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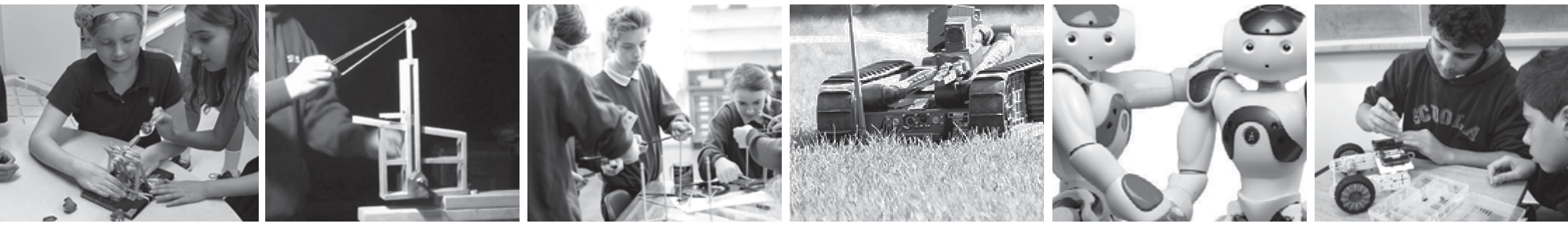

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amt contents

"A journal to serve as a medium both for the exchange of ideas and experiences in the teaching of elementary mathematics and for the instruction of teachers in the trends and developments of mathematics education at home and abroad"

(Editorial, AMT, Vol. 1, No. 1, April 1945.)

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‘Egg-streme’ egg crashes

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Context based learning (CBL) is a powerful tool that utilises areas of student interest framed in meaningful contexts to foster development of new skills and understanding. A rich context that students are familiar with can excite their desire to learn and motivate them to develop their knowledge in a wide range of disciplines simultaneously (Broman, Bernholt, & Parchmann, 2015).For middle school students, engineering activities that relate to real-world problems provide suitable CBL contexts for acquiring conceptual scientific and mathematical understanding.

CBL can be implemented in mathematics education through the teaching strategies associated with Realistic Mathematics Education (RME) (Stephan, 2009). This paradigm encourages students to develop their own mathematical tools within the context of real-world problems. Once understood, students can generalise what they have developed into more formal mathematical knowledge. This approach offers the advantage of allowing students to establish the meaning behind mathematical concepts rather than memorising rules and processes. In RME the teacher takes an interactive, facilitating role, encouraging development of the students’ thinking skills through activities that draw on students’ knowledge of and experience with authentic contexts.

The five characteristics of RME are:

- The use of contexts.
- The use of models.
- The use of students’ own productions and constructions.
- The interactive nature of the teaching process.
- The intertwinement of various learning strands.

By combining context, hands-on modelling and elements from different topics, the mathematics becomes much more connected as a part of interdisciplinary human endeavour. This addresses the need advocated by the Australian Curriculum for students to develop knowledge through collaboration and connecting ideas across the disciplines of science (ACARA, 2015). For this reason, it is important that the contexts used are experientially real; whilst the students need not have experienced the context first hand for themselves it needs to be a context which they could reasonably be able to imagine themselves in (Stephan, 2009, p. 18). Furthermore, the teacher must guide the translation of concepts from students’ contextual models to the abstraction of their understanding to broader mathematical concepts. For this to occur, student thinking about models has to shift from a ‘model of’ to a ’model for’, fostering the ability to translate models developed in one context to solve problems in another context. Discussion and reflection also play a significant part in supporting that shift in thinking (Dickinson & Hough, 2012).

Engineering as a vehicle for RME

Engineering is used here in a very broad sense to mean engagement in a systematic practice of design, to achieve solutions to human and real-world problems (National Research Council, 2013). This type of problem solving is inherently interdisciplinary as well as having a strong mathematical basis. Given this, engineering is a natural bridge for students to use to move between real-world contexts and the underlying mathematics. In order to ensure the context is experientially real, the students may require some introduction to what engineers do and the focus should be on engineers broadly as real-world problem solvers rather than specifics of engineering practice.

