on the base. |

| |
|---|
| Problems Encountered: |
| <ul style="list-style-type: none"> • The certain pulleys that we used are hard to find • Finding cabinets or something high to support the beam may be hard to come by • The bottom base was still too wide (needs to be cut skinnier) |

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| How could this be improved? |
| <ul style="list-style-type: none"> • Add more pulleys for force reduction • Make wood base more stable • Longer support bar on top • Allow it to be used lower (with desks) • Use bolts instead of wood screws for more stabilization |

| |
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| How could this be scaled up? |
| If want to upscale for demonstration outreach program, perhaps add a lot more pulleys and make the base bigger where it can hold more than one person. |

National Curriculum:

KS2

Investigative Skills

- ask questions that can be investigated scientifically and decide how to find answers
- consider what sources of information, including first-hand experience and a range of other sources, they will use to answer questions

Obtaining and Presenting Evidence

- use simple equipment and materials appropriately and take action to control risks

Considering Evidence and Evaluating

- make comparisons and identify simple patterns or associations in their own observations and measurements or other data
- use observations, measurements or other data to draw conclusions
- decide whether these conclusions agree with any prediction made and/or whether they enable further predictions to be made
- use their scientific knowledge and understanding to explain observations, measurements or other data or conclusions
- review their work and the work of others and describe its significance and limitations.

Forces and Motion

- that when objects [for example, a spring, a table] are pushed or pulled, an opposing pull or push can be felt
- how to measure forces and identify the direction in which they act.

KS3

Investigative Skills

- use scientific knowledge and understanding to turn ideas into a form that can be investigated, and to decide on an appropriate approach
- decide whether to use evidence from first-hand experience or secondary sources
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Obtaining and Presenting Evidence

- use a range of equipment and materials appropriately and take action to control risks to themselves and to others

Considering Evidence and Evaluating

- use observations, measurements and other data to draw conclusions
- decide to what extent these conclusions support a prediction or enable further predictions to be made
- use their scientific knowledge and understanding to explain and interpret observations, measurements or other data, and conclusions

Conservation of Energy

- how energy is transferred by the movement of particles in conduction, convection and evaporation, and that energy is transferred directly by radiation

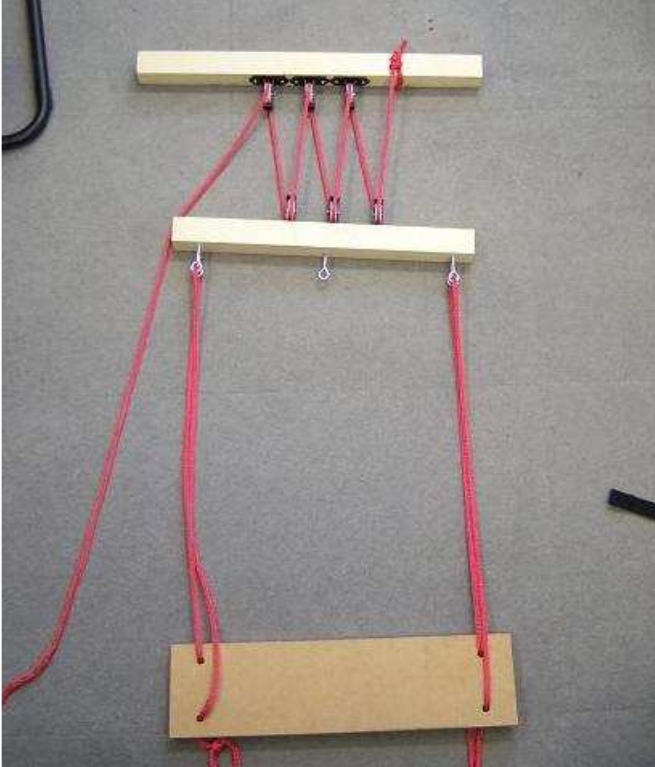
Forces and Motion

- that the weight of an object on Earth is the result of the gravitational attraction between its mass and that of the Earth
- 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

General Recommendations:

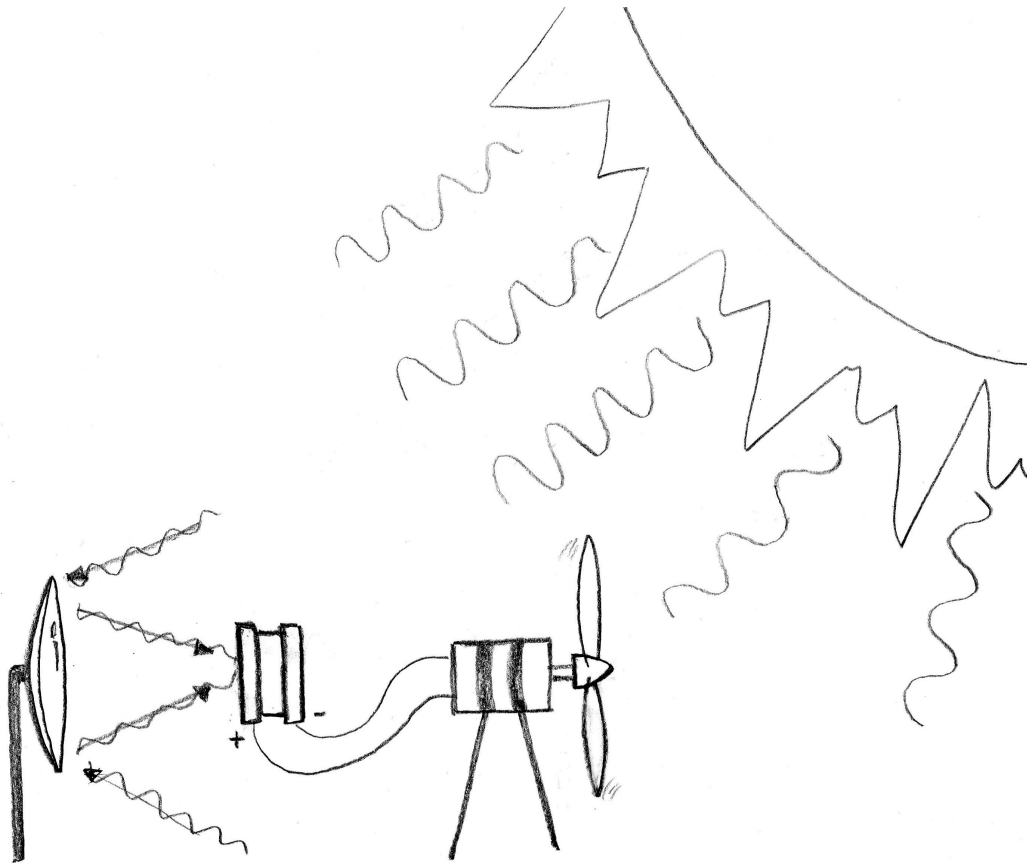
- Very successful demonstration
- Has a lot of potential to be either a classroom or outreach demonstration
- Create a special version that is large scale and can be safely modified with extra pulleys quickly and easily

Pictures:



QAD# 9

Crazy Machine



Crazy Machine

| | |
|----------------|------------|
| WOW Factor | ☀️☀️☀️☀️☀️ |
| Risk | ☀️☀️ |
| Cost Effective | ☀️☀️ |
| Find Materials | ☀️☀️ |
| Ease of Use | ☀️☀️ |
| Building Time | ☀️ |

| | |
|-------------------|------------------|
| Team Name: | Science Museum 1 |
| Activity: | Crazy Machine |

| Material | Specific Use |
|-------------------|------------------|
| Parabolic Mirror | Directs Sunlight |
| Sunlight | Powers Radio |
| Peltier Generator | Converts Energy |
| Wires | Connect Machine |
| Radio | Powered by Sun |
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| Setup Required: |
| 1. Connect wires, radio, and peltier generator together. |

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| Problems Encountered: |
| Finding a peltier generator is difficult |

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|-------------------------|-----------|-------------------------|
| Category: | IBLA | Demonstration |
| End Use: | Classroom | Outreach (Professional) |
| Tested: | Yes | No |
| Effect achieved? | Yes | No |

| | | |
|----------------|------------|-------------------|
| Tested: | Untested | Team Tested |
| | Explainers | Sophie and Rachel |
| | Teachers | Classrooms |
| | Families | Staff: |
| | Other: | |

| |
|-------------------------------------|
| Further development options: |
| This is strictly a QAD |

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| Performing the demonstration: |
| 1. On a sunny day, place set up outside. 2. Direct the sunlight into the peltier generator using the parabolic mirror 3. In theory, the sunlight should power up the radio. |

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| How could this be improved? |
| n/a |

| |
|-------------------------------------|
| How could this be scaled up? |
| n/a |

National Curriculum:

KS2

Investigative Skills

- ask questions that can be investigated scientifically and decide how to find answers
- consider what sources of information, including first-hand experience and a range of other sources, they will use to answer questions

Obtaining and Presenting Evidence

- use simple equipment and materials appropriately and take action to control risks

Considering Evidence and Evaluating

- make comparisons and identify simple patterns or associations in their own observations and measurements or other data
- use observations, measurements or other data to draw conclusions
- decide whether these conclusions agree with any prediction made and/or whether they enable further predictions to be made
- use their scientific knowledge and understanding to explain observations, measurements or other data or conclusions
- review their work and the work of others and describe its significance and limitations.

KS3

Investigative Skills

- use scientific knowledge and understanding to turn ideas into a form that can be investigated, and to decide on an appropriate approach
- decide whether to use evidence from first-hand experience or secondary sources
- carry out preliminary work and to make predictions, where appropriate

Obtaining and Presenting Evidence

- use a range of equipment and materials appropriately and take action to control risks to themselves and to others

Considering Evidence and Evaluating

- use observations, measurements and other data to draw conclusions
- decide to what extent these conclusions support a prediction or enable further predictions to be made
- use their scientific knowledge and understanding to explain and interpret observations, measurements or other data, and conclusions

Conservation of Energy

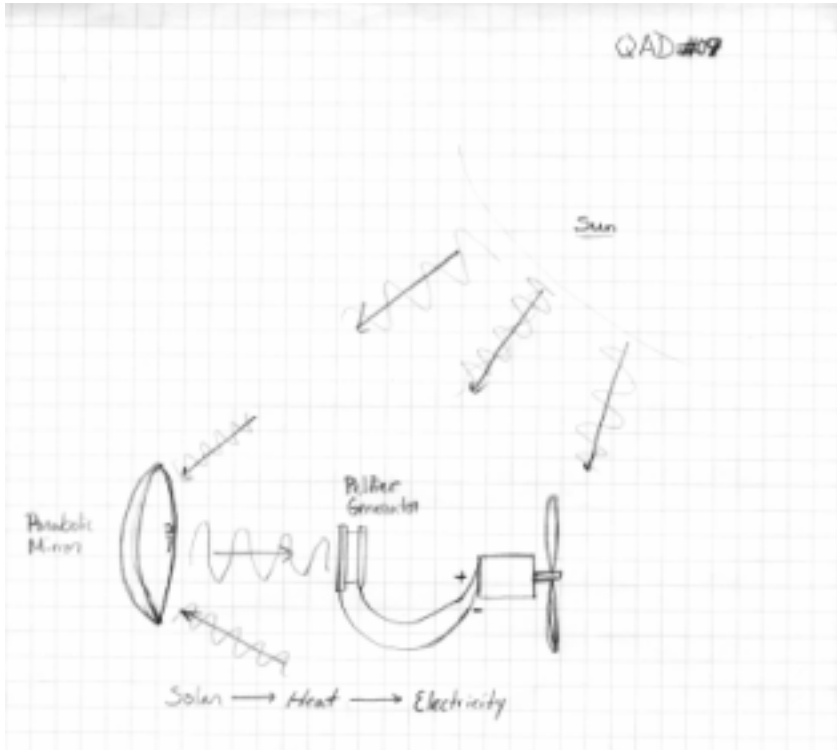
- how energy is transferred by the movement of particles in conduction, convection and evaporation, and that energy is transferred directly by radiation

General Recommendations:

Sourcing the materials is rather easy except the peltier generator. However, if it could be done it would show the scientific concepts of electricity, light, and heat transfer.

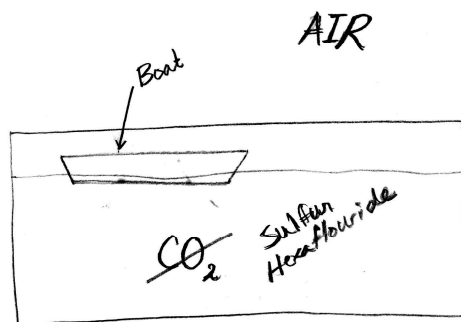
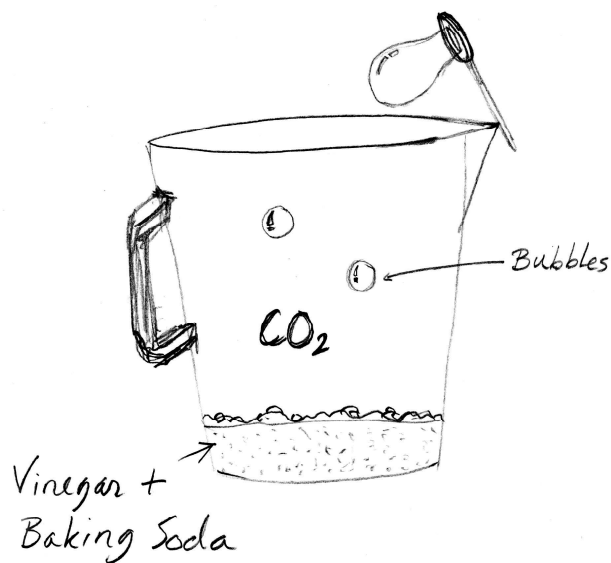
Also, you do not need to use a radio. The sketch below shows a fan instead.

Pictures:



QAD# 10

Floating on CO₂



Floating on CO₂

| | |
|----------------|--------|
| WOW Factor | ☼☼☼☼☼☼ |
| Risk | ☼☼ |
| Cost Effective | ☼☼☼☼ |
| Find Materials | ☼☼☼☼ |
| Ease of Use | ☼☼☼ |
| Building Time | ☼☼☼☼ |

| | |
|-------------------|-----------------------------|
| Team Name: | Science Museum 1 |
| Activity: | Floating on CO ₂ |

| Material | Specific Use |
|--------------|---------------------------|
| Large Bucket | Holds CO ₂ |
| Tissue Paper | Floats on CO ₂ |
| Bubbles | Floats on CO ₂ |
| Vinegar | Creates CO ₂ |
| Baking Soda | Creates CO ₂ |
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| Setup Required: |
| 1. Fill up large bucket with ~2 liters of vinegar and ~5 cups of baking soda. |

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| Problems Encountered: |
| The team tried using aluminum foil but was too heavy. |
| Hard to blow bubbles into the bucket. Only about 10% of the bubbles make it into the bucket. |

| | | |
|-------------------------|------------------|-------------------------|
| Category: | IBLA | Demonstration |
| End Use: | Classroom | Outreach (Professional) |
| Tested: | Yes | No |
| Effect achieved? | Yes | No |

| | | |
|----------------|------------|--------------------|
| Tested: | Untested | Team Tested |
| | Explainers | Sophie and Rachel |
| | Teachers | Classrooms |
| | Families | Staff: |
| | Other: | |

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|---|
| Further development options: |
| Build a boat light enough to float on CO ₂ |

| |
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| Performing the demonstration: |
| 1. First, take bubble mix and blow bubbles over the bucket. They should float on top of the CO ₂ |
| 2. Afterwards, take a piece of light tissue paper (1 ply) and place in the bucket. The CO ₂ should hold up the tissue paper. |

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| How could this be improved? |
| If the resources were available, use a bigger bucket such as a tank. |
| Use a different agent to produce denser gas than CO ₂ . |

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| How could this be scaled up? |
| By using a bigger tank and a denser gas, it should be able to hold heavier items. |

National Curriculum:

KS2

Investigative Skills

- ask questions that can be investigated scientifically and decide how to find answers
- consider what sources of information, including first-hand experience and a range of other sources, they will use to answer questions

Grouping and Classifying Materials

- to compare everyday materials and objects on the basis of their material properties, including hardness, strength, flexibility and magnetic behavior, and to relate these properties to everyday uses of the materials

Changing Materials

- to describe changes that occur when materials are mixed [for example, adding salt to water]
- that non-reversible changes [for example, vinegar reacting with bicarbonate of soda, plaster of Paris with water] result in the formation of new materials that may be useful

KS3

Investigative Skills

- use scientific knowledge and understanding to turn ideas into a form that can be investigated, and to decide on an appropriate approach
- decide whether to use evidence from first-hand experience or secondary sources
- carry out preliminary work and to make predictions, where appropriate

Elements, Compounds, and Mixtures

- how elements combine through chemical reactions to form compounds [for example, water, carbon dioxide, magnesium oxide, sodium chloride, most minerals] with a definite composition

Changing Materials

- about the variation of solubility with temperature, the formation of saturated solutions, and the differences in solubility of solutes in different solvents

General Recommendations:

The demonstration has a significant WOW factor and it does work.

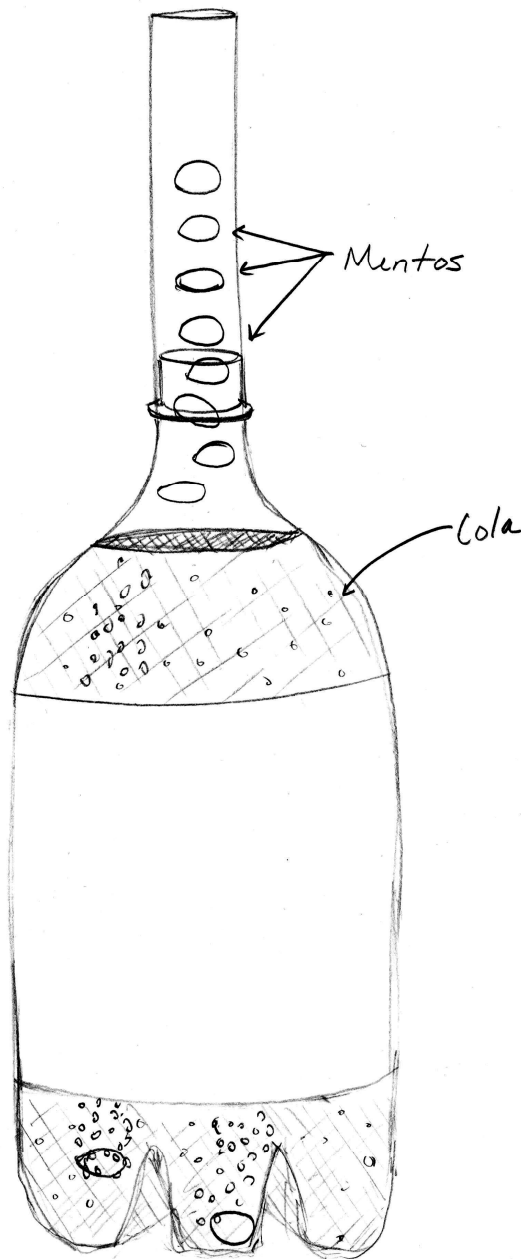
It does use up a lot of vinegar and baking soda and cleaning up is somewhat of a hassle.

Unless the tank/bucket is sealed, it is hard to save the CO₂ for long periods of time.

Pictures:

QAD# 11

Mentos and Soda Rocket



Mentos and Diet Coke Rocket

| | |
|----------------|----------|
| WOW Factor | ☼☼☼☼☼☼☼☼ |
| Risk | ☼☼☼☼ |
| Cost Effective | ☼☼☼☼ |
| Find Materials | ☼☼☼☼ |
| Ease of Use | ☼☼☼☼ |
| Building Time | ☼ |

| | |
|-------------------|--------------------|
| Team Name: | Science Museum 1 |
| Activity: | Mentos/Soda Rocket |

| Material | Specific Use |
|----------------------|--------------------|
| ½ inch diameter PVC | Holds Mentos |
| Soda bottle caps X 2 | Holds Mentos |
| Diet Coke | Creates Reaction |
| Diet Coke Bottle | Acts as Rocket |
| Mentos | Creates Reaction |
| Tissue Paper | Initiates Reaction |
| Super Glue | Holds Pressure |
| | |
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Setup Required:

1. Cut out a hole in one of the soda bottle caps so that a Mentos can fit through easily.
2. Glue the remaining bottle cap into one of the ends of the PVC pipe.
3. After the glue is dry, place Mentos in PVC piping and use the tissue paper to prevent the Mentos from falling out.
4. Fit the PVC piping over the soda bottle filled with diet coke. It should be a very snug fit. Use super glue if the fit is not snug.

