Design Assessment: *Consumer Reports* Style

By Todd R. Kelley

One way to encourage students to consider these bigger impacts of technology is to first allow them to assess the personal impacts of everyday technology.

Introduction

Novices to the design process often struggle at first to understand the various stages of design. Learning to design is a process not easily mastered, and therefore requires multiple levels of exposure to the design process. It is helpful if teachers are able to implement various entry-level design assignments such as reverse-engineering activities. Students will likely develop the ability to tackle larger design and problem-solving projects the more they are exposed to small, design-based activities that require them to learn how to engage in just a few stages of the design process. The following article will feature a design assessment-based activity requiring students to assess an existing technology using a *Consumer Reports*-style approach.

Rationale

Petroski (1998) has indicated that novice designers need to be exposed to multiple design examples as a way to begin learning the essential elements necessary in the design process. Petroski (1996) also suggested studying the design of common everyday artifacts such as a GEM paper clip, the zipper, and aluminum can as presented in the book *Invention by Design: How Engineers Get From Thought to Thing.* Clearly, technology students who need to understand the design process would benefit from assessing an existing technology product. The *Standards for Technological Literacy: Content for the Study of Technology (STL)* document (ITEA [ITEEA], 2000/2002/2007) states: "To become literate in the design process requires acquiring the cognitive and procedural knowledge needed to create a design, in addition to familiarity with the process by which a design will be carried out to make a product or system" (p. 90). Additionally, the *STL* document goes on to state that professional engineers engaging in the design process first begin by setting out to identify and address design criteria as they work under specific constraints. Engineers need to first identify the crucial design criteria and the specific constraints embedded within the design problem. Hill (2006) suggests that technology students struggle to identify design constraints and criteria before they enter the idea selection stage of the design process. Similarly, leaders in technology education have indicated that K-12 design-based instruction often neglected cognitive processes that are important to the engineering design process: the analysis and optimization stages of the design process (Hailey, et al., 2005; Hill, 2006; Gattie & Wicklein, 2007).

McCade (2000) identified that technology assessment is one of three forms of technical problem solving. He also indicates that most technology education practitioners agree that technology assessment is a critical skill but is often difficult to implement in the classroom. McCade suggests that students be guided by a systematic approach to inquiry that can develop critical thinking skills. McCade (2000) provides a strong rationale for technology assessment when he writes: "Wise producers and consumers of technology must be capable of the type of critical thinking necessary to see beyond shallow, short-term considerations and select the most appropriate technologies" (p. 9). He provides technology assessment topics that require students to consider the broader impact of technology on society, individuals, and the environment.

However, a case can be made that one way to encourage students to consider these bigger impacts of technology is to first allow students to assess the personal impacts of everyday technology. A technology education teacher can encourage students to consider the broader impact of the technology by asking challenging questions such as, "Is there a way this product can be properly disposed of when it is no longer useful?" or "Can this product be harmful to humans or the environment if used incorrectly?" Technology students, when given an opportunity to participate in a *Consumer Reports*-style activity, can begin to develop and hone these important cognitive skills within the engineering design process, and through that process will be developing their design knowledge base and building their design capabilities.

Often it appears that students quickly engage in the idea-generation (brainstorming) stage of the design process and, in most cases, are motivated to participate in this stage (Harding, 1995). Likewise, the prototype or model-building stage of the design process is a highly motivating activity for students. Typically, the technology education teacher struggles to keep students from jumping past the other stages of the design process so that they can begin building (Welch & Lim, 2000). Any technology education teacher who has taught design to middle and high school students has struggled to get students to properly plan and design before they begin to build. What doesn't come naturally to students is learning how to consider the multiple facets of the early stages of the design process that are so critical to the later stages and, thus, are also important to the success or failure of the designed artifact. Students often lack the ability to accurately identify the constraints and criteria embedded within that problem, and therefore may lack the ability to design effective solutions.

Consumer Reports Style

Consumer Reports is a publication featuring assessments of many of the popular products we purchase and use every day. Consumers Union (CU) publishes *Consumer Reports* and is an independent and nonprofit organization whose mission is to work for a fair, just, and safe marketplace for all consumers and to empower consumers to protect themselves (consumerreports.org). The Consumers Union organization was founded in 1936 in response to an increase in mass media marketing that left consumers with a lack of reliable sources of product information that made it difficult to determine hype from fact. Most individuals have consulted a *Consumer Reports* magazine issue from time to time before purchasing a new technology. *Consumer Reports* assesses many appliances, cars, tools, and other products in its National Testing and Research Center in Yonkers, NY. The testing center is the largest nonprofit educational and consumer product-testing center in the world where the testing of various brands of products takes place. Consumers Union researchers assess the various models of a product to determine which product is the best value, the most effective, or some other criterion. Using a *Consumer Reports*-style assignment for assessing a technology product provides students with an opportunity to determine the appropriate constraints and criteria to consider when assessing a chosen product.

