First-Year Product Design Challenge: Creative design development for the disabled

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Abstract

There are situations when an engineer will be required to get a concept across to a customer, fellow engineer, or boss without the use of traditional tools. When discussing business over dinner, there typically will not have a pad of paper at available. What could be used to convey concepts? A paper napkin and a pencil of course!

A product design challenge is incorporated into a first year engineering design program at a large research university where students are asked to work on a potential situational creativity problem. The problem is a combination of real world experiences, drawing on a napkin, and creatively developing concepts to solve an engineering problem. The uniqueness of the challenge is the subject matter. Each student is asked to individually design a rake for a disabled person who has unilateral loss of function of the arm and hand. The disabled person in question is a stroke victim who lost functionality of the right limb and is willing to critique the individual designs and work with a student or a team to develop a working prototype rake. The subject is unable to put downward pressure on the rake and can only drag the rake horizontally across the leaves thus raking only the leaves on top. Downward pressure is needed to get the rake between grass, dirt, and other leaves. The rake must be designed so that the user will be able to exert downward force despite his or her disability.

Assessment strategies to collect data to determine the students' perceptions of the learning experience in the Product Challenge Project include a post-survey and a focus group with a sample of students enrolled in the class. The process of developing a product is drawn from the first author’s personal experiences working in industry. This paper will describe the instructional design process, the learning objectives and student perceptions of learning in this design challenge project in a first year design course. This paper will be of interest for those who teach first year engineering students.

Introduction

There are occasions where a concept needs to be conveyed but paper and pencil are not available to convey the concept without a sketch. We have developed a product challenge for first-year students that teaches them the design process. The students are guided through the process where they individually brainstorm and design their own version of a rake for a one handed person. This product challenge follows the How People Learn (HPL)\(^1\) theory where the students are given a problem that they have to solve. The customer is a disabled person that has lost the use of one of their arms.

The customer would like to be able to rake leaves and lead a normal life. The normal rake does not allow the customer to put downward pressure thus the customer can only drag the rake across the tops of the leaves. The rake needs to have a method whereby the customer can apply
downward pressure with only one arm. Usual rakes need to have two hands; the one hand down the rake shaft usually applies the pressure.

This is truly a learning experience where the students learn to develop a product without any outside influence. Each student in the class goes through the engineering design process and develops a prototype. The students learn how to individually brainstorm a product by working through the plan. They identify customer needs, brainstorm concepts, sketch their concepts, and use a concept screening matrix to decide on the best concept, sketch their best concept, and describe it in detail. The objective of this project is to learn and practice an engineering problem, experience a real world problem that some disabled people experience every day, and solve that problem so that disabled people can enhance their quality of life, while applying the engineering design process.

Literature review

Rowe and Klein used the How People Learn (HPL) in which the method for the HPL is outlined for the process (Rowe). The learning environment must be knowledge-centered, student centered, assessment-centered, and community-centered (Rowe). According to [How People Learn (HPL)] theory, students learn best when (1) presented with organized information that (2) relates in some way to their own experiences, and they are given the opportunity to (3) test themselves on their own understanding and to (4) work to develop their understanding with other students” (Gransfored). In this Product Challenge the students work individually.

The Product Challenge uses Problem-Based Learning (PBL) which is an instructional method where relative problems are introduced at the beginning of the instructional cycle which are used to provide the context and motivation for the learning that follows. “This approach involves considerable self-directed learning on the students’ part. Learning becomes active as the students discover and work with content that they determine to be necessary to solve the problem.” (Chatmon) “Problem-based learning as experienced by the student is when a student (1) explores the issues, (2) lists what is known, (3) develops, and writes out, the problem statement in his/her words, (4) lists out possible solutions, (5) lists actions to be taken with a timeline, (6) lists what needs to be known, (7) writes up solutions with supporting documentation, and (8) a debriefing exercise is administered individually and as a group” (Chatmon).