Problems Encountered:

1. Harder to set up compared to other demonstrations that we have built.
2. Unless the PVC piping is completely air tight pressure can seep out of the bottle and therefore not create a rocket.

| | | |
|-------------------------|-----------|-------------------------|
| Category: | IBLA | Demonstration |
| End Use: | Classroom | Outreach (Professional) |
| Tested: | Yes | No |
| Effect achieved? | Yes | No |

| | | |
|----------------|------------|-------------------|
| Tested: | Untested | Team Tested |
| | Explainers | Sophie and Rachel |
| | Teachers | Classrooms |
| | Families | Staff: |
| | Other: | |

Further development options:

Set up in a way similar to our Water Rocket pre-test in the US.

Performing the demonstration:

1. Perform this demonstration outdoors. Find two fairly heavy rocks to support the rocket.
2. When ready flip over the soda bottle so that the soda can seep through the tissue paper and hit the Mentos. Support the rocket using the rockets and stand clear.
3. Pressure will build up in the rocket due to the Mentos/diet coke reaction. When there is enough pressure the bottle should blast out of the PVC piping and go into the air.

How could this be improved?

Can design this process better if time allowing.

How could this be scaled up?

Can set up a holder that can hold more than one bottle. For example, the holder can support five Mentos/diet coke rocket instead of one.

National Curriculum:

KS2

Investigative skills

- ask questions that can be investigated scientifically and decide how to find answers
- consider what sources of information, including first-hand experience and a range of other sources, they will use to answer questions
- 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

Obtaining and presenting evidence

- check observations and measurements by repeating them where appropriate

Considering evidence and evaluating

- use observations, measurements or other data to draw conclusions
- decide whether these conclusions agree with any prediction made and/or whether they enable further predictions to be made
- use their scientific knowledge and understanding to explain observations, measurements or other data or conclusions
- review their work and the work of others and describe its significance and limitations.

Grouping and Classifying Materials

- to recognise differences between solids, liquids and gases, in terms of ease of flow and maintenance of shape and volume.

Changing Materials

- to describe changes that occur when materials are mixed [for example, adding salt to water]
- about reversible changes, including dissolving, melting, boiling, condensing, freezing and evaporating

KS3

Ideas and evidence in science

- that it is important to test explanations by using them to make predictions and by seeing if evidence matches the predictions

Investigative skills

- use scientific knowledge and understanding to turn ideas into a form that can be investigated, and to decide on an appropriate approach
- decide whether to use evidence from first-hand experience or secondary sources
- carry out preliminary work and to make predictions, where appropriate

Considering Evidence

- use observations, measurements and other data to draw conclusions
- decide to what extent these conclusions support a prediction or enable further predictions to be made
- use their scientific knowledge and understanding to explain and interpret observations, measurements or other data, and conclusions

Evaluating

- consider anomalies in observations or measurements and try to explain them
- consider whether the evidence is sufficient to support any conclusions or interpretations made

- suggest improvements to the methods used, where appropriate.

Forces and Motion

- how to determine the speed of a moving object and to use the quantitative relationship between speed, distance and time
- that the weight of an object on Earth is the result of the gravitational attraction between its mass and that of the Earth
- 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
- ways in which frictional forces, including air resistance, affect motion [for example, streamlining cars, friction between tyre and road]

Elements, Compounds, and Mixtures

- how elements combine through chemical reactions to form compounds [for example, water, carbon dioxide, magnesium oxide, sodium chloride, most minerals]with a definite composition

Changing Materials

- to relate changes of state to energy transfers

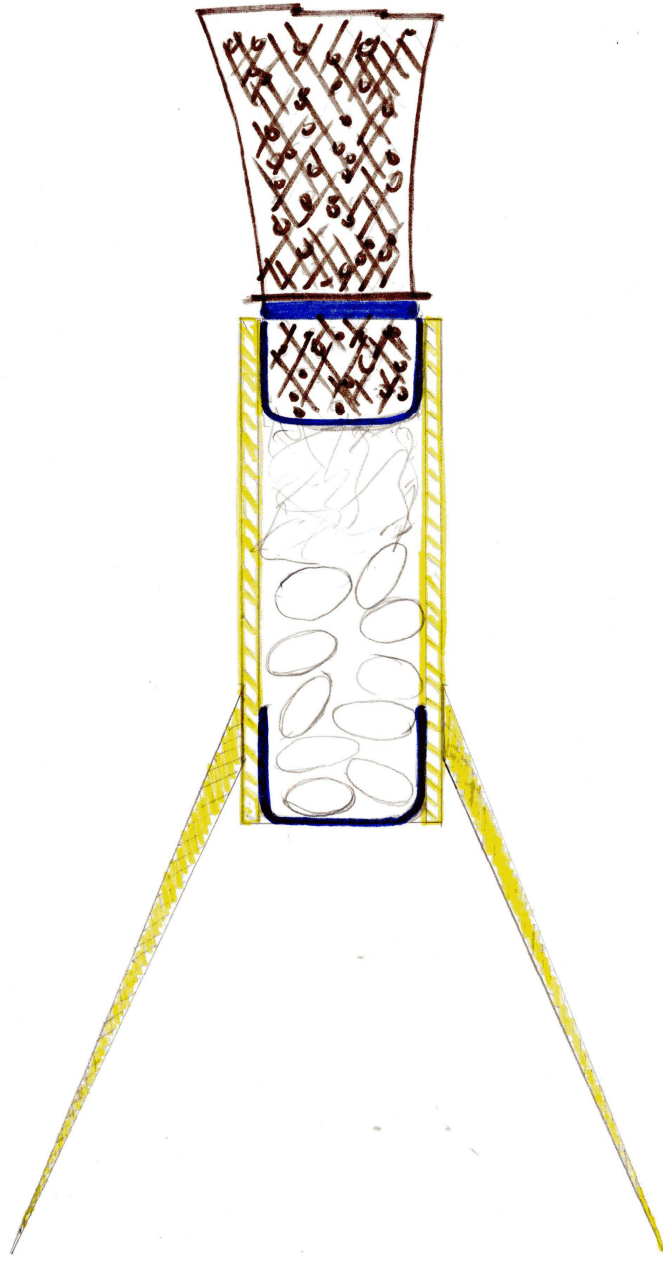
General Recommendations:

The idea of Mentos and soda has been done but this is a different spin on the idea. Combining the water rocket idea using the bottle as a projectile improves the WOW factor.

The coloured sketch on the following page shows a concept of the envisioned design. A cross section of the tube described above is shown with two of its tripod legs.

Pictures:

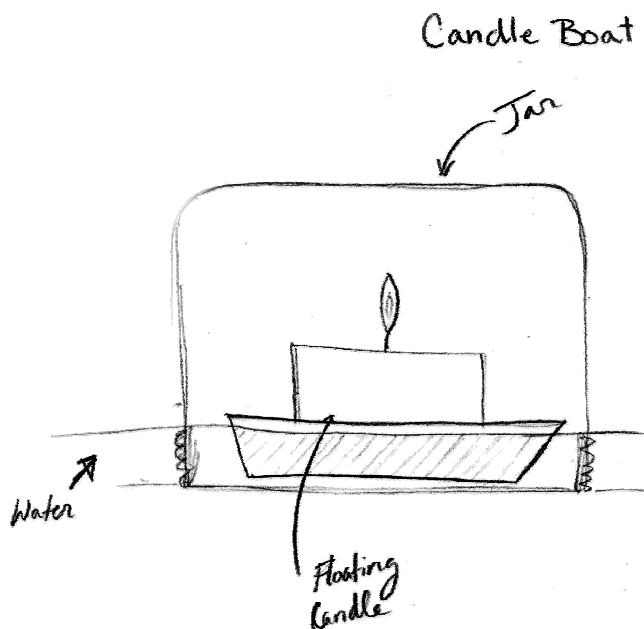
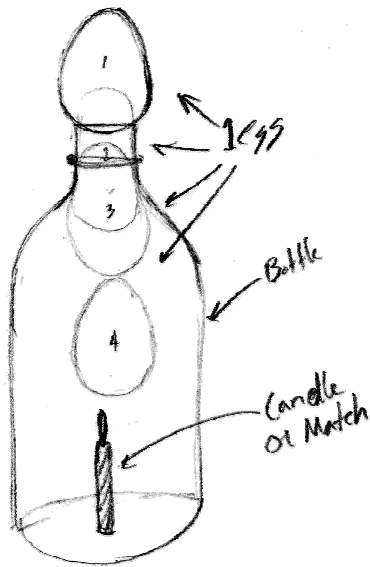




Rocket Base Concept

QAD# 12

Creating a Vacuum or Candle Boat



Creating a Vacuum or Candle Boat

| | |
|----------------|-------|
| WOW Factor | ☼☼☼☼☼ |
| Risk | ☼☼☼☼ |
| Cost Effective | ☼☼☼☼☼ |
| Find Materials | ☼☼☼☼☼ |
| Ease of Use | ☼☼☼☼ |
| Building Time | ☼ |

| | |
|-------------------|---|
| Team Name: | Science Museum 1 |
| Activity: | Creating a Vacuum (1)/ Candle Boat (2) |

| Material | Specific Use |
|-------------------------|-----------------|
| (1) For Creating Vacuum | |
| Hardboiled Egg | Creates Vacuum |
| Glass Bottle (Snapple) | Holds Egg |
| Match | Depletes Oxygen |
| (2) For Candle Boat | |
| Bucket of Water | Holds Boat |
| Jar | Creates Vacuum |
| Candle | Depletes Oxygen |
| Boat | Holds Candle |
| | |
| | |

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| Setup Required: |
| <p>For creating a vacuum:</p> <ol style="list-style-type: none"> 1. Hard-boil an egg and take off the shell. <p>For candle boat:</p> <ol style="list-style-type: none"> 1. Fill up bucket with water 2. Place candle on top of boat |

| |
|---|
| Problems Encountered: |
| <p>For creating a vacuum:</p> <ul style="list-style-type: none"> • A little bit difficult to keep a burning match in the glass bottle. |

| | | |
|-------------------------|------------------|----------------------------|
| Category: | IBLA | Demonstration |
| End Use: | Classroom | Outreach (Professional) |
| Tested: | Yes | No |
| Effect achieved? | Yes | No |

| | | |
|----------------|------------|--------------------|
| Tested: | Untested | Team Tested |
| | Explainers | Sophie and Rachel |
| | Teachers | Classrooms |
| | Families | Staff: |
| | Other: | |

| |
|---|
| Further development options: |
| There is no further development with creating a vacuum. |
| The candle boat (2) has not been developed. |

| |
|---|
| Performing the demonstration: |
| <p>For creating a vacuum:</p> <ol style="list-style-type: none"> 1. Light a match and place it in the bottle. 2. Balance egg on top of the bottle while match is still burning. 3. This should create a vacuum in the bottle and the egg will get sucked into the bottle <p>For candle boat:</p> <ol style="list-style-type: none"> 1. Light the candle boat and float it on the water. 2. Using a glass jar cover the candle boat. 3. Since the oxygen is being burned up, this makes the water level inside the jar rise. |

| |
|---|
| How could this be improved? |
| Either of these demonstrations can be scaled up by making everything bigger. (Get a pool, use a real boat to exaggerate the idea) |

| |
|-------------------------------------|
| How could this be scaled up? |
|-------------------------------------|

National Curriculum:

KS2

Investigative Skills

- ask questions that can be investigated scientifically and decide how to find answers
- consider what sources of information, including first-hand experience and a range of other sources, they will use to answer questions

Obtaining and Presenting Evidence

- use simple equipment and materials appropriately and take action to control risks

Considering Evidence and Evaluating

- make comparisons and identify simple patterns or associations in their own observations and measurements or other data
- use observations, measurements or other data to draw conclusions
- decide whether these conclusions agree with any prediction made and/or whether they enable further predictions to be made
- use their scientific knowledge and understanding to explain observations, measurements or other data or conclusions
- review their work and the work of others and describe its significance and limitations.

KS3

Investigative Skills

- use scientific knowledge and understanding to turn ideas into a form that can be investigated, and to decide on an appropriate approach
- decide whether to use evidence from first-hand experience or secondary sources
- carry out preliminary work and to make predictions, where appropriate

Obtaining and Presenting Evidence

- use a range of equipment and materials appropriately and take action to control risks to themselves and to others

Considering Evidence and Evaluating

- use observations, measurements and other data to draw conclusions
- decide to what extent these conclusions support a prediction or enable further predictions to be made
- use their scientific knowledge and understanding to explain and interpret observations, measurements or other data, and conclusions

Conservation of Energy

- how energy is transferred by the movement of particles in conduction, convection and evaporation, and that energy is transferred directly by radiation

General Recommendations:

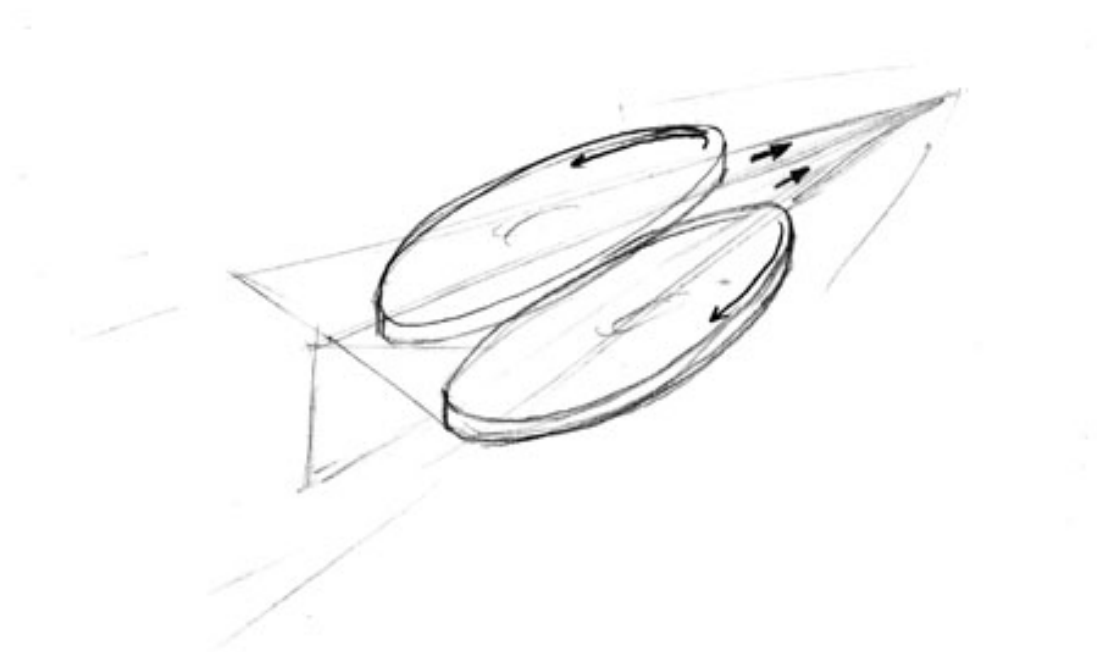
The creating a vacuum idea has been used in the past and therefore no further development has been made on it.

Pictures:



QAD# 13

Paper Airplane Launcher



Paper Airplane Launcher

| | |
|----------------|----------|
| WOW Factor | ☼☼☼☼☼☼☼☼ |
| Risk | ☼☼☼☼ |
| Cost Effective | ☼☼☼☼☼☼ |
| Find Materials | ☼☼☼☼ |
| Ease of Use | ☼☼☼☼☼☼ |
| Building Time | ☼☼☼ |

| | |
|-------------------|-------------------------|
| Team Name: | Science Museum 1 |
| Activity: | Paper Airplane Launcher |

| Material | Specific Use |
|--------------------|-------------------|
| Computer Paper | Creates Airplane |
| Launching Disc X 2 | Launches Airplane |
| Power Source | Powers Discs |
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| Setup Required: |
| <ol style="list-style-type: none"> 1. Have students develop a paper airplane with a flat vertical bottom so that it can appropriately fit in the airplane launcher. 2. Place the discs side by side so that they are touching slightly. 3. Connect the power source to the discs so that they will spin in opposite directions. (Left wheel should go counter clockwise and the right wheel should go clockwise) |

| |
|------------------------------|
| Problems Encountered: |
| Not applicable |

| | | |
|-------------------------|-----------|-------------------------|
| Category: | IBLA | Demonstration |
| End Use: | Classroom | Outreach (Professional) |
| Tested: | Yes | No |
| Effect achieved? | Yes | No |

| | | |
|----------------|------------|-------------------|
| Tested: | Untested | Team Tested |
| | Explainers | Sophie and Rachel |
| | Teachers | Classrooms |
| | Families | Staff: |
| | Other: | |

| |
|-------------------------------------|
| Further development options: |
| This is strictly a QAD |

| |
|--|
| Performing the demonstration: |
| <ol style="list-style-type: none"> 1. After the students have developed their airplane power the airplane launcher. 2. Place the airplane in the launcher and let go immediately. The airplane should be shot off a certain distance depending on the RPM of the wheels. |

| |
|------------------------------------|
| How could this be improved? |
| Not applicable |

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| How could this be scaled up? – n/a |
|---|

National Curriculum:

KS2

Investigative Skills

- ask questions that can be investigated scientifically and decide how to find answers
- consider what sources of information, including first-hand experience and a range of other sources, they will use to answer questions

Obtaining and Presenting Evidence

- use simple equipment and materials appropriately and take action to control risks

Considering Evidence and Evaluating

- make comparisons and identify simple patterns or associations in their own observations and measurements or other data
- use observations, measurements or other data to draw conclusions
- decide whether these conclusions agree with any prediction made and/or whether they enable further predictions to be made
- use their scientific knowledge and understanding to explain observations, measurements or other data or conclusions
- review their work and the work of others and describe its significance and limitations.

Forces and Motion

- that when objects [for example, a spring, a table] are pushed or pulled, an opposing pull or push can be felt
- how to measure forces and identify the direction in which they act.