Classroom Example

The following technology activity can address *STL* technological literacy Standards 8, 9, 10, and 13.

A *Consumer Reports*-style assignment might require students to assess a backpack. Most students use some type of bag or backpack to carry their books and belongings to and from school, so this product is one with which students can easily identify, making it an ideal product to have students assess. The assessment report would require that a group of students (two or three students per group) collect three new or like-new different models of the same product. In this case: a backpack. Next, the students will need to begin to examine the product and collect some product details (take measurements, i.e., linear measurements, weight, etc.) in order to provide a technical, detailed description of each model of the product. Third, the students will identify and list any unique features about the product model. For the backpack example, students might list special compartments to hold specific devices such as an MP3 player or specially designed comfort features such as extra padding, unique shape in the straps, or a lumbar support. Without the students realizing it, they have begun to identify the various constraints and criteria embedded within the product design. This unique outcome of the activity is similar to reverse-engineering activities that allow an individual to benefit from learning design through the study of existing design solutions.

Next, the students will need to develop a nondestructive test to help assess the effectiveness of the various product models. In the backpack example, students could load the various backpack models with books or weights and then have each team member carry the load as they walk around the school. Each team member will take notes of the comfort level of the backpack and any other observations they had as they tested the pack. The group should reassemble and compare notes and provide a performance summary for each model.

Now that the students have begun to identify specific design features (design criteria) and have taken detailed measurements and identified cost, manufacturing requirements, and constraints of the product, these design elements will be used to determine which product model provides the optimal solution. The optimization stage of the engineering design process is a systematic process that uses design constraints and criteria to allow the designer to locate the optimal solution, another often neglected stage of the engineering design process in K-12 design-based instruction (Kelley, 2010). Using the *Consumer Reports*-style assignment, technology education teachers can help students learn how to use a systematic process to select the optimal solution.

Using a Decision Matrix

One optimization technique that uses a systematic approach to determine the most ideal design selection is the decision matrix. The decision matrix allows the designer to assign weights to constraints and criteria as a way to systematically locate the optimum design solution. Each student team would need to identify and list the most essential design criteria and constraints for the product they are assessing. For the backpack problem, students might identify the design criteria as comfort, durability, esthetics, and functionality. The product design constraint may be identified as cost and size. The student team would next need to conduct a group discussion and rank and list these constraints and criteria in ascending order from most important to least important. Next, the student group would need to determine the percentage (weight) of importance for each of the constraints and criteria identified.

Testing of the backpack designs may help the students determine that comfort is one very important criterion, but if the backpack will not carry all their belongings (functionality) then the product would not be as useful, so functionality might emerge as the top criterion. The student team can then create a decision matrix table to be used to assess the various models they are evaluating. See Table 1 for a sample decision matrix for the backpack example. Finally, the team must calculate the mean score for each

Criteria	**Weight (%)**	Product #1	Product #2	Product #3
Functionality	30	5 / 150	3 / 90	4 / 120
Comfort	25	3 / 75	3 / 75	5 / 125
Esthetics	15	4 / 60	5 / 75	3 / 45
Durability	10	2 / 20	3 / 30	4 / 40
Constraints				
Cost	10	3 / 30	5 / 40	1 / 10
Size	10	3 / 30	3 / 30	3 / 30
Total	100	365	340	370

Table 1. Adapted from Edie et al. (1998, p. 117). Rating scale based upon Likert style using 5= excellent; 4 = very good; 3=good; 2= fair; 1= poor. Shaded triangles contain totals of Weight x Rankings.

product category and total the results to determine which product is the best overall design based upon the group's identified criteria. Each student will prepare a final report presenting his or her findings and conclusions.

Class Presentation

After the student groups have conducted their testing and product analysis, each group will compile its results into a technical report to turn in for assessment by the instructor. Furthermore, each group will prepare a report for the entire class to share the results of the group's analysis. A classroom presentation of their analysis will help students synthesize their learning and help develop communication skills.

In Summary

Often technology education teachers are guilty of being like their students, preferring to have students build prototypes and make artifacts instead of assigning a nonbuilding activity. However, providing students with class activities that help them build their capacity to effectively design is essential. The activity presented in this article will allow students to hone their skills in identifying design constraints and criteria, learn through study of existing designs, and experience engineering design techniques for optimization (decision matrix). These are all essential skills for building their capacity to tackle larger design activities.

