9th UICEE Annual Conference on Engineering Education
Muscat, Oman, 11-15 February 2006

Encouraging creativity in design through student competitions

D. G. Wareham, J. LeMasurier & J. Mackechnie

University of Canterbury, Christchurch, New Zealand

ABSTRACT: This paper reports on a student competition in which teams of 4 students were asked to design an egg launching and catching device capable of launching an egg an initial distance of 2 metres without breakage. The design exercise was part of a creativity module in a Systems Engineering course and the objective of the exercise was to illustrate to students how the design process involves trade-offs between sometimes potentially conflicting criteria. Thus, the designs were judged not only on the winning distance but also factored into the total score were points for weight, cost, good appearance and accuracy/repeatability. Anecdotal comments from students indicated an immense enjoyment of the design experience and a full cognisance of the objectives of the competition.

INTRODUCTION

A common proverb is that a test for complexity of a subject is how much difficulty the dictionary has in defining it. Accordingly, a dictionary definition of an engineer reveals that they are "1: a member of a military group devoted to engineering work, 2: a crafty schemer 3a: a designer or builder of engines b: a person who follows as a profession a branch of engineering c: a person who carries through an enterprise by skilful or artful contrivance and 4: a person who runs or supervises an engine or an apparatus"[1]. The definition for engineering is similarly enlightening being "1: the activities or function of an engineer: as a: the art of managing engines b: calculated manipulation or direction (as of behaviour) and 2: the application of science and mathematics by which the properties of matter and the sources of energy in nature are made useful to people in structures, machines, products, systems and processes [1]."

It should come as no surprise that when a final year civil engineering class was asked for their definition of both an engineer and engineering in general; the responses gleaned were substantially different than the above definitions. Although perhaps the last statement about engineering resonated slightly with those definitions forthcoming from the students, there was still a wide gap between what the dictionary states (and by implication what the public thinks of) when the activities of an engineer are defined.

A further test for complexity is the amount of stereotyping surrounding a subject. Some of the more classic concepts include the fact that "engineers are applied scientists". It is fair to say that the students in the final year class didn't like that definition either, as they saw themselves more than just applied scientists who waited around for scientists to think up something so that they could apply it.

Teasing the definition out further began to yield a variety of responses to the point that it was eventually acknowledged by the class that a tight definition would probably not emerge that would be "all things to all people". One strand that did however emerge revolved around the ability of engineers to creatively design using compromise. That is, engineers were seen to create devices, systems and structures via a design process that involved compromise. Exploring these three key words in no particular order reveals an agreement that design is construed as an engineer's core activities [2]. Secondly, it is characterized as creative design and although some people are naturally creative, creativity is seen as a learned skill which can be encouraged and developed.

Finally there is the word compromise. In civil engineering this means that there are several considerations and/or criteria that govern all design and for which compromises must be sought. These are cost (often related to time), weight (often related to cost), purpose (functionality), good appearance (aesthetics), durability, reliability and/or safety, and responsibility (social and environmental). [3]. Engineers routinely balance these potentially conflicting factors through a process known as engineering judgement. For example, a structure could be made lighter and cost less - if one didn't have to worry about durability and/or safety. One could also over design a structure in relation to its purpose if one didn't have to worry about economics. In the process of trading off one criteria against another, risk analysis tools are often used with the ultimate objective of coming up with the best workable solution.

To illustrate the importance of being able to balance some of these criteria during the design of <u>any</u> type of engineering structure, it was decided to set a student assignment that would require them to design a system using a subset of the criteria listed above. The students would receive a score for each of the relevant criteria which would be incorporated into their overall final mark. The specifics of the exercise are outlined below and, in the main, they were adapted from an assignment used at a previous university at which the first author had been employed.

ASSIGNMENT OUTLINE

Objectives: Working in groups of four, the students were asked to design and build an egg launching and catching device. The system was to be capable of launching a raw egg that would travel a minimum distance of two metres through the air before being caught by the catching mechanism. It goes without saying that the egg had to remain intact for the duration of its flight and had to survive the impact of being caught.

Materials: Students could use any commonly available materials under the constraint that they could not purchase any materials other than incidental items costing less than $20.00.

Method**:** There were no restrictions on the design except that the only human control on the device permitted was in the setting of the launcher and its subsequent triggering. In other words, the machine had to carry out the complete launch and catch of the egg.

Design Specifications: The design specifications of the egg launching/catching device consisted of the following criteria...

1) Reproducibility: The launcher/catcher was to function similarly on each trial.
2) Accuracy: This related to how precisely the egg's trajectory was controlled on each launch.
3) Adaptability: This related to how well the device performed if the launch conditions were altered (i.e. if the minimum distance travelled was increased or decreased.)

Evaluation: A contest was held in which 3 eggs (supplied by the lecturer to prevent hard-boiled eggs or other egg tampering mechanisms being tried) were launched by each team in succession. Launches continued in rounds until all 3 egg were broken which eliminated the team from the competition. If a tie occurred between two or more teams, the distance was increased in increments of 0.5 metres.

Performance Criteria: Marks were accrued by each team based on the performance of the system. The performance of the egg launcher/catcher was evaluated according to the following criteria...

1) Creativity: Worth 20 %. How imaginative/innovative had the designers been in their design"? A design drawing of the system was to be submitted and this was scored by judges.
2) Functionality: Worth 40 %. How well did the device perform in terms of its purpose as evidenced in the contest? This was not only related to the winning maximum distance but also points were accrued with respect to the minimum number of successful launches at each interval before breaking all 3 eggs. For example, if they broke one egg before completing a distance with the second egg they would get 0 points (i.e. wrongs subtracted from the rights). If no eggs were broken for a distance increment they would receive 1 point.
3) Cost: Worth 20 %. How much did the device cost? Students were expected to submit a bill of materials that included a realistic itemized cost estimate for their design including the parts that they obtained without cost. Minimum cost was better.
4) Weight: Worth 20 %. The total weight of the egg launching/catching device was recorded. Minimum weight was better.