KS3

Investigative Skills

- use scientific knowledge and understanding to turn ideas into a form that can be investigated, and to decide on an appropriate approach
- decide whether to use evidence from first-hand experience or secondary sources
- carry out preliminary work and to make predictions, where appropriate

Obtaining and Presenting Evidence

- use a range of equipment and materials appropriately and take action to control risks to themselves and to others

Considering Evidence and Evaluating

- use observations, measurements and other data to draw conclusions
- decide to what extent these conclusions support a prediction or enable further predictions to be made
- use their scientific knowledge and understanding to explain and interpret observations, measurements or other data, and conclusions

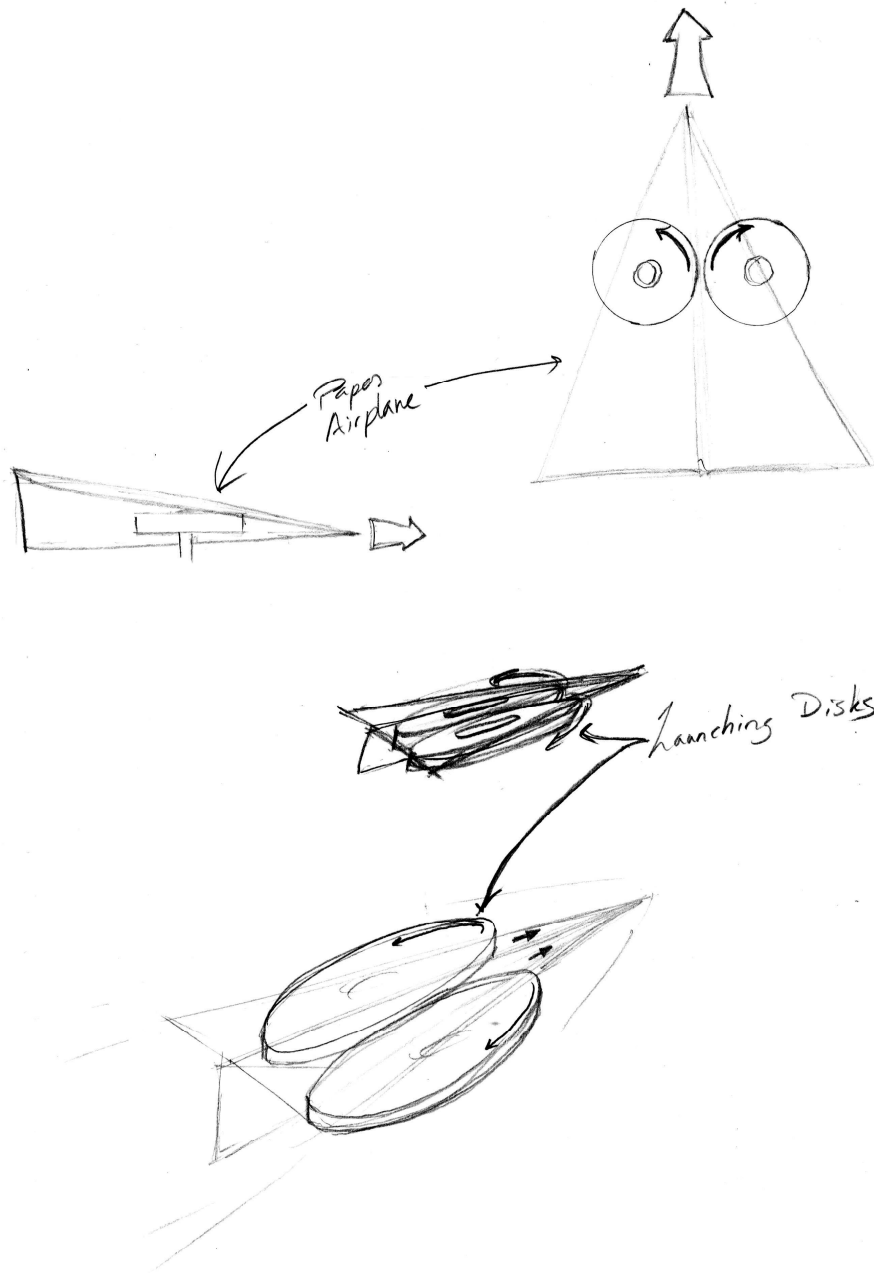
Forces and Motion

- how to determine the speed of a moving object and to use the quantitative relationship between speed, distance and time
- 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

General Recommendations:

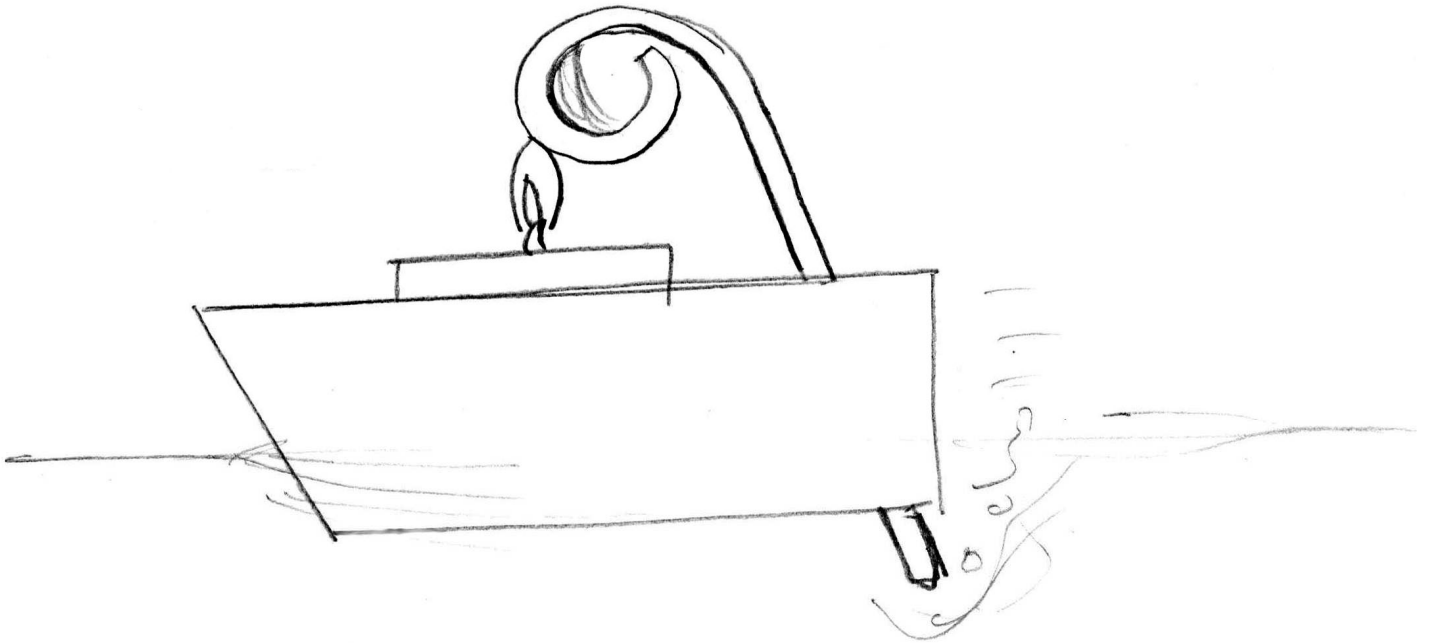
This is a very fun idea for a classroom demonstration. Fairly easy to perform but setting up could be difficult. Sourcing the right materials can also be hard.

Pictures:



QAD# 14

Heat Boat



Heat Boat

| | |
|----------------|--------|
| WOW Factor | ☼☼☼☼ |
| Risk | ☼☼ |
| Cost Effective | ☼☼☼☼☼☼ |
| Find Materials | ☼☼☼☼☼☼ |
| Ease of Use | ☼☼☼☼ |
| Building Time | ☼☼☼☼☼☼ |

| | |
|-------------------|------------------|
| Team Name: | Science Museum 1 |
| Activity: | Heat Boat |

| Material | Specific Use |
|--------------------|------------------|
| Paperclip | Conducts Heat |
| Candle | Produces Heat |
| Boat (Stale Bagel) | Holds Candle |
| Match or lighter | Initiates Candle |
| Bucket of Water | Holds Boat |
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| Setup Required: |
| <ol style="list-style-type: none"> 1. Fill up a bucket of water 2. Unroll a paperclip to shape it similar to a candy cane 3. Stick the paperclip through the stale bagel with the straight end on the bottom. 4. Place candle on the bagel and underneath the top end of the paperclip |

| |
|---|
| Problems Encountered: |
| Set up was easy, materials were easy to find, but the idea did not work as planned. |

| | | |
|-------------------------|-----------|-------------------------|
| Category: | IBLA | Demonstration |
| End Use: | Classroom | Outreach (Professional) |
| Tested: | Yes | No |
| Effect achieved? | Yes | No |

| | | |
|----------------|------------|-------------------|
| Tested: | Untested | Team Tested |
| | Explainers | Sophie and Rachel |
| | Teachers | Classrooms |
| | Families | Staff: |
| | Other: | |

| |
|---|
| Further development options: |
| Little development has been put into this idea. The idea does not seem to work. |

| |
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| Performing the demonstration: |
| <ol style="list-style-type: none"> 1. After filling the bucket with water place the boat into the water. Wait for the boat to be completely still in the water 2. Light the candle using a match or lighter. Doing so will create heat to go through the paperclip and into the water. This should, in theory, make the boat move. |

| |
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| How could this be improved? |
| A better conductive metal could be used over a paper clip. |
| A lighter boat might show a more dramatic effect. |

| |
|---|
| How could this be scaled up? – n/a |
|---|

National Curriculum:

KS2

Investigative Skills

- ask questions that can be investigated scientifically and decide how to find answers
- consider what sources of information, including first-hand experience and a range of other sources, they will use to answer questions

Obtaining and Presenting Evidence

- use simple equipment and materials appropriately and take action to control risks

Considering Evidence and Evaluating

- make comparisons and identify simple patterns or associations in their own observations and measurements or other data
- use observations, measurements or other data to draw conclusions
- decide whether these conclusions agree with any prediction made and/or whether they enable further predictions to be made
- use their scientific knowledge and understanding to explain observations, measurements or other data or conclusions
- review their work and the work of others and describe its significance and limitations.

KS3

Investigative Skills

- use scientific knowledge and understanding to turn ideas into a form that can be investigated, and to decide on an appropriate approach
- decide whether to use evidence from first-hand experience or secondary sources
- carry out preliminary work and to make predictions, where appropriate

Obtaining and Presenting Evidence

- use a range of equipment and materials appropriately and take action to control risks to themselves and to others

Considering Evidence and Evaluating

- use observations, measurements and other data to draw conclusions
- decide to what extent these conclusions support a prediction or enable further predictions to be made
- use their scientific knowledge and understanding to explain and interpret observations, measurements or other data, and conclusions

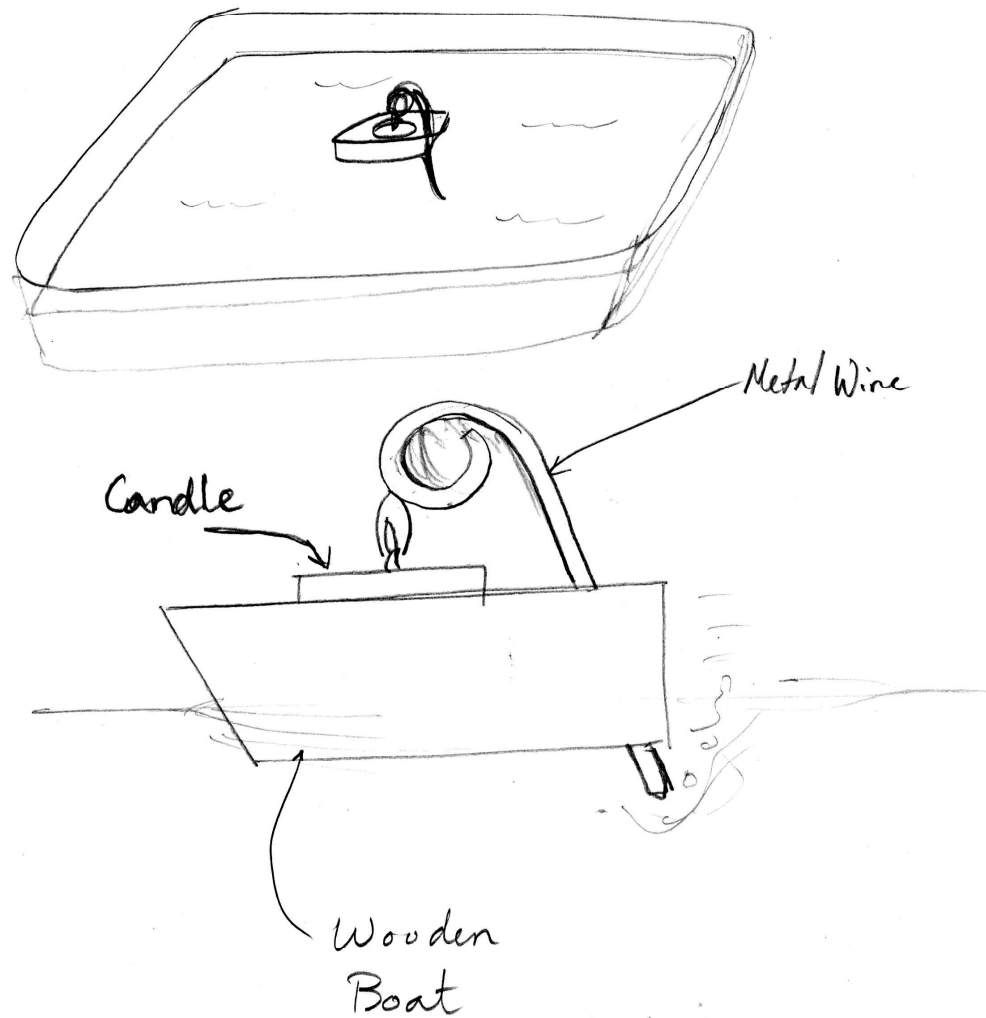
Conservation of Energy

- how energy is transferred by the movement of particles in conduction, convection and evaporation, and that energy is transferred directly by radiation

General Recommendations:

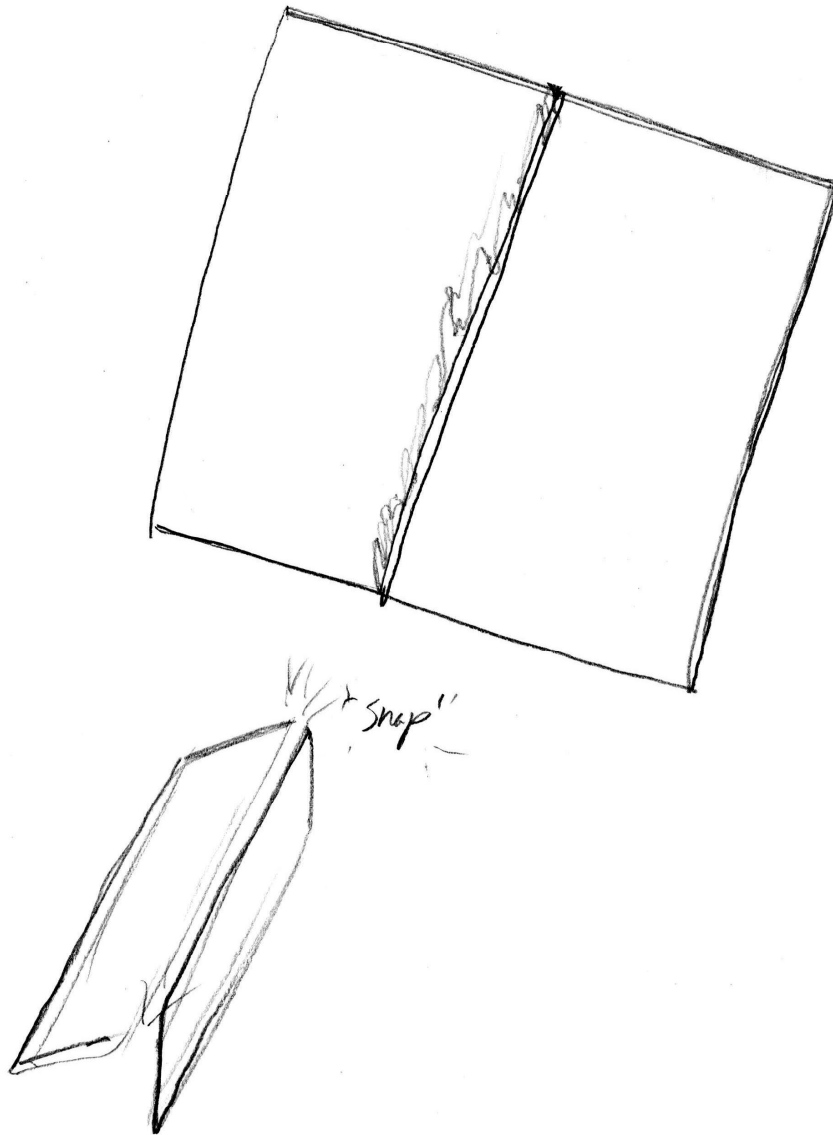
Even if the idea had work, creating a significant WOW factor may have been hard. There is no telling on how fast the boat would travel.

Pictures:



QAD# 15

Breaking Glass



Breaking Glass

| | |
|----------------|---------|
| WOW Factor | ☼☼☼☼☼ |
| Risk | ☼☼☼☼ |
| Cost Effective | ☼☼☼☼☼☼☼ |
| Find Materials | ☼☼☼☼☼☼☼ |
| Ease of Use | ☼ |
| Building Time | ☼☼☼☼☼ |

| | |
|-------------------|------------------|
| Team Name: | Science Museum 1 |
| Activity: | Breaking Glass |

| Material | Specific Use |
|-------------------------|--------------------|
| Glass (bottle or sheet) | Breaking Object |
| Soluble String | Hold Alcohol |
| Rubbing Alcohol | Burning Agent |
| Match or Lighter | Initiates Reaction |
| Bucket of Ice Water | Extinguishes Flame |
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| Setup Required: |
| 1. Soak a piece of string in a cup of rubbing alcohol. |
| 2. Tie the string around the glass bottle (tie near the top) and cut off excess. |
| 3. Have bucket of ice water ready before starting demonstration. |

| |
|---|
| Problems Encountered: |
| Breaking the top part of the bottle was fairly easy. However, when trying to break the bottle in the thicker areas it did not work. |
| Thick glass is much harder to break and may take multiple attempts to get the result. |

| | | |
|-------------------------|------------------|-------------------------|
| Category: | IBLA | Demonstration |
| End Use: | Classroom | Outreach (Professional) |
| Tested: | Yes | No |
| Effect achieved? | Yes | No |

| | | |
|----------------|------------|--------------------|
| Tested: | Untested | Team Tested |
| | Explainers | Sophie and Rachel |
| | Teachers | Classrooms |
| | Families | Staff: |
| | Other: | |

| |
|---|
| Further development options: |
| Using a piece of sheet glass or mirror instead of a glass bottle. |

| |
|---|
| Performing the demonstration: |
| 1. Light the string on fire using a match or lighter. Let it burn around the bottle until the flame is just about to go out. |
| 2. When the flame extinguishes plunge the bottle into the ice water. Make sure when plunging the bottle that the head of the glass bottle hits the bottom of the bucket with a good amount of force. Because of the extreme temperature difference of fire and ice water the glass should make a clean break where the string was tied. |

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| How could this be improved? |
| Use thinner glass to make it easier to break. |
| Children can also make designs out of glass by breaking the glass multiple times in different areas. |

| |
|--|
| How could this be scaled up? |
| Since fire is involved, a large sheet of glass can be used to increase the WOW factor. |

National Curriculum:

KS2

Investigative Skills

- ask questions that can be investigated scientifically and decide how to find answers
- consider what sources of information, including first-hand experience and a range of other sources, they will use to answer questions

Obtaining and Presenting Evidence

- use simple equipment and materials appropriately and take action to control risks

Considering Evidence and Evaluating

- make comparisons and identify simple patterns or associations in their own observations and measurements or other data
- use observations, measurements or other data to draw conclusions
- decide whether these conclusions agree with any prediction made and/or whether they enable further predictions to be made
- use their scientific knowledge and understanding to explain observations, measurements or other data or conclusions

Grouping and Classifying Materials

- 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

Changing Materials

- to describe changes that occur when materials [for example, water, clay, dough] are heated or cooled
- that temperature is a measure of how hot or cold things are

KS3

Investigative Skills

- use scientific knowledge and understanding to turn ideas into a form that can be investigated, and to decide on an appropriate approach
- decide whether to use evidence from first-hand experience or secondary sources
- carry out preliminary work and to make predictions, where appropriate

Obtaining and Presenting Evidence

- use a range of equipment and materials appropriately and take action to control risks to themselves and to others