Teaching Method

The students review the description of the challenge and each student is expected to develop customer needs from the customer’s statements. The customer needs require specifications, which are put into the Needs/Specification matrix (see Table #2 below) where the specifications are developed. All customer needs should have a least one or more specifications. The specifications can be considered a test that will be qualified before the product is released to production. The student is asked to develop three creative designs and rate them, using a concept screening matrix and/or concept scoring matrix (see Table #3 below). The matrices are used to rate the concepts on how well they meet the customer’s needs. Based on their results of the screening and/or scoring matrix, students will select one or more designs to be developed further.
During the activity the instructor has often observed the students acting out the raking motion that lets them test their rake in the air.

If a student or a team of students would like to develop a working prototype, they will follow the design process that has been previously introduced to the students. The student or students will be required to research other designs to prevent infringement on existing patents through the patent office. The students will also benchmark their product against other products that are similar and already on the market.

The observation that some students practice raking in air is an active learning experience where they are practicing to rake leaves in air. “Many professors are aware that active learning is a more effective approach than traditional engineering lecture courses.”\textsuperscript{14} Active learning is being used by some of the students during their conceptual development phase.

1: Design Process

The process uses the following the eight steps (see Figure #1)

1) Identify the problem – The students have been taught the framework of the process where they need to identify the problem. For example, using this analogy, if a front wheel spindle breaks on a Ford pickup truck that had been lifted, what is the problem? Most students would say the problem is that the wheel fell off the truck when in reality the problem is that I can’t drive my truck!

2) Define the problem – Now we can define the problem – The spindle broke and we will need to fix the truck and we will need a tow truck to transport the truck home.

3) Develop the possible solutions – This is the brainstorming part of the process where the student lists as many solutions that they can think of to solve the problem of a broken spindle. For this situation there are two solutions: replace the spindle with a stock spindle or buy a new lifted spindle.
4) Select the best solution – We have two options and the most important factor is cost. An old spindle at home is available or buy a new lift spindle. Since the most important factor is cost, you select to put on the old stock spindles, at a cost $0.

5) Model the solutions – A model is created to meet the spindle.

6) Test and evaluate – Verify that the new spindles meet the customer specifications.

7) Communicate the solutions – Send the documentation to the production facility and make or buy the parts.

8) Refine the solutions as needed – Review and refine the design through a continuous engineering process. (see Figure #1)

Figure #1 Design process (Lau, et al.)

2: Presented with organized information

The students are asked to plan their work. A Gantt chart (see Table #1) is given where they will plan out their work over the next two hours to complete their design process. The students are asked to review the Product Challenge and determine sequence and time allotted to each task. The students use the project plan to plan out their time to complete the Product Challenge on time using the template below. Plan the start and end time by putting an X for the beginning and end of the task. Record the actual start and finish time for each task with an O. If a start or finish O coincides with an X then just circle the X that you planned. The test should take about two (2) hours to finish the test. Use the template below to plan your time effectively.

<table>
<thead>
<tr>
<th>Tasks</th>
<th>1st half hour</th>
<th>2nd half hour</th>
<th>3rd half hour</th>
<th>4th half hour</th>
</tr>
</thead>
<tbody>
<tr>
<td>Planning</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Extra Credit</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>B</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>True/False</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>a. Customer needs</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>b. Communication</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>c. Reference concept</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Design process</td>
<td></td>
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</tr>
<tr>
<td>10</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. Steps</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>2. Engineer’s goal</td>
<td></td>
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<td></td>
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<tr>
<td>Product Challenge</td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>5</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A. Needs Matrix</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>B. Brainstorming</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C. Select your best</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>D. Detailed design</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>E. Communicate</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table #1 - Template (an example of student’s work)
3. Test themselves on their own understanding

Product Design Challenge– A rake for stroke victims

The Problem: One-handed persons cannot work a normal rake. They may have lost their arm to an accident, may have been disabled, or had a stroke. Some stroke patients lose their ability to control one side of their body. Stroke patients that do lose the ability to control one side can stand and walk with a brace on their ankle, knee, etc., on the effected side. Stroke victims still can and want to lead a normal life and do daily chores like raking leaves in the fall. Leaves drop from the trees during the fall season and would typically be raked up with a normal rake but normal rakes will not work for one-handed people. They can walk and carry a rake but cannot effectively move the leaves because they can only drag the rake. Raking leaves takes leverage that is normally applied by the other hand that is placed down on the shaft of the rake.