Engineering design process

The engineering design process (EDP) is a sequential process frequently used in engineering applications (shown in Figure 1). The EDP gives the designers scope to investigate different options and extend their imaginations in developing a potential solution to a problem. The key steps of the EDP are:

1. Identify problem—the engineer must be fully aware of what the problem entails and how this may affect people.
2. Brainstorm solutions—the engineer thinks of any ideas (both possible and improbable) that may lead to a suitable solution to the identified problem.
3. Design—the engineer will select one of the most suitable ideas developed in the brainstorm phase and start to create a full design for this idea.
4. Build—the engineer will build a prototype of the design.
5. Test and evaluate—the engineer will test the prototype under suitable conditions and assess its performance based on the established understanding of the problem.
6. Redesign—the engineer will identify features for improvement, which are redesigned and modified.

The EDP is a continual process. If at first a selected idea is not the optimal solution, the engineer will investigate ways to improve the solution or revisit other ideas identified in the brainstorming stage. After a redesign is completed the engineer will enter into the build, test and evaluate, redesign loop again, and this process will continue to iterate until an appropriate solution has been found.

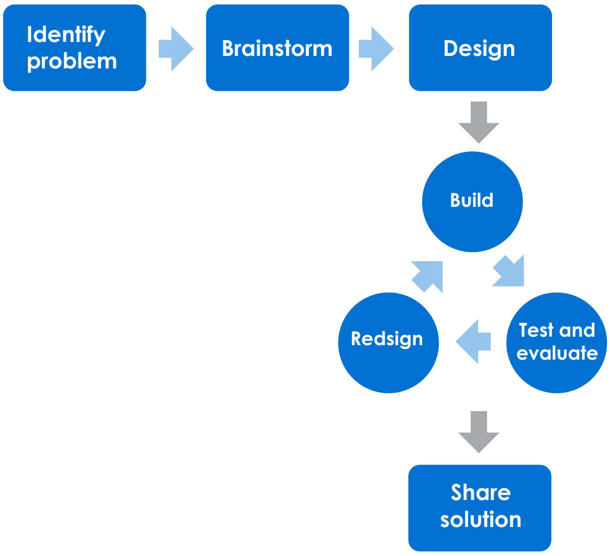

Figure 1. Engineering design process.

Activity: ‘Egg-streme’ egg crashes

In this activity students are tasked with designing a vehicle with sufficient safety features to protect its passenger (the egg). These safety features are tested by releasing the car at the top of an incline ramp (seen in Figure 2), the base of which is up against a wall to simulate a ‘crash test’ scenario. Utilisation of this vehicle engineering context and the EDP allows students to develop concrete understandings of the relationship between angles, forces and speed before these concepts are abstracted to general mathematical relationships.

Materials

The activity is designed to use only low-cost resources such as balloons, cardboard, egg cartons, tape and foam, as seen in Figure 2. These resources can be varied or limited in order to challenge the students.

Eggs, plastic axles and wheels, and a semi-circular ramp that the wheels/axle combination fit within are also required, also seen in Figure 2.

Figure 2. (Clockwise from top) Low cost design materials, incline ramp, eggs, axles and wheels.

Identify the problem

Students are asked to imagine they are engineers, whose job it is to design the safest car possible for their ‘crash test dummy’—the egg. As well as safety, they can be challenged to ensure their cars meet other requirements such as fitting into and rolling (rather than sliding) down the ramp or using restricted amounts of material. These can all be framed as the challenges working engineers face every-day; trying to create the safest product possible within the bounds of real-world limitations.

Brainstorm

A guided class discussion should be used to encourage students to think about the vehicles they have travelled in and what features these have to ensure the safety of their passengers, such as air-bags, seat belts and crumple zones. Students can also be encouraged to consider the types of materials used in real cars and the proportional strength of these materials (such as metals and plastics) and the types of passengers they are protecting (humans) with the types of materials they will use (such as cardboard and foam) and the type of passenger it needs to protect (the egg).

Design

Students then break into groups to design their vehicle on paper before they commence building. In this stage, the teacher facilitates discussion between students about their ideas, as well as encouraging detail in designs, like specific materials or measurements—rough sketches of initial ideas can be formalised in scale drawings.

Build

Once each group's design is complete, they can commence building. Students should be encouraged from this point to test components of their design and make small revisions as they build (for example, test to see if the chassis fit onto the ramp). Examples of designs from teachers and students can be seen in Figures 3 and 4, respectively.