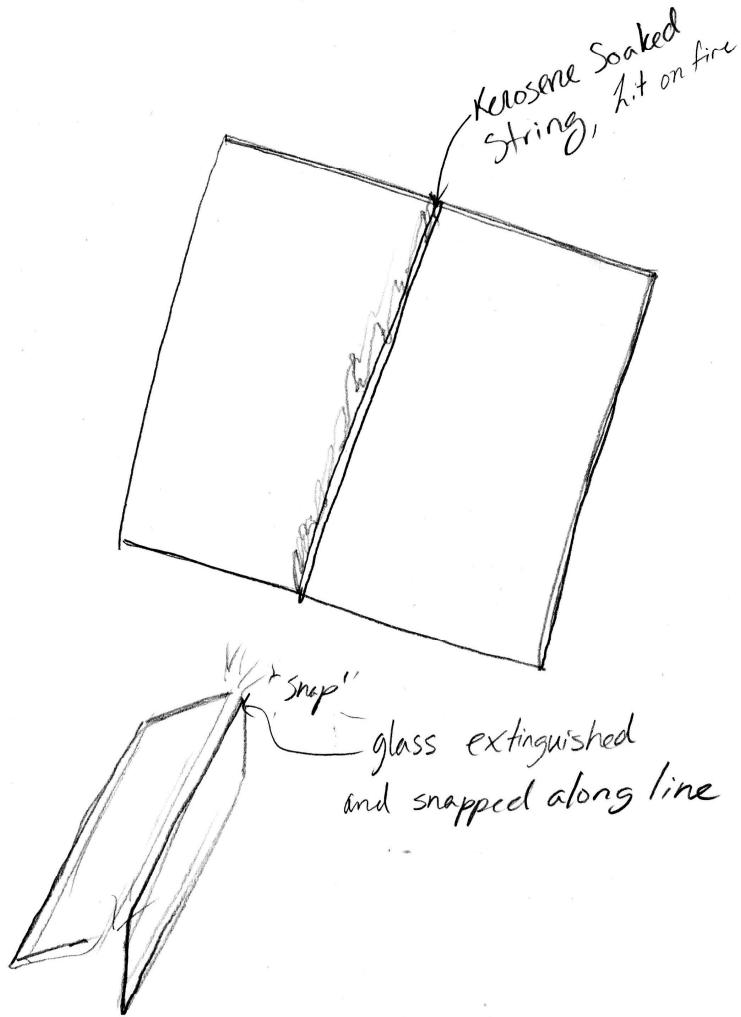
Considering Evidence and Evaluating

- use observations, measurements and other data to draw conclusions
- decide to what extent these conclusions support a prediction or enable further predictions to be made
- use their scientific knowledge and understanding to explain and interpret observations, measurements or other data, and conclusion

General Recommendations:

The idea does work, but not very efficiently. The demo was tried multiple times to get the glass to break in the thicker areas. It is highly recommended to use thinner glass (less than 1/4 inch)

Pictures:



QAD# 16

Imploding Can



Imploding Can

| | |
|----------------|---------|
| WOW Factor | ☼☼☼☼☼ |
| Risk | ☼☼☼☼ |
| Cost Effective | ☼☼☼☼☼☼☼ |
| Find Materials | ☼☼☼☼ |
| Ease of Use | ☼ |
| Building Time | ☼☼☼☼ |

| | |
|-------------------|------------------|
| Team Name: | Science Museum 1 |
| Activity: | Imploding Can |

| Material | Specific Use |
|---------------------|------------------|
| Heat Source | Heats Can |
| Soda Can (no steel) | Imploding Object |
| Bucket of Ice Water | Implodes Can |
| Tongs | Holds Can |
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| Setup Required: |
| 1. Fill bucket of ice water |
| 2. Fill a small amount of water in the can |

| |
|---|
| Problems Encountered: |
| The idea did not work as planned. No effect happened. May be due to lack of heat and not plunging the can in the water correctly. |

| | | |
|-------------------------|-----------|-------------------------|
| Category: | IBLA | Demonstration |
| End Use: | Classroom | Outreach (Professional) |
| Tested: | Yes | No |
| Effect achieved? | Yes | No |

| | | |
|----------------|------------|-------------------|
| Tested: | Untested | Team Tested |
| | Explainers | Sophie and Rachel |
| | Teachers | Classrooms |
| | Families | Staff: |
| | Other: | |

| |
|--|
| Further development options: |
| No further development has been made since effect has not been achieved. |

| |
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| Performing the demonstration: |
| 1. Heat up can until water starts to steam out of the can. The team heated up the can in multiple ways (using a toaster, lighter, and candles) |
| 2. Using tongs grip the can and plunge the can into the ice water with the open mouth hitting the water first. In theory, the can should implode since the temperature difference is very high. Also, the air is not able to escape from the can since the open mouth is covered by the water. |

| |
|---|
| How could this be improved? |
| Since the idea did not work, no improvements can be made. |

| |
|-------------------------------------|
| How could this be scaled up? |
| Not applicable |

National Curriculum:

KS2

Investigative Skills

- ask questions that can be investigated scientifically and decide how to find answers
- consider what sources of information, including first-hand experience and a range of other sources, they will use to answer questions

Obtaining and Presenting Evidence

- use simple equipment and materials appropriately and take action to control risks

Considering Evidence and Evaluating

- make comparisons and identify simple patterns or associations in their own observations and measurements or other data
- use observations, measurements or other data to draw conclusions
- decide whether these conclusions agree with any prediction made and/or whether they enable further predictions to be made
- use their scientific knowledge and understanding to explain observations, measurements or other data or conclusions

Changing Materials

- that temperature is a measure of how hot or cold things are

KS3

Investigative Skills

- use scientific knowledge and understanding to turn ideas into a form that can be investigated, and to decide on an appropriate approach
- decide whether to use evidence from first-hand experience or secondary sources
- carry out preliminary work and to make predictions, where appropriate

Obtaining and Presenting Evidence

- use a range of equipment and materials appropriately and take action to control risks to themselves and to others

Considering Evidence and Evaluating

- use observations, measurements and other data to draw conclusions
- decide to what extent these conclusions support a prediction or enable further predictions to be made

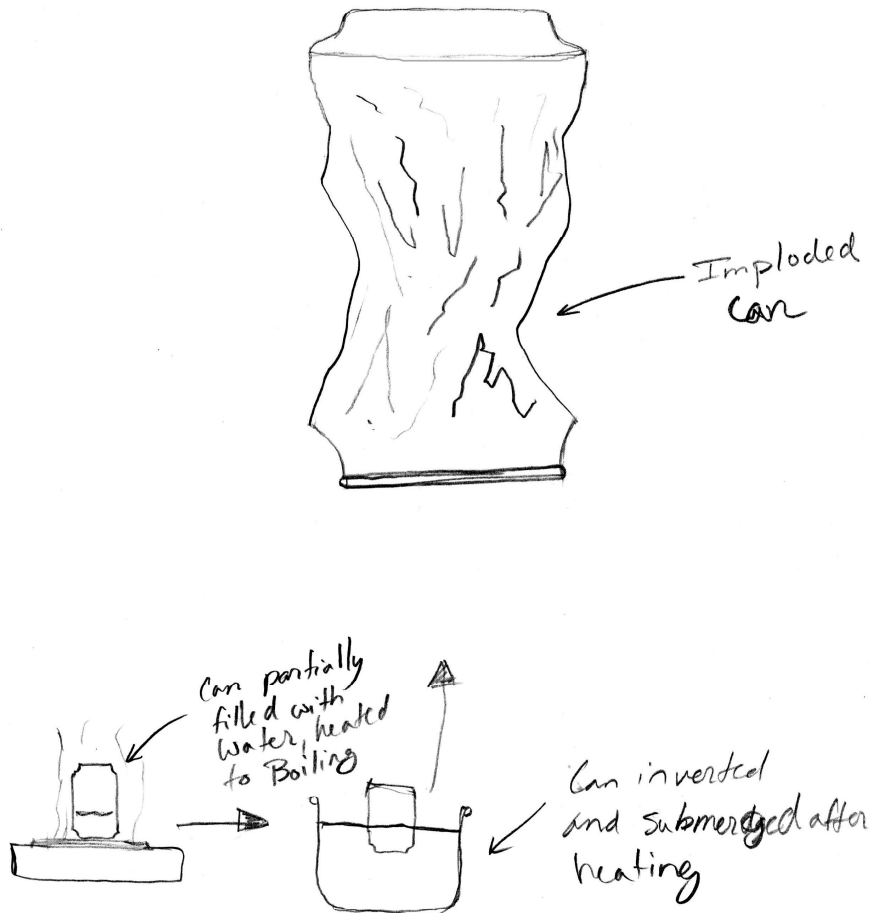
Forces and Pressure

- the quantitative relationship between force, area and pressure and its application [for example, the use of skis and snowboards, the effect of sharp blades, hydraulic brakes].

General Recommendations:

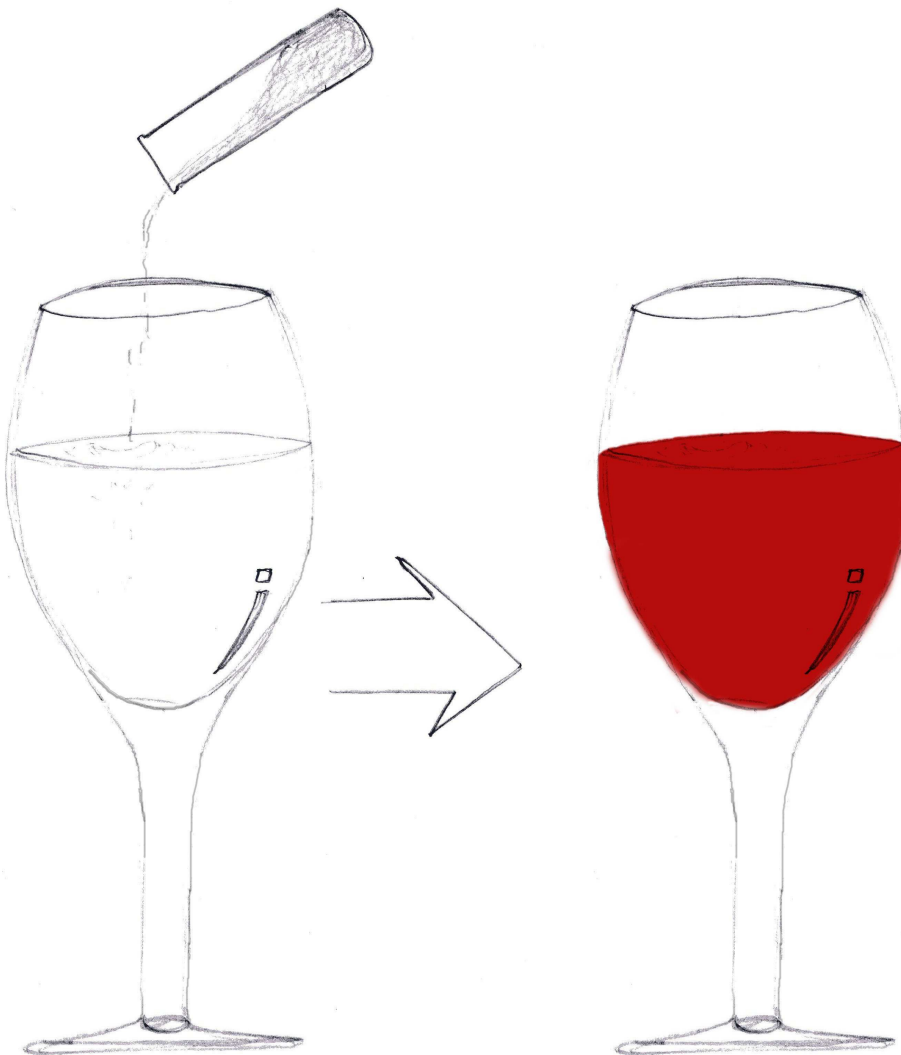
The idea is a rather common but it seems really difficult to execute. The WOW factor is pretty significant with not much set-up work. Unfortunately, the idea did not work properly.

Pictures:



QAD# 17

Water into Wine



Water into Wine

| | |
|----------------|-------|
| WOW Factor | ☼☼☼☼ |
| Risk | ☼☼☼☼☼ |
| Cost Effective | ☼☼☼☼☼ |
| Find Materials | ☼☼☼☼ |
| Ease of Use | ☼☼☼☼☼ |
| Building Time | ☼☼☼☼☼ |

| | |
|-------------------|------------------|
| Team Name: | Science Museum 1 |
| Activity: | Water Into Wine |

| Material | Specific Use |
|----------------------------|----------------|
| Wine Glass | Holds Solution |
| pH Indicator Solution | Changes Colour |
| Magic Powder (baking soda) | Changes Colour |
| Water | Base Solution |
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| Setup Required: |
| 1. Get wine glass and fill with water and pH indicating solution. |

| |
|------------------------------|
| Problems Encountered: |
| Not applicable |

| | | |
|-------------------------|-----------|-------------------------|
| Category: | IBLA | Demonstration |
| End Use: | Classroom | Outreach (Professional) |
| Tested: | Yes | No |
| Effect achieved? | Yes | No |

| | | |
|----------------|------------|-------------------|
| Tested: | Untested | Team Tested |
| | Explainers | Sophie and Rachel |
| | Teachers | Classrooms |
| | Families | Staff: |
| | Other: | |

| |
|-------------------------------------|
| Further development options: |
| This is strictly a QAD |

| |
|---|
| Performing the demonstration: |
| 1. Placing the baking soda in the wine glass will turn the solution red making it look like wine. |
| Other agents can be used other than baking soda. |

| |
|------------------------------------|
| How could this be improved? |
| Not applicable |

| |
|-------------------------------------|
| How could this be scaled up? |
| Not applicable |

National Curriculum:

KS2

Investigative Skills

- ask questions that can be investigated scientifically and decide how to find answers
- consider what sources of information, including first-hand experience and a range of other sources, they will use to answer questions

Grouping and Classifying Materials

- to compare everyday materials and objects on the basis of their material properties, including hardness, strength, flexibility and magnetic behavior, and to relate these properties to everyday uses of the materials

Changing Materials

- to describe changes that occur when materials are mixed [for example, adding salt to water]
- that non-reversible changes [for example, vinegar reacting with bicarbonate of soda, plaster of Paris with water] result in the formation of new materials that may be useful

KS3

Investigative Skills

- use scientific knowledge and understanding to turn ideas into a form that can be investigated, and to decide on an appropriate approach
- decide whether to use evidence from first-hand experience or secondary sources
- carry out preliminary work and to make predictions, where appropriate

Elements, Compounds, and Mixtures

- how elements combine through chemical reactions to form compounds [for example, water, carbon dioxide, magnesium oxide, sodium chloride, most minerals] with a definite composition

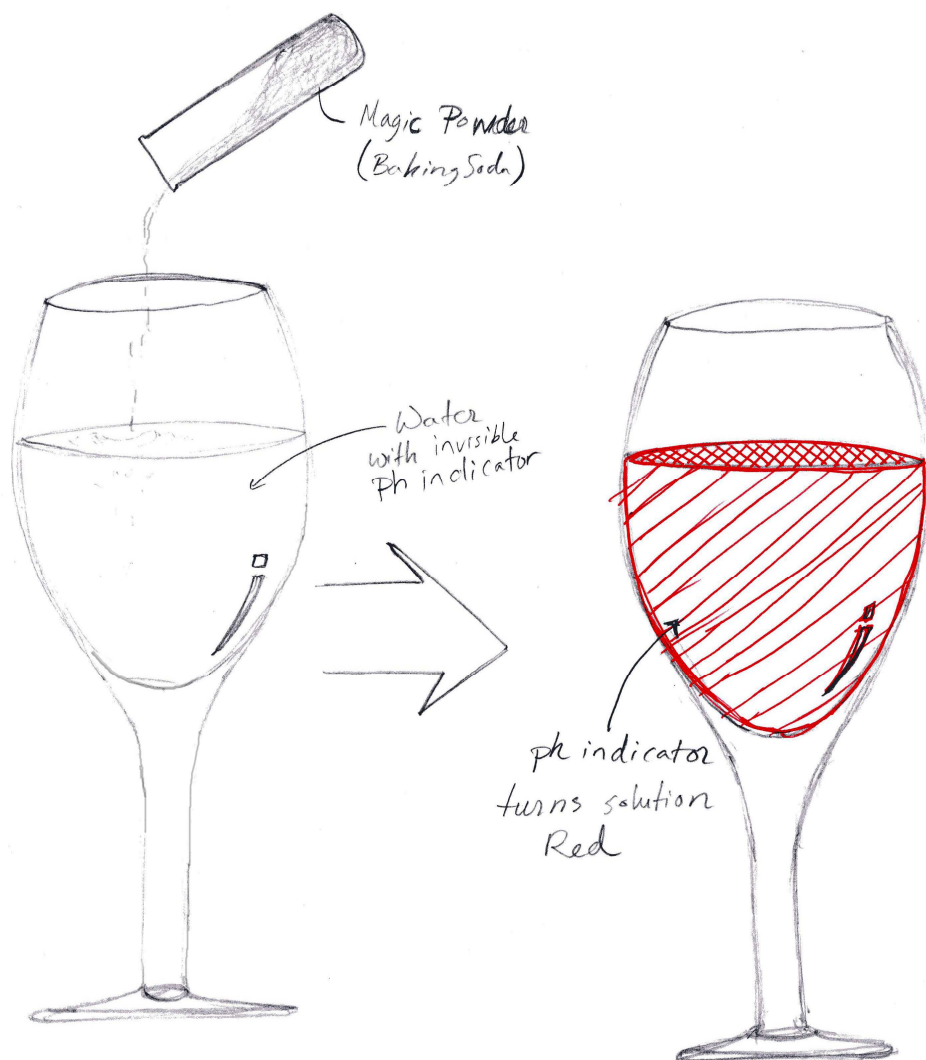
Changing Materials

- about the variation of solubility with temperature, the formation of saturated solutions, and the differences in solubility of solutes in different solvents

General Recommendations:

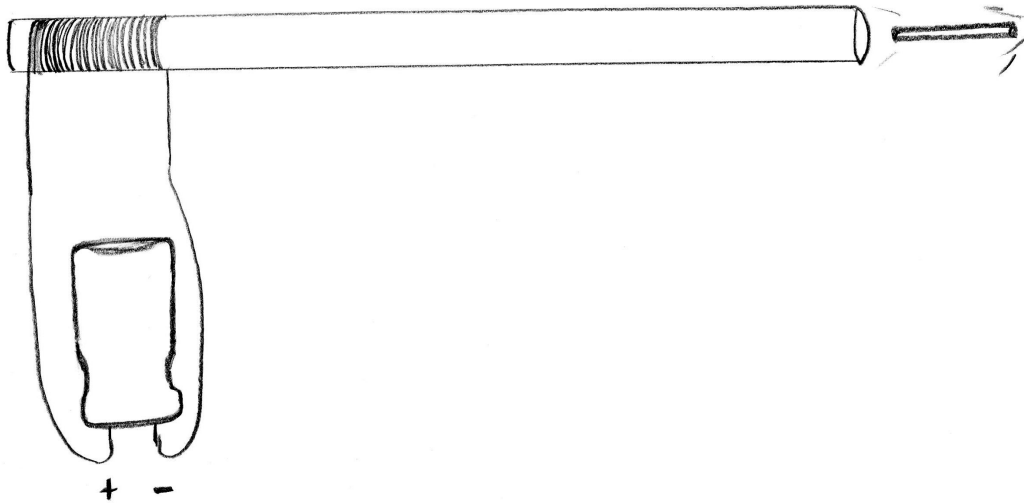
The idea is a very fun idea and easy to set up. It could be used for a demonstration for the outreach team about basic chemistry.