The Challenge: A prospective customer has been asked to come over for dinner and he/she mentions that there may be a market for a rake that can be used by a one-handed person. There is not much time so immediately consider your customer needs and convert the customer needs to metrics using our needs/metrics matrix on the next page. As the engineering design process continues by brainstorming some concepts and selecting one of the concepts using the concept selection matrix. Provide a sketch of the one handed rake on the supplied napkin and describe the key features of your design and how the rake is used.

Your work should include:

- Create metrics for the customer needs
- Sketch the best concept on a napkin
- Brainstorm three (3) or more concepts
- Describe key features of the concept
- Select the best concept

<table>
<thead>
<tr>
<th>Need #</th>
<th>Need</th>
<th>Need 1</th>
<th>Need 2</th>
<th>Need 3</th>
<th>Need 4</th>
<th>Need 5</th>
<th>Need 6</th>
<th>Need 7</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Light Weight</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Can be used with one hand</td>
<td></td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Ability to collect leaves</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Ease of use</td>
<td></td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Factory made</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>6</td>
<td>Use in different types of grass</td>
<td></td>
<td></td>
<td></td>
<td>X</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>Durability</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
<td></td>
</tr>
</tbody>
</table>
See the matrix below to convert the customer needs to metrics:

<table>
<thead>
<tr>
<th>Metric #</th>
<th>Selection Criteria</th>
<th>A</th>
<th>B</th>
<th>C</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Heavy raking head</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>2</td>
<td>Total mass</td>
<td>0</td>
<td>+</td>
<td>-</td>
</tr>
<tr>
<td>3</td>
<td>One hand required to operate</td>
<td>+</td>
<td>+</td>
<td>-</td>
</tr>
<tr>
<td>4</td>
<td>Leaf Storage</td>
<td>-</td>
<td>-</td>
<td>+</td>
</tr>
<tr>
<td>5</td>
<td>Angled raking claw</td>
<td>-</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>6</td>
<td>Total volume</td>
<td>-</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>7</td>
<td>Preassembled</td>
<td>+</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>8</td>
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<tr>
<td>9</td>
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<td>10</td>
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</tbody>
</table>

**Table #3: Concept screening matrix (template for students use)**

Select the best concept using the concept screening matrix.

Transmit the Design: Paper or writing instruments are not available. Creatively using engineering talents ask for a pen or pencil and a paper napkin to sketch your design. Describe key features of the concept (materials, size, benefits, etc.) Clearly list how the rake works with a stroke victim. Be sure to explain the concept in detail and the benefits to stroke victims. Assessment of student’s performance in the Product Challenge is a graded quiz.

Figure #2: Example of napkin and pencil.
Assessment Methods and Participants

Students’ perceptions of learning were used to assess the Product Challenge. Students were asked to volunteer to complete an online survey that targeted feedback on the perceptions of the Product Challenge and participate in a focus group. Students in three sections of the engineering first year design course were consented according to the university Office of Research Protections IRB protocol. Students consented to the use of the survey, focus data and their coursework for the purpose of the research study. The total student enrollment across three sections of the first year design course was 121. The students primarily represented domestic students, with 78 male, 39 female and 16 international. The average age was 18-19 years old. Because the Product Challenge was a graded quiz all students were required to do the quiz whether or not they agreed to participate in the research. The quiz is included in Appendix A. The survey questions are included in Appendix B. The survey results are included in Appendix C.