Test and evaluate

Once a workable design has been built, students are given access to the ramp and eggs to test their completed cars. For the first test the ramp is set up at a slight incline, and increased upon re-tests. This allows students to identify weaknesses in their designs and determine the conditions under which failure may, or may not, occur.

Redesign

The core of the design process is that once a design is built, it is not static. After the vehicle has been tested, it is redesigned and altered in order to improve the design. It should also be stressed that not all alterations will result in improved performance but the method of building, trialling and evaluating is essential for determining the optimal solution. Evaluating the results each time may lead to more modifications or a return to an earlier design. Collecting evidence through quantitative measurement or qualitative observation, upon which to base suggestions for modifications, should be encouraged.

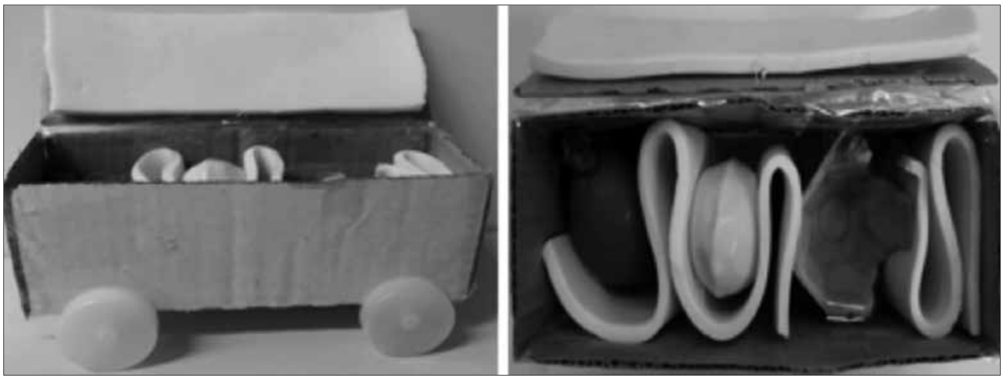

Figure 3. Example vehicle designed by a teacher.

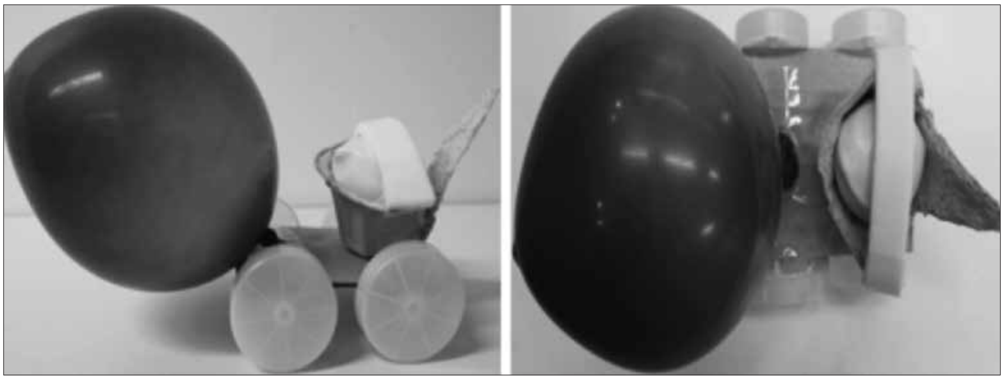

Figure 4. Example vehicle designed by a student.

Developing the mathematics

This activity presents an opportunity for multiple different mathematical concepts to be explored including investigating angles, forces, speed and making measurements. Students can explore the impact of changing one variable upon the performance of their car and can take measurements to produce graphs and make predictions.

Some suitable mathematics projects related to the activity include:

- Changing the angle of the track and seeing how this affects the performance of the car.
- Measuring the speed of the car with different track angles.
- Investigating how the size and spacing of the wheels affects the performance of the car.
- Exploring the weight of the car and the impact that has on the speed and performance of the car.

Curriculum links

The activity links with the *Australian Curriculum: Mathematics* (ACARA, 2015) particularly in the area of number and algebra (linear and non-linear relationships) and measurement and geometry (using units of measurement, shape, and applying geometric reasoning). The specific descriptors in the curriculum for the Year 7 level to which the activity relates are given in Table 1. The activity can also be extended to higher year levels, and can be modified to accommodate and extend the thinking of high achieving students.

Table 1. Curriculum links (ACARA, 2015).