Pictures:



QAD# 18

Electromagnetic Accelerator



Electromagnetic Accelerator

| | |
|----------------|-------|
| WOW Factor | ☺☺☺☺☺ |
| Risk | ☺ |
| Cost Effective | ☺☺☺☺☺ |
| Find Materials | ☺☺ |
| Ease of Use | ☺☺ |
| Building Time | ☺☺☺☺ |

| | |
|-------------------|-----------------------------|
| Team Name: | Science Museum 1 |
| Activity: | Electromagnetic Accelerator |

| Material | Specific Use |
|------------------------------------|------------------------|
| Drinking Straw | Guides projectile |
| Copper Wire | Used to make coil |
| Capacitor | Creates magnetic field |
| Small metal rod (usually aluminum) | Projectile |
| | |
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|-------------------------|------------------|-------------------------|
| Category: | IBLA | Demonstration |
| End Use: | Classroom | Outreach (Professional) |
| Tested: | Yes | No |
| Effect achieved? | Yes | No |

| | | |
|----------------|-----------------|-------------------|
| Tested: | Untested | Team Tested |
| | Explainers | Sophie and Rachel |
| | Teachers | Classrooms |
| | Families | Staff: |
| | Other: | |

| |
|---|
| Further development options: |
| A similar demonstration is already implemented by the museum; therefore no further development options are given. |

| |
|---|
| Setup Required: |
| 1. Wrap copper wire around the straw many times forming a coil around a 3 cm portion of the drinking straw close to one end. Be sure to leave two leads for the ends of the coil. |
| 2. Charge capacitor. |
| 3. Insert metal rod just upstream of the coil. Rod is free floating, so be careful not to tip the straw and let the rod move or fall out. |

| |
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| Performing the demonstration: |
| 1. Aim the straw at a safe target. |
| 2. Discharge the capacitor across the coil via the two leads and watch the projectile fly. |

| |
|------------------------------|
| Problems Encountered: |
| Not applicable |

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|------------------------------------|
| How could this be improved? |
| Not applicable |

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| How could this be scaled up? |
| Not applicable |

National Curriculum:

KS2

Electricity

- to construct circuits, incorporating a battery or power supply and a range of switches, make electrical devices work [for example, buzzers, motors, lights]

Forces and motion

- about the forces of attraction and repulsion between magnets, and about the forces of attraction between magnets and magnetic materials

KS3

Magnetic fields

- about magnetic fields as regions of space where magnetic materials experience forces, and that like magnetic poles repel and unlike poles attract

Electromagnets

- that 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 [for example, relays, lifting magnets]

Forces and motion

- how to determine the speed of a moving object and to use the quantitative relationship between speed, distance and time
- 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

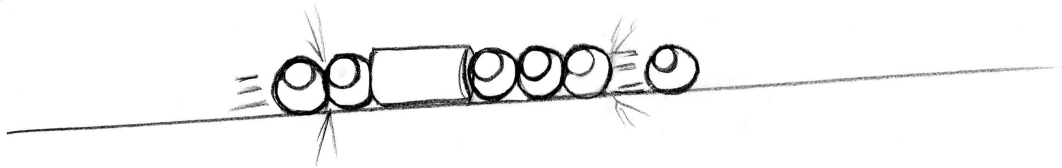
General Recommendations:

Due to the prior existence of this demonstration, no new recommendations are given at this time.

Pictures: N/A

QAD# 19

Gaussian Launcher



Gaussian Launcher

| | |
|----------------|-------|
| WOW Factor | ☺☺☺☺☺ |
| Risk | ☺☺ |
| Cost Effective | ☺☺☺☺ |
| Find Materials | ☺☺☺ |
| Ease of Use | ☺☺☺☺ |
| Building Time | ☺☺☺☺ |

| | |
|-------------------|-------------------|
| Team Name: | Science Museum 1 |
| Activity: | Gaussian Launcher |

| Material | Specific Use |
|---------------------|------------------------|
| Strong Magnet(s) | Attracts Ball Bearings |
| Steel Ball Bearings | Acts as Launcher |
| Track | Holds Ball Bearings |
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| Setup Required: |
| <ol style="list-style-type: none"> 1. Place ball bearings and magnet on track. 2. Place magnet in middle of the tract with 4 or more steel ball bearings on one side of it and 1 ball bearing on the other side of it. 3. Repeat this process as many times as desired. |

| |
|------------------------------|
| Problems Encountered: |
| |

| | | |
|-------------------------|------------------|-------------------------|
| Category: | IBLA | Demonstration |
| End Use: | Classroom | Outreach (Professional) |
| Tested: | Yes | No |
| Effect achieved? | Yes | No |

| | | |
|----------------|------------|--------------------|
| Tested: | Untested | Team Tested |
| | Explainers | Sophie and Rachel |
| | Teachers | Classrooms |
| | Families | Staff: |
| | Other: | |

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| Further development options: |
| Has been slightly developed and the theory does work. Have a series of magnets with ball bearings to create a “roller coaster” effect. |

| |
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| Performing the demonstration: |
| <ol style="list-style-type: none"> 1. Take 1 ball bearing and roll it towards the magnet on the side with one ball bearing. The magnet should then attract the ball with a good amount of force. Similar to Newton’s Cradle this will create the ball from the other side of the magnet to shoot off. Depending on the number of magnet/ball bearing set ups this could cause a chain reaction. <p>**Caution: Be careful and stand clear of where the ball bearing is being launched from.**</p> |

| |
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| How could this be improved? |
| |

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| How could this be scaled up? |
| As mentioned in the further development section, by combining more magnets and ball bearings a “roller coaster” effect can be achieved. The tracks can be set up to do “loops” and have slopes for balls to travel up and down on. |

National Curriculum:

KS2

Investigative Skills

- ask questions that can be investigated scientifically and decide how to find answers
- consider what sources of information, including first-hand experience and a range of other sources, they will use to answer questions

Obtaining and Presenting Evidence

- use simple equipment and materials appropriately and take action to control risks

Considering Evidence and Evaluating

- make comparisons and identify simple patterns or associations in their own observations and measurements or other data
- use observations, measurements or other data to draw conclusions
- decide whether these conclusions agree with any prediction made and/or whether they enable further predictions to be made
- use their scientific knowledge and understanding to explain observations, measurements or other data or conclusions
- review their work and the work of others and describe its significance and limitations.

Forces and Motion

- 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
- how to measure forces and identify the direction in which they act.

KS3

Investigative Skills

- use scientific knowledge and understanding to turn ideas into a form that can be investigated, and to decide on an appropriate approach
- decide whether to use evidence from first-hand experience or secondary sources
- carry out preliminary work and to make predictions, where appropriate

Obtaining and Presenting Evidence

- use a range of equipment and materials appropriately and take action to control risks to themselves and to others

Considering Evidence and Evaluating

- use observations, measurements and other data to draw conclusions
- decide to what extent these conclusions support a prediction or enable further predictions to be made
- use their scientific knowledge and understanding to explain and interpret observations, measurements or other data, and conclusions

Forces and Motion

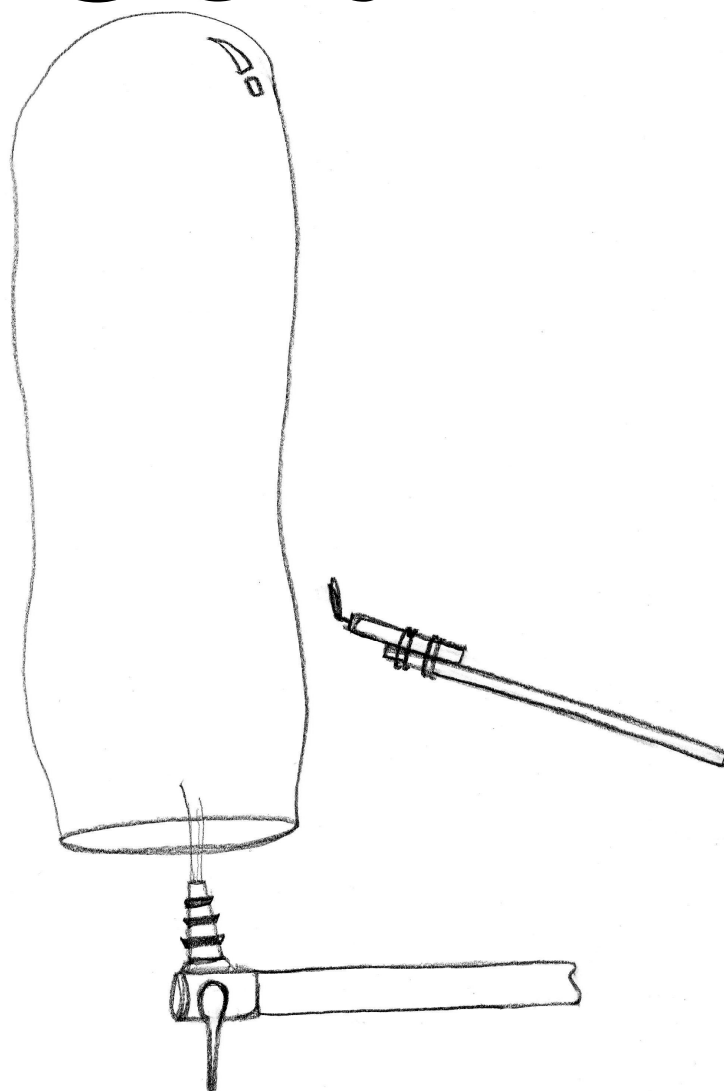
- how to determine the speed of a moving object and to use the quantitative relationship between speed, distance and time
- that unbalanced forces change the speed or direction of movement of objects

Magnetic Fields

- about magnetic fields as regions of space where magnetic materials experience forces, and that like magnetic poles repel and unlike poles attract

QAD# 20

Flammable Methane Bubble Column



Flammable Methane Bubble Column

| | |
|----------------|--------|
| WOW Factor | ☺☺☺☺☺☺ |
| Risk | ☺☺☺ |
| Cost Effective | ☺☺☺☺ |
| Find Materials | ☺☺ |
| Ease of Use | ☺☺☺☺ |
| Building Time | ☺☺☺☺ |

| | |
|-------------------|------------------------------------|
| Team Name: | Science Museum 1 |
| Activity: | Flammable Methane Bubble Column |

| Material | Specific Use |
|-------------|-------------------------|
| Bubble Mix | Creates bubble |
| Methane Gas | Creates flammability |
| Column | Attaches to gas chamber |
| Lighter | Creates Flame |
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|-------------------------|-----------|----------------------------|
| Category: | IBLA | Demonstration |
| End Use: | Classroom | Outreach (Professional) |
| Tested: | Yes | No |
| Effect achieved? | Yes | No |

| | | |
|----------------|------------|-------------------|
| Tested: | Untested | Team Tested |
| | Explainers | Sophie and Rachel |
| | Teachers | Classrooms |
| | Families | Staff: |
| | Other: | |

| |
|---|
| Further development options: |
| This is strictly a QAD. This has been done already. |

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| Setup Required: |
| <ol style="list-style-type: none"> 1. Attach column to the hose where the methane gas will disburse. 2. Apply the bubble mix to the end of the column. |

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| Performing the demonstration: |
| <ol style="list-style-type: none"> 1. Turn on the methane gas to start creating the bubble. 2. Once the column is at its desired size take a lighter and light the bubble. This should create a flame where the bubble was. |

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| Problems Encountered: |
| A similar demonstration is already used by the Science Museum |

| |
|------------------------------------|
| How could this be improved? |
| n/a |

| |
|---|
| How could this be scaled up? – n/a |
|---|

National Curriculum:

KS2

Investigative Skills

- ask questions that can be investigated scientifically and decide how to find answers
- consider what sources of information, including first-hand experience and a range of other sources, they will use to answer questions

Grouping and Classifying Materials

- 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

Changing Materials

- to describe changes that occur when materials [for example, water, clay, dough] are heated or cooled
- that temperature is a measure of how hot or cold things are

KS3

Investigative Skills

- use scientific knowledge and understanding to turn ideas into a form that can be investigated, and to decide on an appropriate approach
- decide whether to use evidence from first-hand experience or secondary sources
- carry out preliminary work and to make predictions, where appropriate

Chemical Reactions

- how mass is conserved when chemical reactions take place because the same atoms are present, although combined in different ways

General Recommendations:

Pictures:

QAD# 21

Liquid Nitrogen Bubbles



Liquid Nitrogen Bubbles

| | |
|----------------|--------|
| WOW Factor | ☼☼☼☼☼☼ |
| Risk | ☼☼ |
| Cost Effective | ☼☼☼☼☼ |
| Find Materials | ☼☼☼ |
| Ease of Use | ☼☼☼☼☼ |
| Building Time | ☼☼☼☼☼ |

| | |
|-------------------|-------------------------|
| Team Name: | Science Museum 1 |
| Activity: | Liquid Nitrogen Bubbles |

| Material | Specific Use |
|-----------------|-----------------------|
| Warm Water | Creates bubbles |
| Liquid Nitrogen | Creates bubbles |
| Bucket | Holds liquid nitrogen |
| Glycerol | Alternative Mix |
| Dish Soap | Creates Bubbles |
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| Setup Required: |
| <ol style="list-style-type: none"> 1. Fill bucket up with water, dish soap, and glycerol. (About 2 liters of water, few tablespoons of dish soap, and few tablespoons of glycerol). 2. Place liquid nitrogen in canister |

| |
|---|
| Problems Encountered: |
| <p>The liquid nitrogen is hard to find.</p> <p>There are safety issues to take in account. Handling liquid nitrogen can be dangerous for a child.</p> |

| | | |
|-------------------------|-----------|-------------------------|
| Category: | IBLA | Demonstration |
| End Use: | Classroom | Outreach (Professional) |
| Tested: | Yes | No |
| Effect achieved? | Yes | No |

| | | |
|----------------|------------|-------------------|
| Tested: | Untested | Team Tested |
| | Explainers | Sophie and Rachel |
| | Teachers | Classrooms |
| | Families | Staff: |
| | Other: | |

| |
|---|
| Further development options: |
| <p>Lots of team testing has been done and results are exciting.</p> |

| |
|--|
| Performing the demonstration: |
| <ol style="list-style-type: none"> 1. Dump liquid nitrogen in bucket of water. This should then create a chemical reaction between the two solutions and create many, many bubbles. |

| |
|--|
| How could this be improved? |
| <p>Finding the perfect ratio of water, dish soap, and glycerol to create maximum amount of bubbles.</p> <p>Use a narrower bucket (taller and skinnier) for bubbles to “immerse” the performer.</p> |

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National Curriculum:

KS2

Investigative Skills

- ask questions that can be investigated scientifically and decide how to find answers
- consider what sources of information, including first-hand experience and a range of other sources, they will use to answer questions

Grouping and Classifying Materials

- to compare everyday materials and objects on the basis of their material properties, including hardness, strength, flexibility and magnetic behavior, and to relate these properties to everyday uses of the materials

Changing Materials

- to describe changes that occur when materials are mixed [for example, adding salt to water]
- that non-reversible changes [for example, vinegar reacting with bicarbonate of soda, plaster of Paris with water] result in the formation of new materials that may be useful

KS3

Investigative Skills

- use scientific knowledge and understanding to turn ideas into a form that can be investigated, and to decide on an appropriate approach
- decide whether to use evidence from first-hand experience or secondary sources
- carry out preliminary work and to make predictions, where appropriate

Elements, Compounds, and Mixtures

- how elements combine through chemical reactions to form compounds [for example, water, carbon dioxide, magnesium oxide, sodium chloride, most minerals] with a definite composition

Changing Materials

- about the variation of solubility with temperature, the formation of saturated solutions, and the differences in solubility of solutes in different solvents

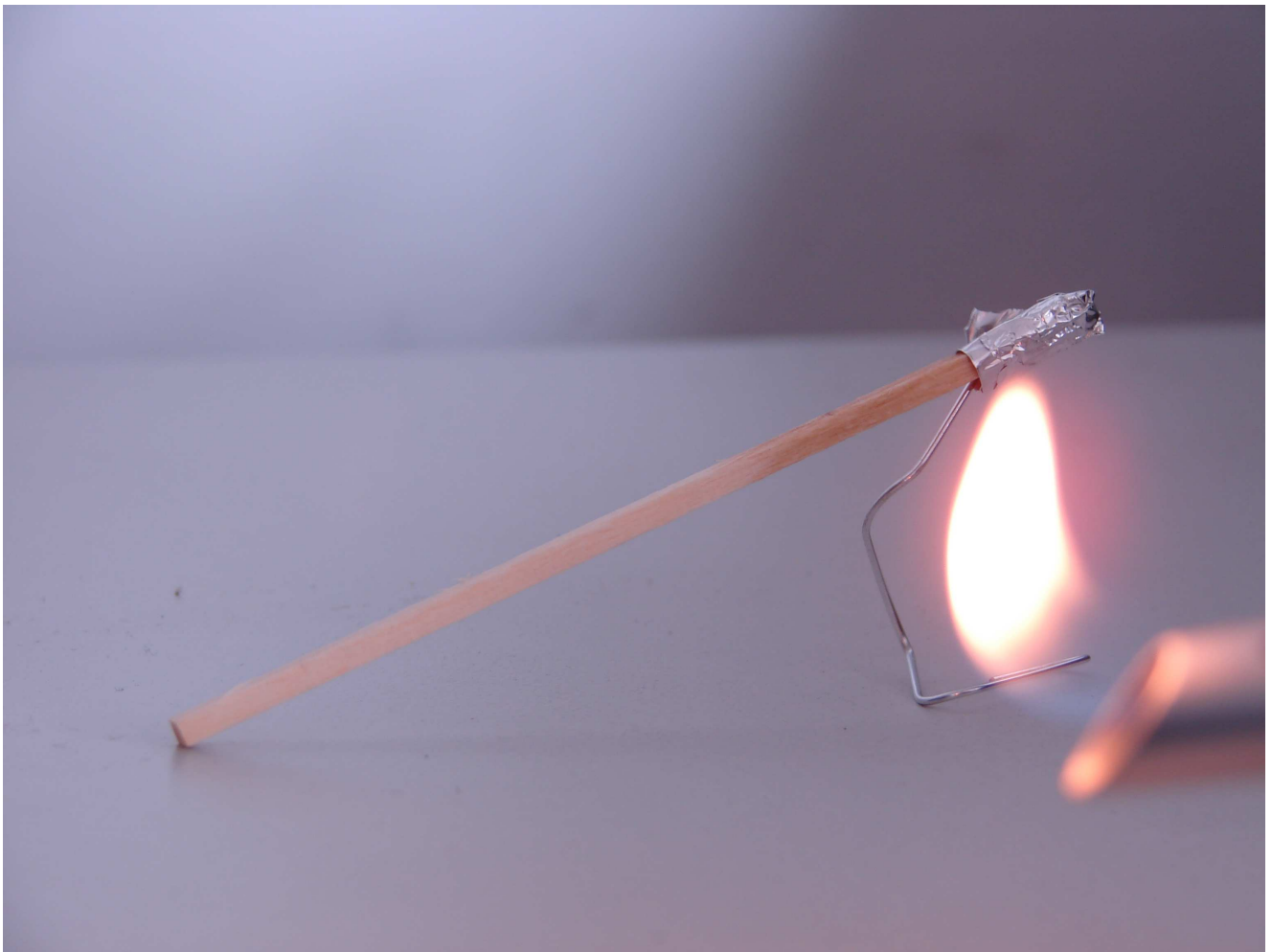
General Recommendations:

Pictures:



QAD# 22

Match Rocket



Match Rocket

| | |
|----------------|--------|
| WOW Factor | ☼☼☼☼☼☼ |
| Risk | ☼☼ |
| Cost Effective | ☼☼☼☼ |
| Find Materials | ☼☼☼☼☼☼ |
| Ease of Use | ☼☼☼☼ |
| Building Time | ☼☼☼☼☼ |

| | |
|-------------------|------------------|
| Team Name: | Science Museum 1 |
| Activity: | Match Rocket |

| Material | Specific Use |
|----------------|-----------------|
| Matches | Produces Rocket |
| Aluminium Foil | Holds Pressure |
| Lighter | Ignites Match |
| Paperclip | Holds Rocket |
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| Setup Required: |
| <ol style="list-style-type: none"> 1. Take a match and wrap the tip of with a small amount of aluminium foil. 2. Reshape the paperclip so that one end can go in the aluminium foil to create an air chamber. 3. With the rest of the paperclip create a stand for the match so that it can stand. (See picture for details) |

| |
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| Problems Encountered: |
| The demonstration did not work. The match would light up and burn through the aluminium foil but not propel. |

| | | |
|-------------------------|-----------|-------------------------|
| Category: | IBLA | Demonstration |
| End Use: | Classroom | Outreach (Professional) |
| Tested: | Yes | No |
| Effect achieved? | Yes | No |

| | | |
|----------------|------------|-------------------|
| Tested: | Untested | Team Tested |
| | Explainers | Sophie and Rachel |
| | Teachers | Classrooms |
| | Families | Staff: |
| | Other: | |

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|---|
| Further development options: |
| Effect was not achieved so no further development was considered. |

| |
|--|
| Performing the demonstration: |
| <ol style="list-style-type: none"> 1. This demonstration should be performed outside with no flammable object nearby. 2. Take the lighter and ignite the match. This should then create the match to heat up and create pressure within the aluminium foil and fire the match like a rocket. |

| |
|--|
| How could this be improved? |
| Not applicable |
| How could this be scaled up? |
| If the demonstration had worked more matches could have been used to make the rocket go farther. |

National Curriculum:

KS2

Investigative skills

- ask questions that can be investigated scientifically and decide how to find answers
- consider what sources of information, including first-hand experience and a range of other sources, they will use to answer questions
- 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

Obtaining and presenting evidence

- check observations and measurements by repeating them where appropriate

Considering evidence and evaluating

- use observations, measurements or other data to draw conclusions
- decide whether these conclusions agree with any prediction made and/or whether they enable further predictions to be made
- use their scientific knowledge and understanding to explain observations, measurements or other data or conclusions
- review their work and the work of others and describe its significance and limitations.