Since this is the first time collecting data on the Product Challenge the researchers used the survey and focus group methods. The survey included both items scored on a 5-point scale, Strongly Agree, Disagree, Neither Agree nor Disagree, Strongly Agree and open-ended items. For this first attempt, the researchers determined survey items based on the need to focus on the objective of the quiz, which to test student’s knowledge and application of the engineering design process. The quiz was given during the fourth week of the semester with first-year, first-semester engineering students. The focus group was added to gain feedback from students in their own words about the Product Challenge. For future semesters the researchers will continue to use the survey and focus group with revisions and to incorporate items that relate to students’ self-efficacy and identity with engineering. For example, “did the Product Challenge learning experience help you to be more confident about becoming an engineer”? The focus group conversations that researchers conduct in the next semester will target items that address student’s behavior, learning and growth as related to the application of the engineering process. Because this was a quiz and students worked independently, not in teams, we were not able to measure any techniques or approaches that were new or any that could be used in future projects. Also, the engineering design process is a singular approach that applies to all engineering problems so it would not be expected that students develop different techniques.

The key points of the survey showed that 95% of the participants found the experience of designing a rake for a disabled person rewarding (figure #3); and the students used a variety of problem solving skills like drawing, brainstorming, planning, and writing (figure #4). When asked how the brainstorming may have been difficult some students considered time constraints commenting that “it was hard to think of many concepts; that it takes time to come up with ideas; and brainstorming was difficult because of time.” One student remarked “it was difficult to understand the problem faced from the perspective of a disabled person.” While another student remarked positively, “It wasn’t bad. Ideas for this specific use came easy. It was figuring out which [idea] fit the needs [,] that was the tough part.”
When asked “how did the product challenge help your learning of the engineering design process?” mostly all of the students said that the challenge helped them because they had to practice all the steps. “It was the first time I had to use the entire engineering design process to create a product concept from start to finish. It took the concepts that I had learned from lecture and made me apply these concepts to real life.”

Very interesting were the responses to the survey item, “What would you prefer to use as an alternate media or engineering tool instead of the pencil and napkin for making the drawing?”

Students creatively said:

- “If I was still at the restaurant I would have asked for a kids coloring menu. I would have gotten a bigger sheet then lose leaf and at least three colors.”
- “Type ideas on a phone or a note card.”
- “A golf score card would be a good idea that is a real world application for sure.”
- “Perhaps a tablet or some form of technology.”
- “Actually no. Drawing without limits is a good start to any thought process.”

![Figure #3: Evidence that it was a satisfactory experience.](image1)

![Figure #5: Skills used](image2)
The open-ended responses are represented in the following Word Clouds, that were created using Wordle\textsuperscript{8} as a research tool. “A word cloud is a special visualization of text in which the more frequently used words are effectively highlighted by occupying more prominence in the representation. Worldle can be useful for studies that involve qualitative/thematic analyses of written or transcribed spoken text. Wordle can be used for preliminary analysis, quickly highlighting main differences and possible points of interest, thus providing a direction for detailed analysis. The word clouds provide an additional support for other analytic tools.”\textsuperscript{9}

“How was the brainstorming difficult for you?” When the responses to this open-ended were put into Wordle, the following word cloud was created. This shows that the words in the larger font were the most prominent in the aggregate of the responses. The same is true for the next survey item.
Figure #7: “How was the brainstorming easy for you?”

Figure #8: “How did the product challenge help in your learning of the engineering design process?”
In addition to the survey, 8 students volunteered to participate in a focus group. The focus group was facilitated by the college Instructional Support Specialist. The instructor of the course was not present during the focus group. The purpose of the focus group was to have a face to face conversation with a represented group of students. The focus group allowed the researchers to garner deeper and rich feedback from the students in their own words on the effectiveness of the teaching design, the activity and suggestions on how to improve the Product Challenge for future students.

