# "Can we do That Again?" Engaging Learners and Developing Beyond the "Wow" Factor in Science

Chris Astall[1] and Warren Bruce[2]

[1]*College of Education, University of Canterbury, Christchurch, New Zealand*
[2] *UC Education* Plus, *University of Canterbury, Christchurch, New Zealand*
chris.astall@canterbury.ac.nz

***Abstract***

Adding Mentos to an open bottle of Diet Coke can produce a fountain of liquid and froth extending several metres high. This activity can engage a wide audience of learners in a relevant and meaningful way, provide a model for creative science teaching, and help to develop learners' attitudes towards school science as a subject. In this paper, the authors describe the use of this activity with primary-aged learners. Some challenges associated with the construction of the delivery mechanism for the Mentos are discussed, and ideas are provided for improving the performance of the fountain.

An activity that provides an unexpected or startling outcome is usually guaranteed to generate interest, excitement, and enthusiasm from learners of any age. Teachers often look to activities that not only inspire learners but also develop curiosity. The Mentos and Diet Coke activity is one such activity that has been made much more accessible to a wider audience through the Mythbusters television programme (Savage & Hyneman, 2006) and the science educator Steve Spangler (Steve Spangler Science, 2010a). Fritz Grobe and Stephen Voltz, the creators of EepyBird, have taken the Mentos and Diet Coke activity and developed new and unusual ways of presenting the activity through performance art, and their 2006 video, *The Extreme Diet Coke & Mentos Experiments* (EepyBird.com, n.d.), has been watched by millions. The popularity of the Mentos and Diet Coke activity has led to thousands of creative home videos being uploaded onto YouTube.

The Mentos and Diet Coke activity has been successfully used by teachers to demonstrate science processes involved in completing an open-ended physics experiment with undergraduate physics students (Coffey, 2008b). The primary goal was to engage the physics students in "real" research. The students worked collaboratively to explore the different aspects of the activity, including the type of sweets used, temperature of the soda, and ingredients in the sweets and soda. The results from the work of these undergraduates were then published in Coffey (2008a). The interest in the Mentos and Coke activity resulted in the students' findings being reported in the popular science magazine *New Scientist* (Muir, 2008). This activity has also been used within undergraduate Chemistry courses to create curiosity and engagement with an authentic science focus (Baur, Baur, & Franz, 2006; De Grys, 2007; Eichler, Patrick, Harmon, & Coonce, 2007; Liljeholm, 2009; McGuyer, Broen, & Dang, 2009) and also as a model for volcanology investigations (Quane, Klos, & Jacobsen, 2009; Wright, Rust, & Cashman, 2006). Howarth and Woollhead (2008) described the use of this activity with younger learners (12- and 13-year-olds) as they modelled the volcano effect during a class on earth science.

## The Mentos and Diet Coke Activity

Adding Mentos to Diet Coke results in a fountain of liquid and froth being ejected from the bottle. The spray can reach several metres high. This effect is a result of a combination of factors. The carbonated Diet Coke is supersaturated with carbon dioxide that is dissolved under pressure. Once the high pressure on the Diet Coke is released, by opening the bottle, it forms an unstable supersaturated solution of carbon dioxide. The carbon dioxide gas immediately starts to come out of solution and appears as small bubbles. Adding Mentos, with their rough pitted surface, causes rapid increase in carbon dioxide bubbles at the site of the pits (nucleation sites). These nucleation sites, coupled with the coating of gum Arabic, result in the very rapid accumulation of carbon dioxide bubbles within the liquid (Becker, 2007; Coffey, 2008a; Savage & Hyneman, 2006). The result is a violent, explosive fountain of Diet Coke. Coffey (2008a) explored a number of variables that could affect the rapid formation of carbon dioxide; the ingredients in the Mentos and soda drink, roughness of the Mentos, temperature of the soda drink, and duration of the fountain. The addition of potassium benzoate and aspartame in the Diet Coke made it easier for carbon dioxide bubbles to form within the liquid. The faster the Mentos fell through the Diet Coke, the more pronounced the effect. This was because, as the carbon dioxide bubbles rose up through the liquid, they themselves acted as growth sites causing even more carbon dioxide to come out of solution and move into the rising bubble. Additionally, Coffey (2008a) reported that increasing the temperature of the Diet Coke resulted in significantly more carbon dioxide being released from solution, resulting in a more explosive effect.