Grouping and Classifying Materials

- to recognise differences between solids, liquids and gases, in terms of ease of flow and maintenance of shape and volume.

Changing Materials

- to describe changes that occur when materials are mixed [for example, adding salt to water]
- about reversible changes, including dissolving, melting, boiling, condensing, freezing and evaporating

KS3

Ideas and evidence in science

- that it is important to test explanations by using them to make predictions and by seeing if evidence matches the predictions

Investigative skills

- use scientific knowledge and understanding to turn ideas into a form that can be investigated, and to decide on an appropriate approach
- decide whether to use evidence from first-hand experience or secondary sources
- carry out preliminary work and to make predictions, where appropriate

Considering Evidence

- use observations, measurements and other data to draw conclusions
- decide to what extent these conclusions support a prediction or enable further predictions to be made
- use their scientific knowledge and understanding to explain and interpret observations, measurements or other data, and conclusions

Evaluating

- consider anomalies in observations or measurements and try to explain them
- consider whether the evidence is sufficient to support any conclusions or interpretations made

General Recommendations:

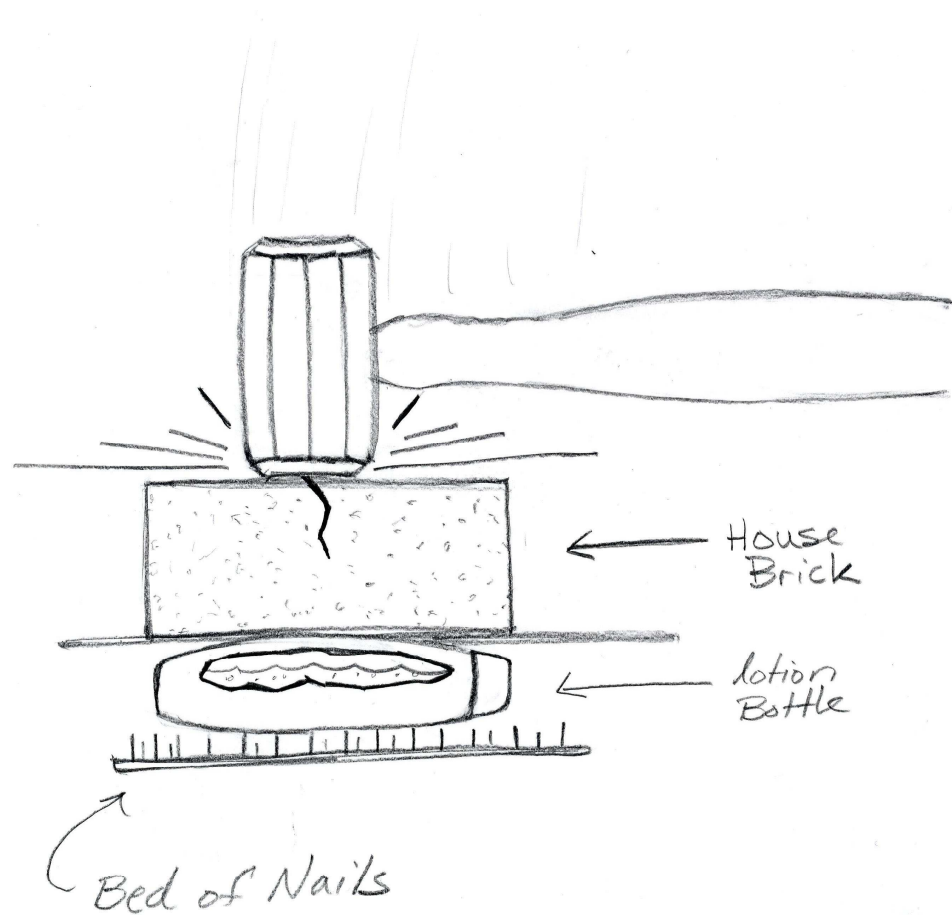
In theory, the match rocket should be able to fire up to 30 feet. There are a lot of safety factors to take into account though. Gloves and goggles are a must.

Pictures:



QAD# 23

Bed of Nails



Bed of Nails

| | |
|----------------|-------|
| WOW Factor | ☆☆☆☆☆ |
| Risk | ☆☆☆ |
| Cost Effective | ☆☆☆☆☆ |
| Find Materials | ☆☆☆☆☆ |
| Ease of Use | ☆☆☆☆☆ |
| Building Time | ☆☆☆ |

| | |
|-------------------|------------------|
| Team Name: | Science Museum 1 |
| Activity: | Bed of Nails |

| Material | Specific Use |
|---------------|---------------------|
| Hammer | Breaks Brick |
| Brick | Lays on Bottle |
| Lotion Bottle | Non-breaking Object |
| Piece of wood | Holds Nails |
| Nails | Lays on Wood |
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| Setup Required: |
| <ol style="list-style-type: none"> 1. Place multiple nails within board. 2. Place lotion bottle on top of the nails 3. Place brick on top of the lotion bottle |

| |
|------------------------------|
| Problems Encountered: |
| n/a |

| | | |
|-------------------------|-----------|-------------------------|
| Category: | IBLA | Demonstration |
| End Use: | Classroom | Outreach (Professional) |
| Tested: | Yes | No |
| Effect achieved? | Yes | No |

| | | |
|----------------|------------|-------------------|
| Tested: | Untested | Team Tested |
| | Explainers | Sophie and Rachel |
| | Teachers | Classrooms |
| | Families | Staff: |
| | Other: | |

| |
|-------------------------------------|
| Further development options: |
| This is strictly a QAD |

| |
|--|
| Performing the demonstration: |
| <p>1. Using the hammer, forcefully hit the brick. In theory, the audience would think that the lotion bottle will explode open since a hammer is pounding on it. However, the nails on the bottom of the lotion bottle act as weight distributors. Therefore, the lotion bottle will not break regardless of how hard the performer swings the hammer.</p> |

| |
|-------------------------------------|
| How could this be improved? |
| n/a |
| How could this be scaled up? |
| n/a |

National Curriculum:

KS2

Investigative Skills

- ask questions that can be investigated scientifically and decide how to find answers
- consider what sources of information, including first-hand experience and a range of other sources, they will use to answer questions

Obtaining and Presenting Evidence

- use simple equipment and materials appropriately and take action to control risks

Considering Evidence and Evaluating

- make comparisons and identify simple patterns or associations in their own observations and measurements or other data
- use observations, measurements or other data to draw conclusions
- decide whether these conclusions agree with any prediction made and/or whether they enable further predictions to be made
- use their scientific knowledge and understanding to explain observations, measurements or other data or conclusions
- review their work and the work of others and describe its significance and limitations.

Forces and Motion

- that when objects [for example, a spring, a table] are pushed or pulled, an opposing pull or push can be felt
- how to measure forces and identify the direction in which they act.

KS3

Investigative Skills

- use scientific knowledge and understanding to turn ideas into a form that can be investigated, and to decide on an appropriate approach
- decide whether to use evidence from first-hand experience or secondary sources
- carry out preliminary work and to make predictions, where appropriate

Obtaining and Presenting Evidence

- use a range of equipment and materials appropriately and take action to control risks to themselves and to others

Considering Evidence and Evaluating

- use observations, measurements and other data to draw conclusions
- decide to what extent these conclusions support a prediction or enable further predictions to be made
- use their scientific knowledge and understanding to explain and interpret observations, measurements or other data, and conclusions

Conservation of Energy

- how energy is transferred by the movement of particles in conduction, convection and evaporation, and that energy is transferred directly by radiation

Forces and Motion

- 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

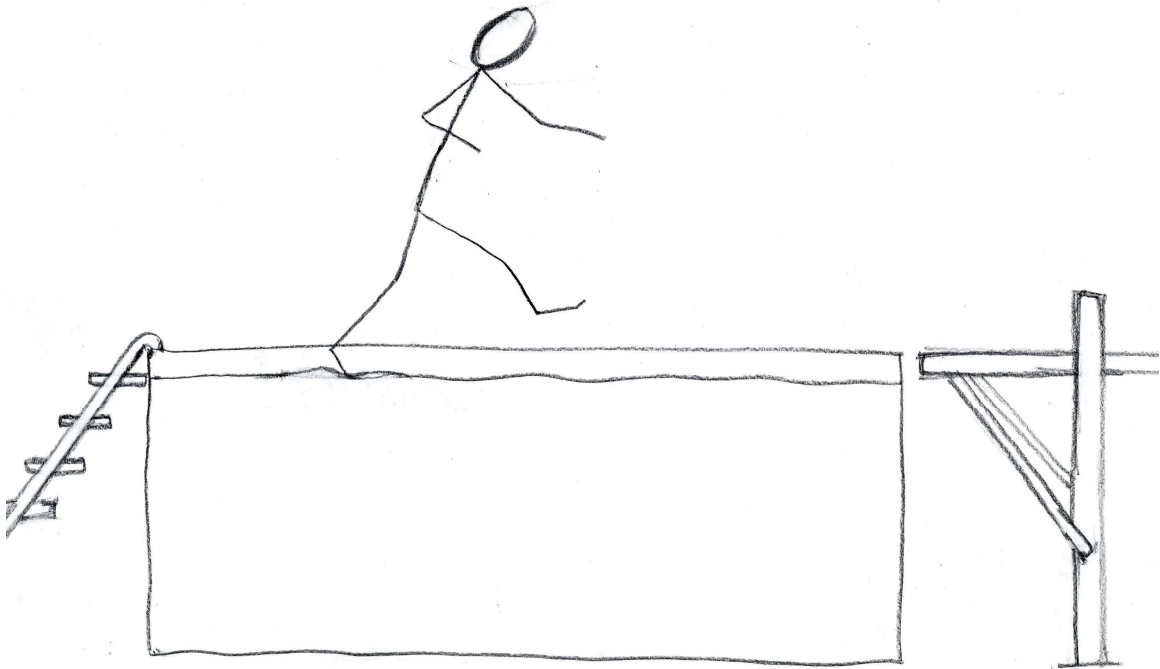
General Recommendations:

Though an untested idea, it still seems to be a fun and exciting demonstration. This idea was not developed due to time constraints.

Pictures:

QAD# 24

“Walking on Water”



“Walking on Water”

| | |
|----------------|--------|
| WOW Factor | ☼☼☼☼☼☼ |
| Risk | ☼☼☼☼☼☼ |
| Cost Effective | ☼☼☼☼ |
| Find Materials | ☼☼☼ |
| Ease of Use | ☼☼☼☼☼ |
| Building Time | ☼☼ |

| | |
|-------------------|------------------|
| Team Name: | Science Museum 1 |
| Activity: | Bed of Nails |

| Material | Specific Use |
|---------------------|-------------------|
| Small Swimming Pool | Holds “water” |
| Cornflower | Creates viscosity |
| Water | Creates mixture |
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|-------------------------|-----------|-------------------------|
| Category: | IBLA | Demonstration |
| End Use: | Classroom | Outreach (Professional) |
| Tested: | Yes | No |
| Effect achieved? | Yes | No |

| | | |
|----------------|------------|-------------------|
| Tested: | Untested | Team Tested |
| | Explainers | Sophie and Rachel |
| | Teachers | Classrooms |
| | Families | Staff: |
| | Other: | |

| |
|-------------------------------------|
| Further development options: |
| This is strictly a QAD |

| |
|---|
| Setup Required: |
| 1. Fill tank with cornflower and water mix it up until the consistency is very viscous. |

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|--|
| Performing the demonstration: |
| 1. Due to the viscosity of the water, one should be able to “walk” on the water without getting wet. However, if one stands in the pool that person will sink. |

| |
|------------------------------|
| Problems Encountered: |
| n/a |

| |
|-------------------------------------|
| How could this be improved? |
| n/a |
| How could this be scaled up? |
| n/a |

National Curriculum:

KS2

Investigative skills

- ask questions that can be investigated scientifically and decide how to find answers
- consider what sources of information, including first-hand experience and a range of other sources, they will use to answer questions
- 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

Obtaining and presenting evidence

- check observations and measurements by repeating them where appropriate

Considering evidence and evaluating

- use observations, measurements or other data to draw conclusions
- decide whether these conclusions agree with any prediction made and/or whether they enable further predictions to be made
- use their scientific knowledge and understanding to explain observations, measurements or other data or conclusions
- review their work and the work of others and describe its significance and limitations.

Grouping and Classifying Materials

- to recognise differences between solids, liquids and gases, in terms of ease of flow and maintenance of shape and volume.

Changing Materials

- to describe changes that occur when materials are mixed [for example, adding salt to water]
- about reversible changes, including dissolving, melting, boiling, condensing, freezing and evaporating

KS3

Ideas and evidence in science

- that it is important to test explanations by using them to make predictions and by seeing if evidence matches the predictions

Investigative skills

- use scientific knowledge and understanding to turn ideas into a form that can be investigated, and to decide on an appropriate approach
- decide whether to use evidence from first-hand experience or secondary sources

Changing Materials

- that when physical changes [for example, changes of state, formation of solutions]take place, mass is conserved
- about the variation of solubility with temperature, the formation of saturated solutions, and the differences in solubility of solutes in different solvents
- to relate changes of state to energy transfers

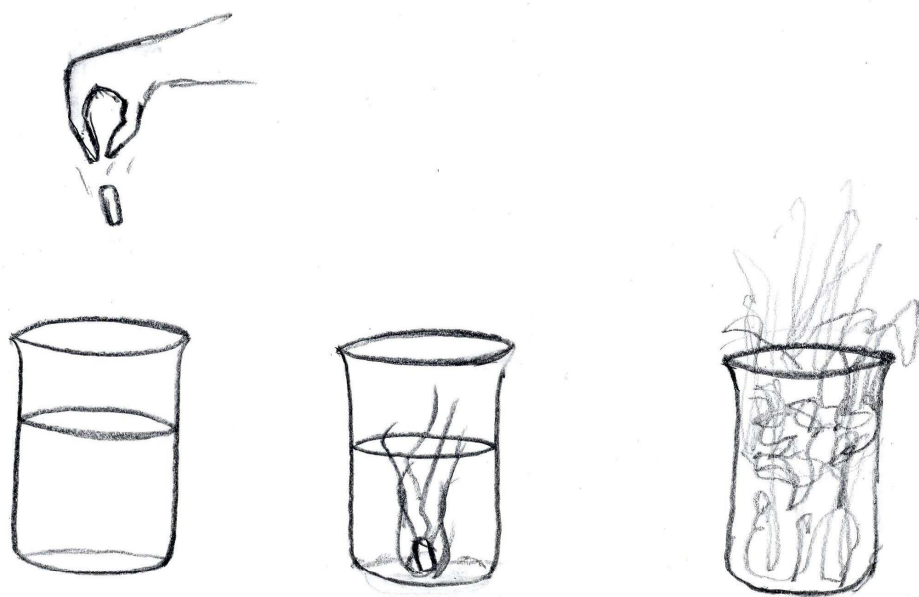
General Recommendations:

The team has tested this idea on a small scale using a bowl. The idea would seem to be very exciting and fun but due to time and room constraints the team was not able to develop this idea.

Pictures:

QAD# 25

Water Explosion



Water Explosion

| | |
|----------------|--------|
| WOW Factor | ☼☼☼☼☼☼ |
| Risk | ☼☼☼ |
| Cost Effective | ☼☼☼ |
| Find Materials | ☼ |
| Ease of Use | ☼☼☼☼☼ |
| Building Time | ☼☼☼☼ |

| | |
|-------------------|------------------|
| Team Name: | Science Museum 1 |
| Activity: | Water Explosion |

| Material | Specific Use |
|----------------------------|---------------------------|
| Beakers | Holds water |
| Elements on periodic table | Creates chemical reaction |
| Lithium (Li) | |
| Sodium (Na) | |
| Potassium (K) | |
| | |
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|-----------------------------|
| Setup Required: |
| 1. Fill up beakers of water |

| |
|------------------------------|
| Problems Encountered: |
| n/a |

| | | |
|-------------------------|-----------|-------------------------|
| Category: | IBLA | Demonstration |
| End Use: | Classroom | Outreach (Professional) |
| Tested: | Yes | No |
| Effect achieved? | Yes | No |

| | | |
|----------------|------------|-------------------|
| Tested: | Untested | Team Tested |
| | Explainers | Sophie and Rachel |
| | Teachers | Classrooms |
| | Families | Staff: |
| | Other: | |

| |
|-------------------------------------|
| Further development options: |
| This is strictly a QAD |

| |
|--|
| Performing the demonstration: |
| 1. By adding in the metals (only use alkali metals) to the water it will create a chemical reaction. As you go farther down the list of metals the chemical reactions become more explosive. |

| |
|-------------------------------------|
| How could this be improved? |
| n/a |
| How could this be scaled up? |
| n/a |

National Curriculum:

KS2

Investigative Skills

- ask questions that can be investigated scientifically and decide how to find answers
- consider what sources of information, including first-hand experience and a range of other sources, they will use to answer questions

Grouping and Classifying Materials

- to compare everyday materials and objects on the basis of their material properties, including hardness, strength, flexibility and magnetic behavior, and to relate these properties to everyday uses of the materials

Changing Materials

- to describe changes that occur when materials are mixed [for example, adding salt to water]
- that non-reversible changes [for example, vinegar reacting with bicarbonate of soda, plaster of Paris with water] result in the formation of new materials that may be useful

KS3

Investigative Skills

- use scientific knowledge and understanding to turn ideas into a form that can be investigated, and to decide on an appropriate approach
- decide whether to use evidence from first-hand experience or secondary sources
- carry out preliminary work and to make predictions, where appropriate

Elements, Compounds, and Mixtures

- how elements combine through chemical reactions to form compounds [for example, water, carbon dioxide, magnesium oxide, sodium chloride, most minerals] with a definite composition

Changing Materials

- about the variation of solubility with temperature, the formation of saturated solutions, and the differences in solubility of solutes in different solvents

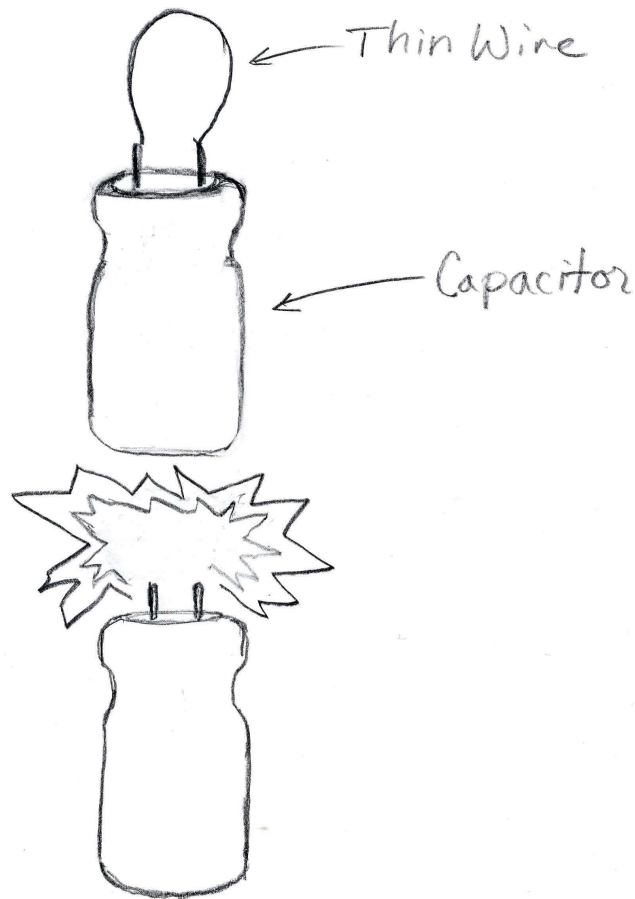
General Recommendations:

This activity has a large Wow factor. However, coming up with the elements can be difficult. Also, safety is a concern since explosions are involved. Strictly recommended for Outreach Demonstration use only.