We represent here the preliminary analysis of the focus group discussion. The student comments are listed in summary form. The researchers acknowledge the importance and value of qualitative data. We plan to have the focus group conversation transcribed as we proceed to the next level of analysis of the qualitative data. This is to code the transcript to determine themes and commonalities among the responses and have the data analyzed for the final version of the paper. Since participants are allowed to react openly and honestly in focus groups, the researchers hope to gain insightful information regarding the Product Challenge. Focus groups are just-in-time and naturalistic.10 The benefit is that “the researcher listens not only for the content of the discussions, but for emotions, ironies, contradictions and tensions. This enables the researcher to learn or confirm not just the facts (as in survey methods), but the meaning behind the facts.”11 In the next round of focus group data collection, the researcher will use the coded data to compare and contrast student’s behavior and reactions to whether the Engineering
Design process was practiced correctly by the students. Did the student’s understand how to apply the engineering design process? How was the quiz difficult for them to understand? Was it clear and easy to implement? Colleagues from the college of engineering teaching and learning center will assist in the coding and analysis of future focus group data, as we move into collection of data in the next semester.

When asked if they were surprised that they had to design on a napkin, students all agreed that they liked this challenge. “It made it more real world.” “It was cool because it was a surprise to us.” “It was good because we had no previous knowledge of the project.”

Students explained that this was not a problem that would have been studied; “a new idea for problem solving.” This was not expected and no one in the class had an advantage. Everyone had an equal chance to use the engineering design process. Additionally the students felt that if you could do this design problem then “you understood the engineering design process.”

An international student shared that it would be better if this was not delivered in a quiz format, but rather as a longer project where students would have more than two hours to solve the problem. To approach the design problem, most students agreed that as they were reading the challenge to design a rake for a one-handed person, they were going through the needs of the user and the process intuitively. However, this was difficult because they had to keep reminding themselves that the rake was for one hand. “You have to put yourself in the mindset…one hand, one hand.” A female student shared that she experienced doing a project in high school that involved using the engineering process and a male student agreed. However, they did not know they were actually using the engineering design process until they reflected upon this in this first year college course.

Regarding how this project was most helpful to your learning, the project and the class in general gave the students more confidence. “I learned how to fix a problem and come up with new ideas. This quiz showed me that I can do this.” “This was the first time I had a quiz with no structure and did not know how to study for this quiz.” Students agreed that there was nothing to memorize; the quiz was problem-solving, application and critical thinking. They all nodded in agreement when one student quipped “I liked this.”

Regarding the format of the quiz, the students said they don’t recall much of what was on the first page of the quiz, however, they did remember the rake problem. They liked the challenge of having to think on their feet because they did not have any prior knowledge of the rake design problem. The focus group discussion ended with the students pleased to have the opportunity to contribute to the feedback on the Product Challenges quiz.
Conclusion and Future Assessment Plan

Almost all the students had a positive experience with the Product Challenge quiz of designing a rake for a disabled person. Most of the students did enjoy drawing on a non-traditional napkin paper and a small pencil. Who knows when a situation may arise when they are without paper and pencil but they will have some experience with sketching and verbalizing a concept.

In the future we would like to compare the time it takes each student to finish each of the steps according to the project plan that is part of the product challenge assignment. We will continue the Product Challenges with the disabled person component included where it is appropriate.

We are considering a fishing pole or a shovel. We think a comparison with a project for a disabled person and a project without the disabled component may be interesting to measure. Will the design be as satisfactory as the disabled project? Will the student’s be as vested in the project? Perhaps we will ask students to select the project and the issue using a team or collaborative approach. Because this was a quiz taken individually no teamwork was used and the faculty were not able to observe student behavior. Using a team approach would provide a more student-centered activity.