## Developing Science Process Skills

Science process skills are "the skills scientists employ when they do science" (Martin, 2009, p. 75). They are those skills that enable the children to think, work like scientists, and develop conceptual understanding. As Harlen (2006) states, "the way in which the processes are carried out crucially influences the ideas that emerge. It follows that children's process skills have a key role in developing understanding" (p. 28).

The Mentos and Diet coke activity provides an ideal way to model a scientific investigation. Such a complex phenomenon, with numerous variables, allows teachers to model a realistic investigation that has relevance to the students. The development of the framework for the experimental design and the data collection and analysis has been described in detail elsewhere for undergraduate students (Coffey, 2008b; Eichler et al., 2007). We were interested in exploring how this activity can be used to help develop the process skills of primary children. These are the key skills that are required by learners as they develop their scientific understanding, and may include hypothesising, observing, questioning, predicting, planning, interpreting, drawing conclusions, and communicating and reflecting (Harlen, 2006; Harlen & Qualter, 2009; Martin, 2009).

In the recently-revised New Zealand Curriculum (NZC) (Ministry of Education, 2007), these process skills are encompassed in the overarching strand called Nature of Science (NoS), which consists of four aspects: understanding about science, investigating in science, communicating in science, and participation and contribution. NoS is the core strand of science in the NZC and will challenge teachers, as it is intended to be the main focus of learning, with the traditional content providing the contexts for learning (Bolstad & Hipkins, 2008). Our challenge has been to find activities that can be used to model and develop understanding of the NoS strand through contexts that are engaging and motivating for both the learner and the teacher. In this paper, rather than describe the procedure that learners may go through to complete a science investigation based on the Diet Coke and Mentos activity, we will provide an example of how we have chosen to use it to help develop learner understanding of a specific process skill; that of questioning. At the same time, it will be seen how the activity can engage 7- to 13-year-old learners in a relevant and meaningful way, provide a model for creative science teaching, and help to develop learners' attitudes towards school science as a subject.

## Inquiry Using the Mentos and Diet Coke Activity

A group of 8 children from each of Year 3 (age 8 years), Year 5 (age 10 years), and Year 7 (age 12 years) were chosen at random by their class teachers and each group was asked to participate separately in the activity with the researchers. Each group observed the Mentos and Diet Coke activity. A clear plastic tube containing 11 mint Mentos, prevented from falling by a metal pin (see Figure 1), was screwed onto the top of a 2-L bottle of Diet Coke that had been kept at room temperature. One child from each group pulled the pin from the tube and the children were asked to observe. Following the demonstration, the children shared some questions with each other about what they might wish to investigate or find out about the demonstration. By sharing their questions, the students were able to start developing their own thinking about the science concepts that they could identify. They were beginning to look for reasons that the Diet Coke erupted from the bottle. These questions could then form the foundation for their own science inquiry.

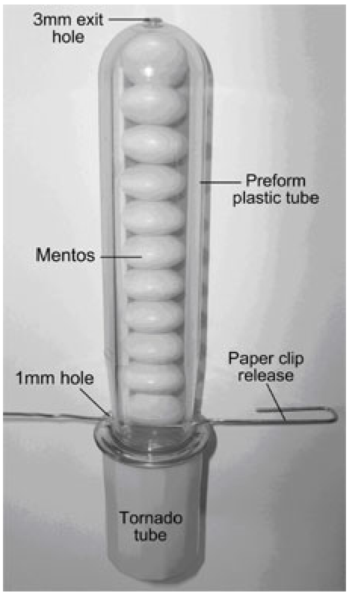


*Figure 1.* The delivery apparatus for the Mentos and Diet Coke activity. The total height of the apparatus is 18cm.

In our experience, many of the questions at this stage are spontaneous, driven by the awe and wonder of the reaction, and are often related to how the phenomenon works. The children ask these questions for a variety of reasons--expressing wonder and interest, wanting to know an answer, and gaining attention--but it is the questions that require complex answers that are more challenging for teachers (Harlen, 2006). We often encountered questions such as the following: "Why does the coke do that?" "Why did the Mentos dissolve into the Coke?" "Why does the Coke react with the Mentos?" "Why is there less coke now [after the 'reaction']?" "How did the Mentos make the Coke go up and up and up?"