Pictures:

QAD# 25

Discharging a Capacitor



Discharging a Capacitor

| | |
|----------------|----------|
| WOW Factor | ☼☼☼☼☼☼☼☼ |
| Risk | ☼☼☼☼ |
| Cost Effective | ☼☼☼☼ |
| Find Materials | ☼☼☼ |
| Ease of Use | ☼☼☼☼ |
| Building Time | ☼☼☼☼ |

| | |
|-------------------|-------------------------|
| Team Name: | Science Museum 1 |
| Activity: | Discharging a Capacitor |

| Material | Specific Use |
|--------------------------|--------------------|
| Fast Discharge Capacitor | Discharge |
| Very thin metal wire | Shorting Capacitor |
| | |
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| Setup Required: |
| 1. Charge capacitor using appropriate available electrical source. |

| |
|------------------------------|
| Problems Encountered: |
| n/a |

| | | |
|-------------------------|-----------|-------------------------|
| Category: | IBLA | Demonstration |
| End Use: | Classroom | Outreach (Professional) |
| Tested: | Yes | No |
| Effect achieved? | Yes | No |

| | | |
|----------------|------------|-------------------|
| Tested: | Untested | Team Tested |
| | Explainers | Sophie and Rachel |
| | Teachers | Classrooms |
| | Families | Staff: |
| | Other: | |

| |
|-------------------------------------|
| Further development options: |
| This is strictly a QAD |

| |
|--|
| Performing the demonstration: |
| 1. Carefully short the capacitor by using the wire to connect the leads of the capacitor together. 2. The wire should vaporize because of the intense heat created by the rapid current being released. |

| |
|-------------------------------------|
| How could this be improved? |
| n/a |
| How could this be scaled up? |
| n/a |

National Curriculum:

KS2

Changing materials

- about reversible changes, including dissolving, melting, boiling, condensing, freezing and evaporating
- that burning materials [for example, wood, wax, natural gas] results in the formation of new materials and that this change is not usually reversible.

Grouping and classifying materials

- 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 some materials are better electrical conductors than others

Electricity

- to construct circuits, incorporating a battery or power supply and a range of switches, to make electrical devices work [for example, buzzers, motors]
- how changing the number or type of components [for example, batteries, bulbs, wires] in a series circuit can make bulbs brighter or dimmer
- how to represent series circuits by drawings and conventional symbols, and how to construct series circuits on the basis of drawings and diagrams using conventional symbols.

KS3

Electricity and magnetism

- how to design and construct series and parallel circuits, and how to measure current and voltage
- that energy is transferred from batteries and other sources to other components in electrical circuits

Conservation of energy

- ways in which energy can be usefully transferred and stored
- how energy is transferred by the movement of particles in conduction, convection and evaporation, and that energy is transferred directly by radiation
- that although energy is always conserved, it may be dissipated, reducing its availability as a resource.

Changing materials

- that when physical changes [for example, changes of state, formation of solutions] take place, mass is conserved
- to relate changes of state to energy transfers

General Recommendations:

Pictures:

Appendix D

Inquiry-based Learning Activities

Appendix D: Inquiry-based Learning Activities

Sound



Mystery Powder



Solar Powered Toys

Each IBLA is rated and each objective was based on a controlled set of criteria, illustrated below. Rating boxes can be found in the upper right corner of the each IBLA recommendation page.

WOW Factor – Perceived based on the experience of both the project team and museum staff.

- ☼ = No excitement, not fun, boring
- ☼☼ = Little bit of fun but not very exciting
- ☼☼☼ = Fun and little bit exciting
- ☼☼☼☼ = Very fun and exciting
- ☼☼☼☼☼ = The most fun and exciting

Risk – Based on average risk assessment or perceived risk

- ☼ = Fatally Dangerous, needs heavy development
- ☼☼ = Serious Injury may occur, needs development
- ☼☼☼ = Somewhat dangerous, needs some development
- ☼☼☼☼ = Little risk or minor injury, just about ready for testing
- ☼☼☼☼☼ = Safe, ready for testing

Cost Effective

- ☼ = >100£
- ☼☼ = 41£ - 100£
- ☼☼☼ = 21£ - 40£
- ☼☼☼☼ = 11£ - 20£
- ☼☼☼☼☼ = <10£

Find Materials

- ☼ = Unique items required, extremely hard to find
- ☼☼ = Not very common items to find
- ☼☼☼ = Everything can be found within reason
- ☼☼☼☼ = Everything can be found with local shopping
- ☼☼☼☼☼ = Classroom/Science lab items

Ease of Use

- ☼ = Very hard to use, hard to make it work
- ☼☼ = Hard to use
- ☼☼☼ = Not very user-friendly to use
- ☼☼☼☼ = Easy to use
- ☼☼☼☼☼ = Easy, simple, user-friendly

Building Time

- ☼ = >2 hours
- ☼☼ = 1 hour – 2 hours
- ☼☼☼ = 31 minutes – 1 hour
- ☼☼☼☼ = 10 minutes – 30 minutes
- ☼☼☼☼☼ = <10 minutes

IBLA #1

Sound

Sound

Lesson Plan

Objective: Project sound of a ticking clock using normal everyday items

Materials We Used:

- Clock
- Plastic Cups
- Tape
- Metal Bowls of Varying Sizes
- Plastic Tubing (~1 meter each)
- Nails
- Funnels
- Cardboard Boxes of Varying Sizes
- Red Herring Items: packaging material, wire, clothing, cup coasters, etc.

Strategy:

1. Pupils work in groups to discuss their ideas on how to direct the sound along their chosen route (across the room, through an assault course, up the wall, etc.). Encourage them to use pencil and paper to document their ideas. Planning should take about 10 minutes
2. Let each group build their ideas for about 20 minutes.
3. Teacher should be supervising, if the children seem to be struggling with ideas the teacher should give small hints.
4. Each group will test their product one by one. Depending on number of groups, this time will vary.
5. After each test trial, the teacher or judge should give them points based on the table above.
6. After testing, the children should discuss their experiences with the challenge. This can include relating their designs/ideas to things they have seen, heard, or studied. After this experiment, the children may be intrigued by this challenge and may use the internet or other research methods to find out more about this project.
7. If all goes well, the children should learn how sound travels and how it can be amplified. If not, the teacher should explain the conclusions.

Steering Tips:

- Let the children know that connecting tubing together will give them low points on ingenuity and originality.
- Vibration will help amplify noises
- Making sounds go through solids are better than going through air.

Awards Table

| Criteria | Multiplying Scale | Rating (0 to 5) | Score |
|-------------------|-------------------|-----------------|-------|
| Ingenuity | X 5 | | |
| Originality | X 5 | | |
| Aesthetics | X 1 | | |
| Applied Knowledge | X 5 | | |
| Team Work | X 3 | | |
| Success | X10 | | |
| | | Total | |

Conclusions:

- The results should show that sound travels better in solids than gases.
- The denser the solid, the better sound travels.
- Increasing surface area of the sound source creates amplification.

Tested Ways of Amplifying and Propagating Sound

Sound Project 1—Nails and Bowl

1. Place clock down so that the hands cannot be seen
2. Place three nails on the black part of the clock with the tips pointing up
3. Balance one of the metal bowls on tip of the 3 nails

Methods:

- Placed the project down on the basement floor
- Used Funnel in ear to help hear the sound

Results:

- Strongly amplifies sounds
- Could hear sounds several stories up, however, it has the room had to be completely silent
- The sound travels upwards
- Perhaps, too hard for children to figure out
- Very original, high level of applied knowledge
-

Sound Project 2—Pure Tubing

1. Using the PVC pipes connect all of them together (use tape to connect if necessary)

Methods:

- Place clock next to one end of the tubing
- Listen on other side of tube

Results:

- Example of how sound travels, not amplifying sound
- Can hear sound very clearly
- Very high resistance to other noise
- Easy and quick to set up
- Not very original, aesthetically unpleasing

Sound Project 3—Stethoscope

1. Use funnel and attach it to the back of the clock (it should be a snug fit)
2. Attach the appropriate sized PVC tubing to the funnel
3. Attach another funnel to the other side of the tube

Methods:

- Encase ear in the funnel

Results:

- Can hear the sound clearly and loudly
- Can change the direction of sound travel in any way
- High originality, high creativity, aesthetically pleasing

Sound Project 4—Broomstick

1. Place one end of broomstick on the backside of the clock

Methods:

- Place ear on other side of broomstick

Results:

- Changes the sound
- Sound travels through broomstick
- Amplifies sound
- Very simple, some applied knowledge, low aesthetics, low ingenuity

Sound Project 5—Broomstick with bowl

1. Place broom stick on clock vertically
2. balance metal bowl on top of the broomstick

Methods:

- Place ear near the open end of the bowl

Results

- Amplifies sound more than just the broomstick project
- Hard to keep metal bowl steady on the broomstick
- Still very simple, more applied knowledge than just broomstick

Questions

- Amplifying sound vs. Sound travel, which one is more important?
- Should the children be able to take apart the clock?
- Defining how Award Points can be Distributed
 - Includes: ingenuity, complexity, originality, applied knowledge, aesthetics

WORKSHEET

Introduction

You and your team are spies, trying to hear a very quiet sound from far away. If you put your ear right up next to it, the enemies will catch you. Can you design a device that will allow you to hear the secret message without getting caught?

Listen for the sound that you will be trying to amplify. Can you hear it on your own?

You will be able to use the following objects to hear the secret message:

- Plastic Cups
- Tape
- Metal Bowls of Varying Sizes
- Plastic Tubing (~1 meter each)
- Nails
- Funnels
- Cardboard Boxes of Varying Sizes
- Packaging material
- Wire
- Cloth
- Cup coasters

If you brought an item from home, you may use that as well.

Brainstorming

Once you have been divided into groups, look at the materials that have been provided and think about a variety of ways that you could use them to hear the secret sound. Write down all your ideas (or draw small pictures, but do not take too much time) so that you will remember them later. If you can think of any other objects that you might find in the classroom, make a note of them, and ask your teacher if you can use them. Write down any ideas that you have, even if they might not work. If an idea seems silly, tell your group anyway; it might give someone else on your team an idea!

Once you have a list of ideas, think about which ideas seem like they would work the best. You will be evaluated based upon whether your design works, but also on how clever and creative it is, how well you work with your group, and what the design looks like. Keep in mind how sound travels, and the questions that you answered in your homework. Have you ever thought that a sound was travelling further or seemed louder than you would have expected? Use any experience you have to your advantage. And remember! You will have to work quickly to intercept the secret message.

Building

Once you and your team mates have settled on a design that you think will work, construct it from the materials that have been provided. Again, if you feel that any other materials will enhance your design, ask your teacher if you may use them. Work as quickly as you can without making mistakes.

Testing

Once your design is complete, each team will have an opportunity to test the device. Does it work? What is the secret message? Look at the other groups designs. If you were to design another device, what would you do differently? Why would it work better?

Conclusions

Please answer the questions below on a separate sheet of paper.

1. Were you able to hear the secret message? What was it?
2. Which of the objects provided did you use in your final design? What did you bring from home? Did you use it?
3. Did you design your device such that the vibrations travelled through a solid, a liquid, or a gas? Why did you choose the material that you did? Was that the optimal choice?
4. Of all of the designs that you saw your classmates use, which seemed to be the most effective? Why? Having constructed and tested *your* design, what else would you be interested in trying to improve your results?
5. Can you think of a time when you listened to something through a gas? A liquid? A solid? How did they sound?
6. Have you ever cupped your hand around your ear to hear something better? Did it work? Why or why not?
7. Draw and attach a picture of your design, labelling anything that might be unclear.

HOMEWORK SHEET

Tomorrow in class you will be taking a very small sound that you can barely hear and using what you have learned about vibrations (sound in particular), to amplify that sound, or make it louder. Keeping this in mind, please answer the following questions:

- 1.** What do you already know about sound? How do vibrations travel?
- 2.** Write down three materials that you think sound would travel well through and three things you think would not carry sound well
- 3.** Look up the definition of a vacuum (not the one you clean the floor with!). Do you think sound would travel well through a vacuum? Why or why not?
- 4.** If you were trying to hear a sound that was far away that was being carried through air, what could you do? Can you think of any animals that hear better than you do? What could be one reason for that?
- 5.** Think of one thing that you have around the house that might help you hear something far away. Indicate what it is below. If possible, bring that object with you to class tomorrow to help you hear the very quiet sound.

Sound

| | |
|----------------|--------|
| WOW Factor | ☼☼☼☼☼☼ |
| Risk | ☼☼☼☼☼☼ |
| Cost Effective | ☼☼☼☼ |
| Find Materials | ☼☼☼☼☼☼ |
| Ease of Use | ☼☼☼☼☼☼ |
| Building Time | ☼☼☼☼ |

| | |
|-------------------|------------------|
| Team Name: | Science Museum 1 |
| Activity: | Sound |

| Material | Specific Use |
|------------------------|----------------------|
| Metal Bowls | Amplify Sound |
| Metal Nails | Amplify Sound |
| Broomstick | Amplify Sound |
| Clock | Produces Sound |
| PVC Piping | Amplify Sound |
| Water Bottles | Amplify Sound |
| Funnels | Amplify Sound |
| Others can be found in | Appendix D of report |
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| Setup Required: |
| <ol style="list-style-type: none"> 1. Gather necessary materials and present worksheet to the children a day prior to the actual activity. 2. Make sure they understand the basic concepts of sound and refer to the lesson plan, worksheet, and homework sheet for more details in Appendix D. |

| |
|--|
| Problems Encountered: |
| No problems were encountered. Just needs more testing. |

| | | |
|-------------------------|-----------|-------------------------|
| Category: | IBLA | Demonstration |
| End Use: | Classroom | Outreach (Professional) |
| Tested: | Yes | No |
| Effect achieved? | Yes | No |

| | | |
|----------------|------------|-------------------|
| Tested: | Untested | Team Tested |
| | Explainers | Sophie and Rachel |
| | Teachers | Classrooms |
| | Families | Staff: |
| | Other: | |

| |
|---|
| Further development options: |
| Perhaps use an MP3 or a recorder to tape actual messages. Can be turned into a spy-themed activity where the children has to figure out a "secret message". |

| |
|--|
| Performing the demonstration: |
| <ol style="list-style-type: none"> 7. Pupils work in groups to discuss their ideas on how to direct the sound along their chosen route (across the room, through an assault course, up the wall, etc.). Encourage them to use pencil and paper to document their ideas. Planning should take about 10 minutes 8. Let each group build their ideas for about 20 minutes. 9. Teacher should be supervising, if the children seem to be struggling with ideas the teacher should give small hints. 10. Each group will test their product one by one. Depending on number of groups, this time will vary. 11. After each test trial, the teacher or judge should give them points based on the table above. 12. After testing, the children should discuss their experiences with the challenge. This can include relating their designs/ideas to things they have seen, heard, or studied. After this experiment, the children may be intrigued by this challenge and may use the internet or other research methods to find out more about this project. 7. If all goes well, the children should learn how sound travels and how it can be amplified. If not, the teacher should explain the conclusions. |

| |
|--|
| How could this be improved? |
| Replace the clock with an MP3 player or recording to tape "secret messages". |
| How could this be scaled up? |
| Not applicable |

General Recommendations:

Very fun activity to do. Easy to set up and easy to perform. Highly recommended to further develop and put into classrooms.

Pictures:



IBLA #2

Mystery Powder

Mystery Powder

Lesson Plan

Child's Objective: Identify mystery powder using materials and tools commonly available in classroom.

Educational Objectives:

- Gain experience using lab equipment
- Encourage creativity
 - Sourcing materials and equipment from classroom
 - Devising tests

Materials We Used:

- Zip lock bags
- Water
- Vinegar
- Litmus paper
- Test tubes / beakers
- Matches
- 1.5v battery
- Wire
- Small light bulb
- Safety goggles
- Weighing scales
- Magnifying glass
- Various powders
 - Bicarbonate soda
 - Corn flour
 - Cream of tartar
 - Salt
 - Baking powder
 - Sugar
 - Flour
 - Crushed up meringue cookie
 - Etc...

Strategy:

Introduction:

The activity should be presented to the students as follows. A janitor has discovered multiple bags containing mysterious powders in a teacher's drawer; the police were notified and the teacher arrested pending an investigation. It is the job of the students to identify the mystery powders and decide if the teacher is guilty of any crime.

Necessary equipment outlined above should be setup for students prior to their arrival. Labelled samples of all powders should be made available to the students for comparison. One of the labelled samples may be marked as an “illegal” substance; this should be an uncommon powder the children will not be familiar with.

This activity requires groups of around 3-4 students per team, although the number is flexible. Each group will receive a different bag of mystery powder with one group getting the “illegal” substance. With minimal input from the teacher, the students should test their mystery powder by comparing it to the labelled samples using the provided test equipment and be able to accurately identify it at the end of the lesson.

Brainstorming:

Groups should be given 5-10 minutes at the start of class to brainstorm and discuss various ways of testing their powder. They may be asked to write down five questions they’d like to investigate. The teacher should encourage them to look around the room and come up with possible creative ways to test the various powders.

Testing:

Each group will spend the majority of the class, 25-30 minutes, testing their mystery powder. They should be encouraged to make a table listing the various controlled samples and their properties. If so desired, a template may be produced by the teacher already listing the labelled powder samples. An example of one such template is provided below.

Students should be left to test the powders as they wish, if a group appears stuck, the teacher should ask questions that get the students thinking about additional properties of powders to test and compare. Examples of tests are included below.

Discussion:

With 15-20 minutes remaining in the lesson, students should have come to a decisive conclusion, or at least have a good idea as to what their mystery powder is. At this point, all the groups will present their findings to the class and teacher (judge). The class as a whole will then deliver their verdict. The teacher will then reveal what the mystery substances were and whether any were “illegal” or not.

Modifications and Suggestions:

Depending on the age of the students more elaborate samples and testing means may be employed. Older children may be given non food based powders such as laundry detergent for their mystery powder and sample with the stipulation that since this is a mystery powder and the police are treating it as suspicious, it is unknown whether it is toxic or not and must not be tasted or inappropriately. The students may be made to wear gloves and aprons for added effect.

In addition, the sample powders and equipment may be left in their original locations (salt in cabinet, matches in drawer, detergent under sink...) and it will be up to the students to source them for comparison. In this scenario the teachers only input is to set the scenario and present the students with the bag.

Sample Powder Property Table

| Labelled Powder | <i>Flammability</i> | <i>Smell</i> | <i>Etc...</i> |
|------------------------|---------------------|--------------|---------------|
| Salt | | | |
| Baking powder | | | |
| Corn flour | | | |
| Bicarbonate soda | | | |
| Sugar | | | |
| “illegal” substance | | | |
| Etc... | | | |

Sample Tests

1. Visually compare grains
2. Combustibility
3. Solubility
4. Electrical conductivity when dissolved in water
5. PH level when dissolved in water
6. Density
7. Taste

Mystery Powder Worksheet

Introduction

Mr. Clean, your schools janitor, discovered several bags containing mysterious powders in the drawer of Mr. Newton, one of your teachers. He notified the police and Mr. Newton is being held, pending an investigation into the legality of the powders. It is up to you and your team to identify the powder your teacher gives you and decide if Mr. Newton is guilty of any crime.

Brainstorming

In your group, look over the mystery powder your teacher has given you. It is your job to figure out what it is. Look around you; do you have known powder sample to compare it to? If not, where can you find them? Do you have any tools or equipment to test the powder? Can you find any more you would like to use?