The assessment plan will be revised to include a pre-survey to assess student’s prior knowledge of the engineering design process, the quiz with observations during the quiz by the researchers to assess student behavior; a post survey to obtain feedback on students perceptions and a focus group at the end of the semester. Revisions to the survey items and focus group protocol will include collecting data on student’s self-efficacy, using a self-efficacy scale\textsuperscript{12} and identity with the major of engineering. This plan will allow for a more systematic approach to evaluation of the Product Challenges quiz and data analysis, both quantitatively and qualitatively.\textsuperscript{13}

The author’s would like to thank the Pennsylvania State University, College of Engineering, Leonhard Center for the Enhancement of Engineering Education for support of this project.
Bibliography


Appendix A

A. (15 points) Review the test and determine sequence and time allotted to each task. Create a project plan to complete this test on time using the template below. Plan your start and end time by putting an X for the beginning and end of the task. Record your actual start and finish time for each task with an O. If a start or finish O coincides with an X then just circle the X that you planned. You have about two (2) hours to finish the test. Use the template below to plan your time effectively.
Product Design Challenge (25 points) – A rake for stroke victims!

The Problem: One-handed persons cannot work a normal rake. They may have lost their arm to an accident, may have been disabled, or had a stroke. Some stroke patients lose their ability to control one side of their body. Stroke patients that do lose the ability to control one side can stand and walk with a brace on their ankle, knee, etc., on the effected side. Stroke victims still can and want to lead a normal life and do daily chores like raking leaves in the fall. Leaves drop from the trees during the fall season and would typically be raked up with a normal rake but normal rakes will not work for one-handed people. They can walk and carry a rake but cannot effectively move the leaves because they can only drag the rake. Raking leaves takes leverage that is normally applied by the other hand that is placed down on the shaft of the rake.

The Challenge: You are having dinner with a prospective customer and he/she mentions that there may be a market for a rake that can be used by a one-handed person. You don’t have much time so you immediately consider your customer needs and convert your customer needs to metrics using our needs/metrics matrix on the next page. You continue the engineering design process by brainstorming some concepts and selecting one of the concepts using the concept selection matrix. Provide a sketch of your one handed rake on the supplied napkin and describe the key features of your design and how the rake is used.

Your work should include:

- Identify the customer needs
- Create metrics for the customer needs
- Brainstorm three (3) or more concepts
- Select your best concept
- Sketch your best concept on a napkin
- Describe key features of your concept

A. (5 points) Use the matrix below to convert the customer needs to metrics:
NEEDS METRICS:

B. (5 points) Brainstorm at least three concepts (Let me know if there are additional pages or where your concepts sketches are located.):

C. (5 points) Brainstorm at least three concepts (Let me know if there are additional pages or where your concepts sketches are located.):

D. (5 points) Select the best using the concept screening or concept scoring matrix.
E. (5 points) You do not have paper or writing instrument so you use your creative engineering talents and ask for a pen or pencil and a napkin (a paper napkin) to sketch your design.

F. (5 points) Transmit your design: Describe key features of your concept (materials, size, benefits, etc.) Clearly list HOW the rake works with a stroke victim. Be sure to explain the concept in detail and the benefits to stroke victims.

Appendix B

Product Challenges Project Fall 2013

The purpose of this survey is to obtain student feedback on your learning experience in the "Napkin Drawing Product Challenge". Please tell us about your experience with the Product Challenge:

<table>
<thead>
<tr>
<th>Metric #</th>
<th>Selection Criteria</th>
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<tbody>
<tr>
<td>1</td>
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<td></td>
<td>Strongly Disagree</td>
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<tr>
<td>2.a</td>
<td>The product challenge was challenging learning experience.</td>
</tr>
<tr>
<td>2.b</td>
<td>Using a napkin to convey the concept was difficult.</td>
</tr>
<tr>
<td>2.c</td>
<td>Designing a rake for a disabled person helped me to think more critically.</td>
</tr>
<tr>
<td>2.d</td>
<td>Given a choice, I would have chosen a napkin to convey the concept.</td>
</tr>
<tr>
<td>2.e</td>
<td>Drawing on a napkin is a real-world situation.</td>
</tr>
<tr>
<td>2.f</td>
<td>Designing a rake for a disabled person is gratifying.</td>
</tr>
<tr>
<td>2.g</td>
<td>I was able to empathize with the human subject.</td>
</tr>
<tr>
<td>2.h</td>
<td>The disability and restrictions of the user were clear to me.</td>
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</tbody>
</table>
Regarding design of the product...