With each group of children, we then introduced the idea of an investigable question-starter stem as a strategy to turn the more complex type of question into one that can be investigated (Harlen, 1985). We have often found that children have had little experience of asking science questions. Providing children with a question-starter stem results in a richer variety of questions being asked, questions that could then be investigated by the children to help develop their conceptual understanding. Using the question-starter stem "what would happen if…?" each student was asked to share their new question with the rest of the group. The responses from students in each group were as follows:

*Year 3 (8-year-olds)*: “What would happen if:

- there was Mentos in the bottle and you poured coke inside it?”
- you put sugar into the bottle instead?”
- you just put two Mentos into the bottle?”
- you put Mentos into the bottle but the bottle was not standing on a flat surface but on an angle?”
- you put the bottle on its side?”
- You quickly put the Mentos in, put the lid on, and shook it all up?”

*Year 5 (10-year-olds)*: “What would happen if:

- you used a different [size] bottle?”
- you used a different soft drink [soda]?”
- we tried a different lolly [sweet] instead of Mentos?”
- you dropped the Mentos in one-by-one?”
- the top was completely sealed so there was no place for the coke to come out?”
- we used different sorts of Mentos?”
- If you put something on top of the hole [where the Diet Coke comes out ]?”
- added the Mentos and turned the bottle upside down? Would it take off like a rocket?”
- you didn’t have that thing [geyser tube] and just left it open and dropped them [Mentos] into the bottle?”

*Year 7 (12-year-olds)*: “What would happen if:

- we tried it with a different lolly [sweet]?”
- we had a bigger bottle [of soda]?”
- we tried only one Mentos?”
- the bottle fell over?”
- we tried it with something else that would fizz up the same as Diet Coke, another liquid like Fanta?”
- we used juice because juice isn’t fizzy?”
- there was only half the amount of Diet Coke in the bottle; would it still fizz?”
- we used flat Diet Coke?”
- we added dry ice instead of Mentos; would it do the same thing?”
- you tried baking soda instead of Mentos?”
- you used the stuff to make a volcano--vinegar and baking soda--in the bottle?”
- you used baking soda and vinegar; would it go higher?”
- you didn’t have holes in the tube; would it explode?”
- you changed the number of holes?”
- you change where you put the hole?”

It became clear that the responses not only reflected children’s previous experiences (e.g., older children have reacted baking soda with vinegar and have seen the fizzing that occurs, and related this fizzing to what they had seen), but also the development of other process skills such as observation and predicting. The younger children placed greater emphasis on their own observations and the previous responses of the other children within the group; a number of times the children repeated the same question or reworded it. We have found that the process of generating questions leads naturally into exploring which of those questions can be investigated, which in turn leads to the identification of those variables that may affect what is observed. The children can choose one of the questions to investigate and then design an experiment to test this question. We have often found that much of the rich discussion comes from challenging the children's experimental designs. In discussing children's learning, Harlen (2006) emphasises that "children's process skills have a key role in developing understanding" (p. 29). The Mentos and Coke activity certainly supports the development of the process skills that are embedded within typical frameworks for science investigations.

The types of questions that children ask can also give teachers greater insight into students' understandings of the science concepts within the activity. Teachers can use this type of formative assessment in their teaching, maybe using this as an opportunity to identify any potential student misconceptions and then providing an opportunity for the students to explore their ideas.

## Inspiring Creativity

In our experience, an activity such as the Mentos and Diet Coke one provided children with a real sense of awe and wonder. They were engaged in the activity and wanted to participate. They showed curiosity, not only about how the process worked, but also about ways in which they could change or develop it, and this often led to a wealth of questions. Children sharing their thinking and questioning aloud appeared to engage the rest of the group so they become more willing to share their own ideas and opinions of what was happening. Oliver (2006) identified that creative science teaching means teachers value speculation and original thinking, allow children to share and generate ideas, and give children time to talk. Encouraging wonder and curiosity and providing challenging activities are also characteristics of creative teaching (Feasey, 2005; Oliver, 2006). However, the activity becomes all the richer if the children are able to explore and test their own ideas. Young learners often think creatively when challenged. For example, when we discussed the children's questions and started to think about how we could test their ideas, we asked the children how they could gather data when they used different drinks or when they used a different number of Mentos. They suggested a number of methods, including some very creative ideas: measuring the height of the coke fountain, placing holes in the side of the release tube and measuring the horizontal distance the fountain travelled, measuring how much liquid was left in each bottle, simply lining the bottles up side by side to form a comparative "bar graph," and measuring the weight of the bottle before and after the reaction.

