

Bringing a Short Hands-On Engineering Activity Into High School Classrooms

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ABSTRACT

Hands-on, team-based engineering applications of science and math were designed which could be brought into a high school classroom, with the goal of transferring an excitement for creative engineering to young people. Development of one such activity considered the challenges of matching the activity to the level of mathematical and technical background of students, as well as fitting the topic to a broad scope of high school curriculum areas. This approach combined basic math and familiar subjects to allow students to discover how tools they already know are used in engineering problem-solving. Self-directed student groups worked through the hands-on portion of the project with the assistance of handout procedures and instructor assistance. Questions generated during and after groupwork served as a basis for a discussion matching the interests and knowledge level of students. This project was presented to the high school teachers' workshop and then to a high school class of chemistry and math students. Experiential results and feedback from high school teachers provide a basis for evaluating this approach.

INTRODUCTION

As part of a continuing effort to introduce high school students to the world of engineering, Omaha campus faculty at the University of Nebraska-Lincoln's College of Engineering and Technology prepared a week-long series of workshops for high school teachers of math, science, and technology. The goal was to make engineering exciting to teachers and to give them working projects they could take back to their classrooms, transferring that excitement and interest to their students.

Faculty were presented with the challenge of developing hands-on engineering application activities which teachers could take directly into their classrooms. At the forefront of frustration in developing these activities was the difficulty of matching an activity with the diverse interest areas of science, math, and technology teachers. An additional problem was matching the activity to the level of mathematical and technical background of teachers and students. A hands-on activity was developed with specific approaches to overcome these challenges.

APPROACH

Developing an appropriate hands-on activity was clearly felt as a challenge to faculty in the manufacturing area. Previous departmental experience with presentations to high schools and

even high school teachers had already demonstrated the difficulty in communicating the problems of a manufacturing environment to those unfamiliar with manufacturing.

The hands-on project was selected and developed using the following strategies:

Keep it basic. To meet the challenge of appealing to students and teachers from diverse backgrounds in math, science, and technology, a project was desired which would build on basic applications of math and science that students had already learned or were currently learning. The concept of the existence of variation in the manufacturing system and the engineering challenge it presents was chosen as a basic idea to get across to students. Simple statistics such as average, standard deviation, and graphical depiction of distribution were selected as mathematical applications which might have connections to a range of science and math courses.

Build on familiar examples. To help students understand the nature of engineering problems in manufacturing, an activity was desired which could draw on familiar things in life. A familiar product with measurable variation was desired to demonstrate the concept of manufacturing systems and the variation inherent in them. *M&m*TM candies were selected. Student teams could measure the large diameters of a sample of *m&m*'sTM and determine their sample statistics. It was hoped that the colorful and tasty candies students would begin to capture the imagination of students and lead them to think about how manufacturing processes affect the things they purchase use in their own lives.

Provide a step-by-step procedure sheet and a simple worked example for student teams to follow independently. Since it was hoped that high school teachers could take the activity back into their classrooms, these procedures and examples were intended to maximize teacher comfort level in presenting the material without being an engineering “expert” themselves.

Fill-in-the-blank worksheets were provided to lead the students through the math and other procedures. This strategy hoped to minimize instructor effort, as well as to smooth out problems with differences in student background. Students not sure what to do next could simply fill in the next box or follow the next procedure. Byrd and Hudgins (1995)¹² and others have noted the need for structure in classroom teamwork. The author's own research (1996)³ has demonstrated the effective use of worksheets to guide teams as needed through a particular problem solving process.

A different familiar example, the process of producing breakfast toast of a consistent desired darkness, was used to introduce the students to the concept of manufacturing variation and to the procedures they would be following in the activity. This example problem was designed for use in a classroom introduction to the activity, but it was also provided in paper form which students could read individually or consult during groupwork as necessary. It was also hoped that this worked example would provide sufficient resource information for teachers attempting to bring this activity into their classrooms on their own.

Provide suggested learning objectives at various levels. A set of possible learning objectives, as shown in Figure 1, were designed to help the project find a place within a wide scope of science,

math, and technology classrooms. Using the same basic hands-on data collection activity, the project could be simplified or expanded within the instructor-led class discussion portion of the activity to meet the needs and mathematical and technical background of the particular classroom. If desired, an instructor could also use these objectives as a guide to fine-tune the actual student activity to more closely target desired objectives.

<p style="text-align: center;">Variation in Manufacturing: How Big is an <i>m&m</i>TM Candy?</p> <p><u>Possible Basic Topics</u></p> <ul style="list-style-type: none">• Correctly use and read manufacturing measuring equipment (micrometers or calipers).• Construct and use histograms to aid in visualization of part or process data.• Discover how choices of scales in graphing can lead to biased interpretation.• Apply basic statistical analysis tools: normal distribution, average, process spread (range, standard deviation, estimation of standard deviation). <p><u>Possible Advanced Topics</u></p> <ul style="list-style-type: none">• Use the z-distribution tables (to estimate the percentage of “good” parts).• Compare a sample taken from the process to the known “running good” condition. <p><u>Other Ideas</u></p> <ul style="list-style-type: none">• Apply spreadsheets for problem-solving.
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Figure 1. Possible Learning Objectives for High School Student Activity

RESULTS

High school teacher response. This project was presented to a group of twenty high school math, science, and engineering teachers within a two-hour time block as part of a larger teacher workshop on engineering applications of math and science. During the workshop, the concern of various “student” background experience was apparent. Required use of measuring instruments such as micrometers and calipers was new to some science and math teachers while technology teachers were experts. Some teachers handled the calculations with no special instruction needed, while others relied on guidance. Given the team-based design of the project and the mix of participating teachers, these background differences could be handled within the groups. However, in a homogeneous classroom, special instruction needs should be considered.