Assessment Report Sample

Name ____

Group Member ________________________________

Group Member ________________________________

1. Technical product information
   Provide all necessary technical information about the model being assessed. This information includes a *physical* description (size, shape, color, capacity, etc); technical description (for electronics—energy capacity, etc), *special feature* descriptions (unique capabilities of the product model). Include a picture of each model.
   a. Model and Brand #1 description:
   b. Model and Brand #2 description:
   c. Model and Brand #3 description:

2. Measurements of products
   Conduct all possible measurements (length, width, height, weight) of the various models and record below.
   a. Model and Brand #1 measurements:
   b. Model and Brand #2 measurements:
   c. Model and Brand #3 measurements:

3. Unique features of products
   List of the unique features of each product model. Does the model have different features than the other models?
   a. Model and Brand #1 unique features:
   b. Model and Brand #2 unique features:
   c. Model and Brand #3 unique features:

4. Limitations of products
   List any limitations of each model being studied. Are there any missing features from the product model? Does the model have limited abilities from other model designs?
   a. Model and Brand #1 limitations:
   b. Model and Brand #2 limitations:
   c. Model and Brand #3 limitations:

5. Cost of each product model
   When recording the cost of each model, try to list the standard cost instead of providing a bargain sale amount.
   a. Model and Brand #1 total cost:
   b. Model and Brand #2 total cost:
   c. Model and Brand #3 total cost:

6. Testing each product model
   Now that you have carefully studied each model, put each one to the test. Develop a nondestructive test for the product. For example: if you were testing a backpack, you could load the backpack with textbooks and have each group member walk around the school running track to test it for its comfort and effectiveness to carry your belongings.

Assessment Report continued on page 16

Assessment Report continued from page 15

Test description: Provide a detailed description of the test your group developed. Provide pictures and take notes of the results and observations for each model.

a. Model and Brand #1 test results:
b. Model and Brand #2 test results:
c. Model and Brand #3 test results:

7. Constraints and Criteria identified from testing
List several design constraints or design criteria that were revealed through your testing. For example, if testing a backpack with weights: *comfort* might emerge as a design criteria, and *capacity* (size limits) might emerge as a constraint.
    a. List of design criteria identified from testing:
    b. List of design constraints identified from testing:

8. List all other design constraints and design criteria
Review the results from your report items 1-5 on the three models. What other design criteria and constraints have been identified? Please list below:
    a. List of design criteria:
    b. List design constraints:

9. Each group member must *rank* each of the constraints and criteria identified. List the constraints in ascending order, from most important to least important. Compare your results with the rest of the group. Discuss and determine the top five design constraints and criteria for the group. Discuss the value or weight of each of the five constraints and criteria; see Table 1 for an example. Now create your decision matrix like the sample in Table 1. Each group member should print out the decision matrix and fill it out using his/her own individual rankings, then return to the group and fill out a group decision matrix that contains the *mean* scores of the group for each category for each product model to determine which model is ranked the highest. Again, see Table 1 for a sample.

10. Provide a summary of your report
Your group should discuss the results of the decision matrix. Please provide a summary of your results, including general observations and specific discoveries encountered through this activity.

References

Consumers Union. (2009). *Consumer Reports history.* Retrieved from http://consumerreports.org

Eide, A. R., Jenison, R. D., Marshaw, L. H., & Northrup, L. (2001). *Engineering fundamentals and problem solving* (4th ed.). Boston: McGraw-Hill.

Gattie, D. K. & Wicklein, R. C. (2007). Curricular value and instructional needs for infusing engineering design into K-12 technology education. *Journal of Technology Education, 19*(1), 6-18.

Hailey, C. E., Erickson, T., Becker, K., & Thomas, T. (2005). National center for engineering and technology education. *The Technology Teacher, 64*(5), 23-26.

Harding, R. (1995). Professional designers in primary schools: How successful are they at teaching children design skills? *Design and Technology Teaching, 28*(1), 19-21.

Hill, R. B. (2006). New perspectives: Technology teacher education and engineering design. *Journal of Industrial Teacher Education, 43*(3), 45-63.

International Technology Education Association. (2000/2002/2007) *Standards for technological literacy: Content for the study of technology.* Reston, VA: Author.

Kelley, T. R. (2010). Optimization, an important stage of engineering design. *The Technology Teacher, 69*(5), 18-23.

McCade, J. (2000). Problem solving: Much more than just design. *Journal of Technology Education, 2*(1) pp. 1-10.

Petroski, H. (1998, October). Polishing the GEM: A first-year design project. *Journal of Engineering Education,* pp. 313-324.

Petroski, H. (1996). *Invention by design: How engineers get from thought to thing.* Cambridge: Harvard University Press.

Welch, M. & Lim, H. (2000). The strategic thinking of novice designers: Discontinuity between theory and practice. *The Journal of Technology Studies, 26*(2).

Todd R. Kelley *is an assistant professor in the College of Technology at Purdue University, West Lafayette, IN. He can be reached at trkelley@purdue.edu.*

This is a refereed article.