The children start to then move beyond just the awe and wonder into "doing" science. This type of constructivist learning occurs when the learner is provided with opportunities to build and develop their own conceptual understanding of the science concepts and skills through experience.

## Challenges With Constructing the Apparatus

### *Delivering Mentos Into the Bottle*

In our experience, one of the greatest challenges is to find a way to deliver the Mentos into the bottle of Diet Coke. Placing a number of Mentos (5 or 6) into a rolled tube of paper and then dropping them into the open mouth of a bottle of Diet Coke is effective. However, once started, the effect is so quick that often not all the Mentos have time to drop into the liquid.

Another method is to drill a small hole (about 5-mm diameter) through the cap of a Diet Coke bottle and thread a piece of wire through the cap (EepyBird.com, 2009). A hole is drilled into each of three or four Mentos and they are threaded onto the wire on the bottom side of the cap. This requires pouring a small amount of Diet Coke out of the bottle to allow enough space for the Mentos to hang just above the surface of the liquid. The cap is then screwed back on the bottle, with the wire held in place externally by a spring clip. Releasing the clip causes the wire to fall through the hole in the cap and the Mentos, attached to the wire, to fall to the bottom of the Diet Coke.

Steve Spangler has developed a geyser tube that allows a larger number of Mentos to be delivered into the Diet Coke in a more controlled manner (Steve Spangler Science, 2010b). However, we found there was a loss of liquid from the area where the release mechanism was screwed to the top of the bottle and from the hole at the base of the tube when the release pin was pulled. The commercial mechanism has a collar that drops down when the pin is pulled, but the collar is very loose and it does not stop liquid coming out over the collar.

### *Reducing Soda (Diet Coke) Loss*

We looked for ways to reduce this soda loss by using a 2-L soda bottle preform tube and a tornado tube connector (Tornado Tube, 2008), as shown in Figure 1. A tornado tube connector allows two soda bottles to be joined together without leaking. The hole in the tornado tube connector was enlarged, using a keyhole saw, to allow the Mentos to pass smoothly through the tube into the Coke. The size of the exit hole does have an effect on the distance the soda travels, as well as the duration of the reaction (Coffey, 2008b). Using this apparatus, it is possible to prepare a number of preform tubes with different-diameter exit holes. This is a variable that could be explored further by the learners. However, we have found that a 3-mm hole creates a fountain that lasts longer, and is higher, than those obtained using holes of other diameters.

A 1-mm hole was drilled, through both sides, just above the lip of the inverted preform tube (Figure 1). The preform tube was filled with Mentos and a straightened paper clip was inserted through the 1-mm holes, preventing the Mentos from falling out of the tube. The tube was then screwed tightly onto the tornado tube connector. The “loaded” preform tube was then screwed onto a bottle of soda. To release the Mentos into the soda, the paper clip was pulled from the tube.

However, we still found that a small amount of soda was again lost through the two holes when the paper clip was removed. So, instead of drilling two holes for the paper clip release mechanism, we are now using a small, steel ball-bearing held in place by a strong magnet. The position of the ball bearing prevents the Mentos from falling into the soda. When the magnet is removed, the ball bearing drops into the soda, along with the Mentos. This proves most successful, as there is no loss of Diet Coke from any point other than the 3-mm hole at the top.

## Conclusion

Concerns over the decline in primary-student attitudes towards science has been the subject of recent debate, both in New Zealand and in other countries such as the United Kingdom and Australia (Bolstad & Hipkins, 2008; Crooks & Flockton, 2003; Crooks, Smith, & Flockton, 2007; Milne, 2010; Porter & Parvin, 2008; Tytler, Osborne, Williams, Tytler, & Clarke, 2008). Early engagement in science matters if we are to develop students’ ideas and interest in science (Tytler et al., 2008). The Mentos and Diet Coke activity is a good example of an activity that can be used by teachers to provide a context for students that is meaningful and relevant to them. Such science contexts are important if students are to develop their science process skills (Harlen, 2006). This activity can also provide students with a positive experience of learning science that leads to increasing engagement with, and enthusiasm for, science.

***Acknowledgements***

We thank the reviewers for their perceptive comments that have helped shape this paper. We are also indebted to Peter Eastwell for his editing skills and advice.

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