Written survey comments regarding the presentation of this high school student activity were unfortunately confounded with comments from another manufacturing activity, but appear to confirm appreciation for good hands-on activities which can be brought into their classrooms. Of the nineteen teachers completing the survey, eighteen answered positively to the question “The materials presented were useful to you,” and seventeen answered positively to the question “Is this material you could use in your classroom?” All respondents affirmed that “a sufficient amount of material was included.” Six teachers took the time to include positive written

comments praising how applicable or enjoyable the combined manufacturing activities were. General comments from the entire workshop of activities from various engineering and technology areas reflected teacher appreciation for hands-on activities they could bring into their own classrooms.

Perhaps more telling feedback was the invitation from one of the teacher workshop participants to present the “Variation in Manufacturing” activity, as-is, to a combined group of chemistry and math students. While neither of these classes had any specific coverage of topics in manufacturing or variation, the principles presented in the activity were considered by these teachers to be broad enough to be beneficial to their students and worthy of classroom time.

Experience from the High School Classroom. The small-group activity was a very manageable way to engage students in the classroom. In one classroom we divided fifty students into groups of three or four, with presenter and teachers floating from one group to the next to answer questions or present next-step instructions. Because the students could guide themselves through the handout and fill-in-the-blank tables, teachers actually had some time to spare.

To meet the allotted time for the activity, the each teacher acquainted her students in the use of micrometers on a previous class day.

Although the worked sample problem may be good for setting the stage of what the students will be trying to accomplish in their group assignment, the students seemed more anxious to dive into the hands-on portion. Rather than risk losing student attention with a lengthy introduction, it may be more prudent to keep introductions to a minimum and let the students discover their path themselves, consulting each other, their handout reference, and the instructor along the way as necessary. This decision depends on the goal of the activity. In this case, the goal was to transfer the excitement of creative engineering applications, so it was deemed more appropriate to work with student questions as they came than to insist that students meet specific learning objectives.

Students were astute at asking pertinent questions, noticing, for example, that the *m&m*'s weren't perfectly round, or that one person may measure the same candy but obtain a different reading. The team-activity environment was conducive to such questions being voiced among the not-so-threatening small group of team members. Questions were then brought to or overheard by instructors floating from team to team. Such questions were found to be useful for developing class discussion about the engineering concepts involved in the activity.

One initial fear of the “keep it basic” strategy was that the activity might end up being too simple, thereby boring students. Although the teachers of these classes attest that these students had covered the concept of standard deviation before, the students, when asked, told me that they hadn't done this before. Review, said one of the teachers, doesn't hurt them. Although this activity was performed in two honors classes, students did not seem insulted by basic math, but, on the contrary, rather eager to apply to reality what they already know. In this case, simplicity was appropriately used to capture student interest and led to further creative thinking and discussion about the problem, the analysis, conclusions, and related issues.

The list of possible learning objectives would be helpful in working with high school teachers in discovering an objective which would be a good “fit” for particular classes or groups. Since our goal was to capture the excitement and imagination of the students, only one basic learning objective seemed to be necessary for a one- or two-hour hands-on activity, especially if a creative professor is available to work with student responses.

CONCLUSIONS

High school teachers appreciated hands-on engineering application projects which they could bring to students in their classrooms. Step-by-step procedure sheets made this easier.

The developmental strategies which applied basic science and math concepts and which built on examples familiar to the students resulted in an activity which sufficiently engaged the interest of high school students. The use of step-by-step procedure sheets to guide student teamwork proved to be an efficient means of managing the project in a classroom setting. Self-guided groupwork also encouraged student questions and exploration. Student questions and hands-on exploration led to discussion of engineering concepts aimed at the students’ level of understanding and points of interest.

Time flies in the classroom, and one or two hours is really a short time to acquaint students to an application they’ve never really seen before, even if the math is simple. Since the goal of these projects was not to teach new concepts, but to transfer the excitement of creative engineering applications, this approach was successful. Students were excited to learn how the math and science concepts they already knew could be applied to real life.

REFERENCES

¹ Byrd, Joseph S. And Jerry L. Hudgins, “Teaming in the Design Laboratory,” *Journal of Engineering Education*, vol. 84, no. 4, October 1995, pp. 335-341.

² Morse, Julia L., “Design of a Gage R&R Experiment for a Basic Manufacturing Processes Course,” Thesis, Auburn University, 1996, p. 99.

BIOGRAPHICAL INFORMATION

JULIA MORSE is an Assistant Professor within the University of Nebraska-Lincoln College of Engineering and Technology (Omaha campus). She earned a B.S.I.E. from the University of Tennessee-Knoxville and an M.S. in Manufacturing Systems Engineering from Auburn University. Her work in the automotive industry includes engineering experience in quality control, industrial engineering, and product design and development.