EXPERIMENTAL WORKSHOP

The contest was scheduled for an afternoon laboratory workshop between 2:00 and 4:00 pm as part of a Systems Engineering course. The workshop was linked with lectures on "Creativity in Design" that involved exploring various psychological and procedural techniques to improve one's capacity to be creative. Although the assignment was given out during these set of lectures, it was several weeks before the competition actually took place. During those ensuing weeks, it was quite evident to the first author that the designs were being prepared with a fair degree of secrecy, so that design ideas could not be plagiarised. This was in particular regards to the launching mechanism and the material /design of the catching device. Figures 1 and 2 show two examples of the egg launchers and their catching devices.

Figure 1: 1st Example of Egg Launching/Catching System

Figure 2: 2nd Example of Egg Launching/Catching System

On the afternoon of the workshop the egg launching/catching devices were unveiled 30 minutes before the competition to allow the judges (fellow lecturers) to examine the designs and make a preliminary (admittedly subjective) scoring with respect to aesthetics and how creative/imaginative the design teams had been. As the competition was being held in a public area of the university the various designs attracted a significant crowd of other interested engineering students all keen to see what the competition entailed (Figure 3).

Figure 3: Interested Spectators Observing Competition

Prior to the start of the competition, all teams were allowed to use their own eggs to ensure that their devices were capable of launching and catching the egg after it had travelled the minimum distance of 2 metres. Some of the smarter students had pre-boiled their eggs in order not to unnecessarily waste eggs smashed during the calibration period. The start line (Figure 3) was subsequently moved a considerable distance back when it was discovered that a family of ducks were nestled in the bush watching the competition. In particular, the mother duck was sitting on her nest, thus it was decided in the interest of environmental responsibility not to unduly stress her, by allowing her to witness what could only be construed as the whole-scale slaughter of her kith and kin's offspring.

One of the more amusing incidents occurred when one team unveiled their device which was clearly shaped like a blunderbuss. It was complete with a large cylindrical firecracker (15 cm long by 2 cm in diameter) with the attendant fuse all packed into the back end of the device. The judges inspected the device somewhat dubiously however they had to admit it to the competition as there were no specific marks allocated for safety. However, during its calibration trial, the crowd quickly backed away as the lit fuse got shorter, and then KABOOM!!!! – the egg was blown to smithereens spraying all and sundry including the judges with raw egg remains. Before a special commission could be formed to investigate the failure of the device, the team promptly unveiled their real entry to the competition which they had hidden inside a classroom. The judges were much relieved to see that it was a more muted and elegant device than the previous entry.

The competition was then started and all competitors remained in the game after the first round with only 1 group losing the first of their 3 eggs, thereby losing that point for that round. All the egg catching devices were then moved back a further 0.5 metres and the competition continued with teams slowly dropping out as they broke the remainder of their allotted number of eggs. The winning distance was over 6 metres won by the launching device and catcher system depicted in Figure 4. It was apparent that the use of nylon stockings donated by a female student made an ideal catching device due to the inherent resistance of the material which yielded substantially upon impact with the egg.

Figure 4 The Winning Egg Launcher/Catcher Device

At the close of the competition, all systems were taken down to the laboratory for weighing on the structural engineering scales. The bill of materials and the design drawings were also submitted for further evaluation and inspection by the first author.

CONCLUSIONS AND RECOMMENDATIONS

In addition to the fact that the students obviously enjoyed the exercise, there were several other valuable objectives obtained as a result of this assignment. Firstly, although not all of the considerations were necessarily relevant to the design of this type of system; it was clear that the students did indeed weigh some factors off against others, particularly because of the way points were accrued in the assessment part of the assignment. Any reasonable points system could have been generated however the system eventually decided upon was a practical way of getting the students to appreciate that in real-life engineering these factors often have to be balanced out against each other (i.e. success isn't only measured by the winning distance). One recommendation following on from this objective is that the lecturer could have billable consulting hours that are charged out whenever advice is sought by the student groups with regards to design. These hours can be converted to points which can be factored into the total score in some manner as a disbenefit (i.e. less points is better).

The second concept that the students clearly gained was the importance of creativity and lateral thinking in design. As mentioned, the exercise had been tied to the lectures on creativity where standard techniques to enhance creativity (eg. role-playing and brainstorming) were discussed. It was perhaps hard to quantify creativity, but when discussing the progress of the design with each of the student groups, it was clear that each group member's imagination was being stimulated by the ideas coming from the others and this resulted in a large number of ideas being generated for the design of the egg launching/catching system.

Finally, there were some lateral benefits with regards to this type of project; namely the students learned that good design involves iteration and that working in teams and communicating effectively is all part of engineering.

ACKNOWLEDGEMENTS

The authors would like to thank those students who participated in the competition and Dr. Duncan McInnis who provided the initial idea for the competition when he and the first author were previously employed at the Hong Kong University of Science of Technology, Hong Kong.

REFERENCES

1. Webster's 9th New Collegiate Dictionary, Merriam-Webster Inc., T. Allen & Son Ltd. Markham, Ont. Canada, 1984.
2. Canadian Professional Engineering: Practice and Ethics, G. C. Andrews and J. D. Kemper, Holt , Rinehart and Winston of Canada, Ltd. , 1992, pgs. 395.
3. Introduction to Engineering, 2nd Edition, P. H. Wright, John Wiley and Sons Inc., 1994, pgs. 261.