Curriculum descriptions	Links to the activity
Establish the formulas for areas of rectangles, triangles and parallelograms and use these in problem-solving (ACMMG159)	Students construct their cars from a variety of different shapes. In drawing a plan view of the car, students consider the shapes of the components in their vehicle and calculate the area of these components to assess how much material is required to construct the car.
Draw different views of prisms and solids formed from combinations of prisms (ACMMG161)	In the brainstorm and design phase of the activity, students draw their vehicle and highlight the main safety features. This provides a useful opportunity to draw different shapes and more complex structures and construct scale drawings.
Introduce the concept of variables as a way of representing numbers using letters (ACMNA175)	As students start to understand the key concepts presented by the activity they relate these concepts to key variables and representations, such as time, distance, and angles.
Create algebraic expressions and evaluate them by substituting a given value for each variable (ACMNA176)	Students formulate equations to explain what they observe when testing their cars.
Extend and apply the laws and properties of arithmetic to algebraic terms and expressions (ACMNA177)	Students solve algebraic expressions developed and make predictions about what will occur outside of the tested range (e.g., extending the ramp angle beyond the range of angles tested).
Solve simple linear equations (ACMNA179)	Students formulate simple equations to explain their observations and learn to solve these equations.
Investigate, interpret and analyse graphs from authentic data (ACMNA180)	Students construct graphs from data collected, analyse the data, and draw conclusions based on this evidence gathered.

Conclusions

This activity has been implemented extensively with school groups in Southern Tasmania and students have demonstrated positive engagement with the mathematics and engineering ideas presented. It introduces students to engineering as a mechanism for gaining a real-world understanding of key mathematical concepts, within the familiar context of vehicle safety. Attention to the design scope and choice of variables that students have within the activity enables them to develop a comprehensive understanding of angles, forces, speed and measurement. Students also extend their knowledge of the equations related to these variables, which can be formalised by exploring concepts of velocity and acceleration in relation to the angle of the ramp. The additional use of data logging equipment and software would provide the opportunity to collect accurate empirical data and generate graphical representations to analyse.

References

Australian Curriculum, Assessment and Reporting Authority [ACARA]. (2015). *The Australian curriculum: mathematics & science*. Version 8.0. Retrieved 12 April 2016 from http://www.australiancurriculum.edu.au/download/f10

Broman, K., Bernholt, S., & Parchmann, I. (2015). Analysing task design and students' responses to context-based problems through different analytical frameworks. *Research in Science & Technological Education, 33*(2), 143–161.

Dickinson, P., & Hough, S. (2012). *Using realistic mathematics education in UK classrooms*. Retrieved 12 April 2016 from http://www.mei.org.uk/files/pdf/rme_impact_booklet.pdf

National Research Council. (2013). *Next generation science standards*. Retrieved 12 April 2016 from http://nextgenscience.org/next-generation-science-standards

Stephan, M. L. (2009). What are you worth? *Mathematics Teaching in the Middle School, 15*(1), 16–23.

From Helen Prochazka's
Scrapbook

An old Chinese saying:

> "The infinite is a square with no corners."

An old Indian saying:

> "Like the crest of a peacock so is mathematics at the head of all knowledge".

Walter Sawyer:

> "The fear of mathematics is a tradition handed down from days when the majority of teachers knew little about human nature, and nothing at all about the nature of mathematics itself."

Powerful designers

The American designers, Charles and Ray Eames, created numerous 20th century icons such as the stacking plastic chair.

In 1961, IBM collaborated with the couple to create Mathematica, an interactive exhibition dedicated to mathematics, which is still on display in New York more than half a century later. Part of the exhibition has been developed as an iPad app, Minds of Modern Mathematics, which gives a chronological view of the development of mathematics.

In 1977, the Eames made a short film called Powers of Ten. It begins with a shot of a sleeping man at a picnic. Every ten seconds, the camera zooms out one order of magnitude, that is ten times further, until the viewer is standing at the edge of the observable universe. The camera then returns to the picnic and zooms into the man's hand until the viewer is taken into the interior of a carbon atom.

Powers of Ten Day is celebrated each year on October 10, the tenth day of the tenth month. One of its aims is that people will develop an understanding of where we fit into the scale of the universe with the hope that this will increase our acceptance of others. For instance, if we zoomed in on the faces of a group of people, to a 10 000 × magnification, we would not be able to distinguish any differences in their skin colours!