Spend the next 5-10 minutes in your group discussing various ways to test the mystery powder to figure out what it is. Write down any ideas your group has to refer back to. Try to come up with at least five questions you would like to have answered that would help you figure out what the powder is. Can you figure out ways to answer them?

Keep in mind, you will be evaluated on not only identifying the powder, but how creative your testing was, as well as how long it takes you. So work smart, use the time wisely and work efficiently!

Testing

Now that you have discussed with your team what you want to figure out and how, it is time to test the powder. You may ask the teacher questions, but remember, it is your task to decipher the mystery, not your teachers. Do whatever it takes as long as it is safe i.e. don't taste a powder if your teacher tells you that the police are unsure if it is toxic or not.

When all the groups believe they know what the powder is, the teacher, who has been asked to play the role of a judge by the police, will hear from each group what substance they believe they were dealing with and whether or not Mr. Newton has committed a crime. Be prepared to back up your testimony with evidence you have gathered during your investigation.

Conclusions

Please answer the questions below on a separate sheet of paper.

1. Were you able to figure out what the powder was? What was it?
2. What tests did you run on the mystery powder? Which was most effective?
3. Are there any other tests you would have like to run had proper equipment been available to you?

Mystery Powder

| | |
|----------------|----------|
| WOW Factor | ☼☼☼☼☼☼☼☼ |
| Risk | ☼☼☼☼☼☼☼☼ |
| Cost Effective | ☼☼☼☼☼☼☼☼ |
| Find Materials | ☼☼☼☼☼☼☼☼ |
| Ease of Use | ☼☼☼☼☼☼☼☼ |
| Building Time | ☼☼☼☼☼☼☼☼ |

| | |
|-------------------|------------------|
| Team Name: | Science Museum 1 |
| Activity: | Mystery Powder |

| Material | Specific Use |
|------------------|-----------------------|
| Powders X 10 | Find in Grocery Store |
| Litmus Paper | Measure pH |
| Beakers | Dissolves powders |
| Magnifying Glass | Examine Powder |
| Bunsen Burner | (optional) |
| Latex Gloves | Protection |
| Spoons | Stir Solution |
| Ziplock Bags | Holds Mystery Powde |
| Vinegar | Test pH |
| | |
| | |
| | |
| | |

| |
|--|
| Setup Required: |
| 1. Gather up all materials and present a mystery powder to a group (2-3) and have them figure out what the mystery substance is by using scientific methods. |
| **A detailed explanation of how to perform this IBLA can be found in Appendix D of the report.** |

| |
|---|
| Problems Encountered: |
| Target age should be between 10-12. If the performers are too young, they may not understand the concept fully and may need assistance to help figure out the activity. |

| | | |
|-------------------------|-----------|-------------------------|
| Category: | IBLA | Demonstration |
| End Use: | Classroom | Outreach (Professional) |
| Tested: | Yes | No |
| Effect achieved? | Yes | No |

| | | |
|----------------|------------|-------------------|
| Tested: | Untested | Team Tested |
| | Explainers | Sophie and Rachel |
| | Teachers | Classrooms |
| | Families | Staff: |
| | Other: | Public |

| |
|--|
| Further development options: |
| Heavy testing has been done with this IBLA. Ready for classroom testing. |

| |
|--------------------------------------|
| Performing the demonstration: |
| |

| |
|---|
| How could this be improved? |
| If children are finding that one powder is too easy to solve try combining two or more to make it more challenging. |

| |
|-------------------------------------|
| How could this be scaled up? |
| Not applicable |

IBLA #3

Solar Power Toys

Solar Power Toys

| | |
|----------------|--------|
| WOW Factor | ☼☼ |
| Risk | ☼☼☼☼☼☼ |
| Cost Effective | ☼☼☼ |
| Find Materials | ☼☼☼ |
| Ease of Use | ☼ |
| Building Time | ☼☼☼☼ |

| | |
|-------------------|------------------|
| Team Name: | Science Museum 1 |
| Activity: | Solar Power Toys |

| Material | Specific Use |
|------------------|----------------|
| Solar Power Toys | Moving Object |
| PVC piping | Directs Light |
| Poster Tubing | Directs Light |
| Aluminium Foil | Reflect Light |
| Mirrors | Reflect Light |
| Magnifying Glass | Focus Light |
| Torch | Produces Light |
| | |
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|--|
| Setup Required: |
| <ol style="list-style-type: none"> 1. Place a torch that has to remain stationary in a room. Preferably, place the torch on an elevated area such as a table or chair. 2. Place solar power toy on the ground or on a surface that is on a different level with the torch. |

| |
|---|
| Problems Encountered: |
| <ul style="list-style-type: none"> • Torch light by itself works better than using tools with it. • Lots of work goes into making the solar power toy work to only get minimal results (small vibration) • Reflecting the light is very difficult to do. And if it is done, the intensity of the light is minimized. |

| | | |
|-------------------------|-----------|-------------------------|
| Category: | IBLA | Demonstration |
| End Use: | Classroom | Outreach (Professional) |
| Tested: | Yes | No |
| Effect achieved? | Yes | No |

| | | |
|----------------|------------|-------------------|
| Tested: | Untested | Team Tested |
| | Explainers | Sophie and Rachel |
| | Teachers | Classrooms |
| | Families | Staff: |
| | Other: | Public |

| |
|--|
| Further development options: |
| IBLA was very difficult to perform, needs better light source, and bigger toy. |

| |
|---|
| Performing the demonstration: |
| <ol style="list-style-type: none"> 1. Have the children build the most ingenious way possible to use the tools to direct the light into the solar power toy. |

| |
|---|
| How could this be improved? |
| Needs a better light source and perhaps a more efficient solar power toy. |

| |
|-------------------------------------|
| How could this be scaled up? |
| Not applicable |

Appendix E

Risk Assessment Forms

Appendix E: Risk Assessment Forms

This appendix contains risk assessment forms for most of the demonstrations that were tested during this project. It also contains a sample risk assessment form, for those whom are unfamiliar, and the number criteria, scoring is based on, for easy reference.

Demonstrations with risk assessment available here:

- QAD# 05 Deflecting Laser
- QAD# 07 Lemon Battery
- QAD# 10 Floating on CO₂
- QAD# 11 Mentos and Soda Rocket
- QAD# 12 Creating a Vacuum
- QAD# 14 Heat Boat
- QAD# 15 Breaking Glass
- QAD# 16 Imploding Can
- QAD# 19 Gaussian Launcher
- QAD# 21 Liquid Nitrogen Bubbles
- QAD# 22 Match Rocket

NMSI Risk Assessment Form (SAMPLE)

| | | | | | |
|---|--|--|--|--------------------------------------|--|
| Nature / type of task being assessed and location/s | | | | | |
| Date of Assessment | | Date by when assessment must be reviewed | | Assessment Completed by / Department | |
| How many people could be at risk? | | What category of person may be at risk (e.g. employee, contractor, public, young, old, special needs?) | | | |

| Hazard / risk | Consequence | Likelihood | Score C x L | Risk rating | Action/solution | Time scale | ✓ |
|---------------|-------------|------------|----------------|----------------|-----------------|---------------|---|
| | | | | | | | |
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| 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 | - |
| Dangerous - 2 (serious injury or damage) | likely - 2 (to occur at some time) | 2 | Tolerable | Keep control measures under review | within 3 months |
| | | 3-4 | Moderate | | within 3 months |
| Very dangerous - 3 (could cause death or widespread injuries) | very likely - 3 | 6 | Substantial | Fine tune control measures | within 1 month |
| | | 9 | Intolerable | Urgent control measures needed | immediately |
| | | | | Stop activity until risk reduced | |

- 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.

Remember

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

NMSI Risk Assessment Form

| | | | | | | | |
|---|-----------|--|--|--------------------------------------|-------------------------------|--|--|
| Nature / type of task being assessed and location/s | | Deflecting Laser QAD#5 | | | | | |
| Date of Assessment | 24-4-2007 | Date by when assessment must be reviewed | | Assessment Completed by / Department | WPI – Science Museum 1 | | |
| How many people could be at risk? | | What category of person may be at risk (e.g. employee, contractor, public, young, old, special needs?) | | Public, young, classroom | | | |

| Hazard / risk | Consequence | Likelihood | Score C x L | Risk rating | Action/solution | Time scale | ✓ |
|--|-------------|------------|----------------|------------------|--|------------|---|
| Laser pointer points in eye | 1 | 1 | 1 | trivial | Keep children or participants from shining the laser pointer into anyone's eyes. | - | |
| Burns from hot plate or heat source | 1 | 2 | 2 | Tolerable | Remind anyone involved that the hotplate is active and hot. Place clear signage nearby if necessary to indicate heat. | 3 months | |
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NMSI Risk Assessment Form

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|---|-----------|--|--------------------------|--------------------------------------|-------------------------------|
| Nature / type of task being assessed and location/s | | Lemon Battery QAD#7 | | | |
| Date of Assessment | 24-4-2007 | Date by when assessment must be reviewed | | Assessment Completed by / Department | WPI – Science Museum 1 |
| How many people could be at risk? | | What category of person may be at risk (e.g. employee, contractor, public, young, old, special needs?) | Young, classrooms | | |

| Hazard / risk | Consequence | Likelihood | Score C x L | Risk rating | Action/solution | Time scale | ✓ |
|--|-------------|------------|-------------|------------------|--|------------|---|
| Sharp nails are involved that may puncture skin | 1 | 1 | 1 | Trivial | Provide warning about the danger of the nails | - | |
| Lemon juice squirts in eye | 1 | 2 | 2 | Tolerable | Unlikely to cause damage, use acceptable caution. | | |
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NMSI Risk Assessment Form

| | | | | | |
|---|-----------|--|----------------------|--------------------------------------|-------------------------------|
| Nature / type of task being assessed and location/s | | Floating on CO₂ QAD#10 | | | |
| Date of Assessment | 24-4-2007 | Date by when assessment must be reviewed | | Assessment Completed by / Department | WPI – Science Museum 1 |
| How many people could be at risk? | | What category of person may be at risk (e.g. employee, contractor, public, young, old, special needs?) | Young, public | | |

| Hazard / risk | Consequence | Likelihood | Score C x L | Risk rating | Action/solution | Time scale | ✓ |
|---|-------------|------------|-------------|----------------|----------------------------|------------|---|
| Solution of baking soda with vinegar may be irritant to the skin | 1 | 1 | 1 | Trivial | Avoid skin contact. | - | |
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NMSI Risk Assessment Form

| | | | | | |
|---|----------|--|---------------------------------|--------------------------------------|-------------------------------|
| Nature / type of task being assessed and location/s | | Mentos and Soda Rocket QAD# 11 | | | |
| Date of Assessment | 24-4-007 | Date by when assessment must be reviewed | | Assessment Completed by / Department | WPI – Science Museum 1 |
| How many people could be at risk? | | What category of person may be at risk (e.g. employee, contractor, public, young, old, special needs?) | Public, Young, Classroom | | |

| Hazard / risk | Consequence | Likelihood | Score C x L | Risk rating | Action/solution | Time scale | ✓ |
|---|-------------|------------|-------------|------------------|---|-----------------|---|
| Bottle hitting a person due to accidental launch (may hit in head, eye area) | 2 | 1 | 2 | Tolerable | Instruct observers to stand a safe distance away from the rocket before and during launch. | 3 months | |
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NMSI Risk Assessment Form

| | | | | | |
|---|-----------|--|---------------------------------|--------------------------------------|-------------------------------|
| Nature / type of task being assessed and location/s | | Creating a Vacuum QAD#12 | | | |
| Date of Assessment | 24-4-2007 | Date by when assessment must be reviewed | | Assessment Completed by / Department | WPI – Science Museum 1 |
| How many people could be at risk? | | What category of person may be at risk (e.g. employee, contractor, public, young, old, special needs?) | Public, Young, Classroom | | |

| Hazard / risk | Consequence | Likelihood | Score C x L | Risk rating | Action/solution | Time scale | ✓ |
|--|-------------|------------|----------------|------------------|---|-----------------|---|
| Burn self with lighter or match | 1 | 2 | 2 | Tolerable | Drop match into bottle carefully, but quickly to avoid burns to fingers and hands. | 3 months | |
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|---|-----------|--|---------------------------------|--------------------------------------|-------------------------------|
| Nature / type of task being assessed and location/s | | Heat Boat QAD#14 | | | |
| Date of Assessment | 24-4-2007 | Date by when assessment must be reviewed | | Assessment Completed by / Department | WPI – Science Museum 1 |
| How many people could be at risk? | | What category of person may be at risk (e.g. employee, contractor, public, young, old, special needs?) | Public, Young, Classroom | | |

| Hazard / risk | Consequence | Likelihood | Score C x L | Risk rating | Action/solution | Time scale | ✓ |
|--|-------------|------------|-------------|------------------|---|-----------------|---|
| Burns self with candle or heat source on boat | 1 | 2 | 2 | Tolerable | Avoid coming in contact with flame during demonstration. | 3 months | |
| Prick finger when reshaping paperclip | 1 | 2 | 2 | Tolerable | Task should be performed using extra care. Gloves or pliers would increase safety in this situation. | 3 months | |
| | | | | | | | |
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NMSI Risk Assessment Form

| | | | | | |
|---|-----------|--|----------------------------------|--------------------------------------|-------------------------------|
| Nature / type of task being assessed and location/s | | Breaking Glass QAD#15 | | | |
| Date of Assessment | 24-4-2007 | Date by when assessment must be reviewed | | Assessment Completed by / Department | WPI – Science Museum 1 |
| How many people could be at risk? | | What category of person may be at risk (e.g. employee, contractor, public, young, old, special needs?) | Public, Young, Classrooms | | |

| Hazard / risk | Consequence | Likelihood | Score C x L | Risk rating | Action/solution | Time scale | ✓ |
|--|-------------|------------|----------------|------------------|---|------------|---|
| Cutting self with sharp glass (This can only happen after the demonstration has been done). | 1 | 2 | 2 | Tolerable | Use gloves to conduct experiment and do not allow un protected hands to touch the glass. | 3 months | |
| Burning self when lighting the string on fire to heat up glass | 1 | 2 | 2 | Tolerable | Use gloves to conduct experiment and keep burning materials a safe distance away from the body or any flammable materials. | 3 months | |
| | | | | | | | |
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NMSI Risk Assessment Form

| | | | | | |
|---|-----------|--|---------------------------------|--------------------------------------|-------------------------------|
| Nature / type of task being assessed and location/s | | Imploding Can QAD#16 | | | |
| Date of Assessment | 24-4-2007 | Date by when assessment must be reviewed | | Assessment Completed by / Department | WPI – Science Museum 1 |
| How many people could be at risk? | | What category of person may be at risk (e.g. employee, contractor, public, young, old, special needs?) | Public, Young, Classroom | | |

| Hazard / risk | Consequence | Likelihood | Score C x L | Risk rating | Action/solution | Time scale | ✓ |
|---|-------------|------------|-------------|------------------|---|------------|---|
| Burns self when handling hot soda can after heating it up | 1 | 2 | 2 | Tolerable | Use gloves to handle soda can during and after experiment while it remains at dangerous temperatures. | 3 months | |
| Burn self when handling heat source (Bunsen burner, candles, etc) | 1 | 2 | 2 | Tolerable | Pay careful attention to the heat source for both those conduction the demonstration and those observing. Avoid accidental contact with the heat source. | 3 months | |
| One may examine the soda can closely while its heating up. Steam is released and may burn face/eye | 2 | 1 | 2 | Tolerable | Do not put face or body parts over or near the heat operation. | 3 months | |
| | | | | | | | |
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NMSI Risk Assessment Form

| | |
|--|---------------------------------|
| Nature / type of task being assessed and | Gaussian Launcher QAD#19 |
|--|---------------------------------|

| | | | | | |
|-----------------------------------|-----------|--|-------------------------|--------------------------------------|-------------------------------|
| location/s | | | | | |
| Date of Assessment | 24-4-2007 | Date by when assessment must be reviewed | | Assessment Completed by / Department | WPI – Science Museum 1 |
| How many people could be at risk? | | What category of person may be at risk (e.g. employee, contractor, public, young, old, special needs?) | Young, Classroom | | |

| Hazard / risk | Consequence | Likelihood | Score C x L | Risk rating | Action/solution | Time scale | ✓ |
|--|-------------|------------|-------------|------------------|---|------------|---|
| If a series of launchers are set up, the steel ball bearings may hurt someone due to a larger force from the magnets. | 1 | 2 | 2 | Tolerable | Avoid placing any part of the body in the path of the projectile. Also avoid aiming the projectile at hard surfaces that may cause unpredictable ricochet. | 3 months | |
| Since strong magnets are involved, it may attract other metal objects and hurt someone that is handling the magnet | 1 | 1 | 1 | Trivial | Have participants handle magnets carefully and responsibly. Remind participants that magnets are brittle and will break if handled incorrectly. | - | |
| If young are present, they may put balls in mouth. | 3 | 1 | 3 | Moderate | Do not allow participants to place any part of the demonstration in their mouth. | 3 months | |
| | | | | | | | |
| | | | | | | | |

NMSI Risk Assessment Form

| | |
|--|---------------------------------------|
| Nature / type of task being assessed and | Liquid Nitrogen Bubbles QAD#21 |
|--|---------------------------------------|

| | | | | | |
|-----------------------------------|-----------|--|---------------------------------|--------------------------------------|-------------------------------|
| location/s | | | | | |
| Date of Assessment | 24-4-2007 | Date by when assessment must be reviewed | | Assessment Completed by / Department | WPI – Science Museum 1 |
| How many people could be at risk? | | What category of person may be at risk (e.g. employee, contractor, public, young, old, special needs?) | Public, Young, Performer | | |

| Hazard / risk | Consequence | Likelihood | Score C x L | Risk rating | Action/solution | Time scale | ✓ |
|---|-------------|------------|-------------|-------------|--|------------|---|
| Liquid nitrogen spilling on someone | 1 | 1 | 1 | Trivial | If it happens just let the body heat evaporate the liquid nitrogen. No part of the body should be submerged in liquid hydrogen. | - | |
| Someone holds hand in liquid nitrogen causing frost bite | 2 | 1 | 2 | Tolerable | Warn the audience about the potential hazards of liquid nitrogen. No part of the body should be submerged in liquid hydrogen | 3 months | |
| Bubbles that form are cold so that if the bubbles covered in presenter may cause frost bite. | 1 | 1 | 1 | Trivial | Bubbles and nitrogen gas should be at safe temperatures to touch with bare skin. Avoid breathing nitrogen gas. | 3 months | |
| | | | | | | | |
| | | | | | | | |

NMSI Risk Assessment Form

| | | | | | | | |
|---|-----------|--|--|--------------------------------------|-------------------------------|--|--|
| Nature / type of task being assessed and location/s | | Match Rocket QAD#22 | | | | | |
| Date of Assessment | 24-4-2007 | Date by when assessment must be reviewed | | Assessment Completed by / Department | WPI – Science Museum 1 | | |
| How many people could be at risk? | | What category of person may be at risk (e.g. employee, contractor, public, young, old, special needs?) | | Public, Young, Classroom | | | |

| Hazard / risk | Consequence | Likelihood | Score C x L | Risk rating | Action/solution | Time scale | ✓ |
|--|-------------|------------|----------------|------------------|--|------------|---|
| Burn self while lighting the match | 1 | 1 | 1 | Trivial | Take caution when lighting matches. This should only be performed by an adult or under strict supervision. | - | |
| Puncturing skin while reshaping the paperclip to create the match holder | 1 | 1 | 1 | Trivial | Use caution while shaping paper clip. | - | |
| Match rocket is accidentally launched prematurely and hits someone. (Body) | 1 | 1 | 1 | Trivial | Instruct audience to stand clear and at a safe distance. Avoid walking at any point in front of the rocket. | | |
| Match rocket is accidentally launched prematurely and hits someone. (Head/eyes) | 2 | 1 | 2 | Tolerable | Instruct audience to stand clear and at a safe distance. Avoid walking at any point in front of the rocket. | | |
| | | | | | | | |