<table>
<thead>
<tr>
<th></th>
<th>Strongly disagree</th>
<th>Disagree</th>
<th>Neither Agree nor Disagree</th>
<th>Agree</th>
<th>Strongly Agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>11.a Creating the customer's needs was easy for me.</td>
<td>〇</td>
<td>〇</td>
<td>〇</td>
<td>〇</td>
<td>〇</td>
</tr>
<tr>
<td>11.b The needs metrics matrix was difficult to create.</td>
<td>〇</td>
<td>〇</td>
<td>〇</td>
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<td>〇</td>
</tr>
<tr>
<td>11.c The needs/metrics matrix was familiar to me.</td>
<td>〇</td>
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<td>〇</td>
</tr>
<tr>
<td>11.d The brainstorming activity was challenging.</td>
<td>〇</td>
<td>〇</td>
<td>〇</td>
<td>〇</td>
<td>〇</td>
</tr>
<tr>
<td>11.e The concept screening or concept scoring matrix were difficult to create.</td>
<td>〇</td>
<td>〇</td>
<td>〇</td>
<td>〇</td>
<td>〇</td>
</tr>
<tr>
<td>11.f I was able to practice the raking motion during brainstorming.</td>
<td>〇</td>
<td>〇</td>
<td>〇</td>
<td>〇</td>
<td>〇</td>
</tr>
</tbody>
</table>

3. What skills did you use in order to complete the project? Check all that apply.

- Brainstorming
- Planning
- Giving feedback
- Receiving feedback
- Writing
- Drawing
- Others? State below. ____________________

4. How was the brainstorming difficult for you?

5. How was the brainstorming easy for you?

6. How did the product challenge help you learn how to brainstorm better?

7. How did the product challenge help in your learning of the engineering design process?

8. How did you feel about using a pencil and napkin as your design tools?

9. What would you prefer to use as an alternate media or engineering tool instead of the pencil and napkin for making the drawing?

12. Would you be willing to invest time to develop a working concept?

- Why? ____________________
Why not? ____________________

10. What would you suggest as a future product challenge that consists of a real world example?

Appendix C

Responses for the question “Please tell us about your experience with the Product Challenge”

- The product challenge was a challenging learning experience.
- Using a napkin to convey the concept was difficult.
- Designing a rake for a disabled person helped me to think more critically.
- Given a choice, I would have chosen a napkin to convey the concept.
Regarding the design of the product...

- Drawing on a napkin is a real-world situation.
- Designing a rake for a disabled person is gratifying.
- I was able to empathize with the human subject.
- The disability and restrictions of the user were clear to me.
Creating the customer's needs was easy for me.

The needs metrics matrix was difficult to create.

The needs/metrics matrix was familiar to me.

The brainstorming activity was challenging.
2. Please tell us about your experience with the Product Challenge

<table>
<thead>
<tr>
<th>Statement</th>
<th>Strongly Disagree</th>
<th>Disagree</th>
<th>Neither Agree nor Disagree</th>
<th>Agree</th>
<th>Strongly Agree</th>
<th>Total Responses</th>
</tr>
</thead>
<tbody>
<tr>
<td>The product challenge was challenging learning experience.</td>
<td>1.82%</td>
<td>5.45%</td>
<td>9.09%</td>
<td>67.27%</td>
<td>21.82%</td>
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<td>Using a napkin to convey the concept was difficult.</td>
<td>7.41%</td>
<td>24.07%</td>
<td>27.78%</td>
<td>31.48%</td>
<td>12.96%</td>
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<td>Designing a rake for a disabled person helped me to think more critically.</td>
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<td>0.00%</td>
<td>12.73%</td>
<td>47.27%</td>
<td>40.00%</td>
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</tr>
<tr>
<td>Given a choice, I would have chosen a napkin to convey the concept.</td>
<td>7.27%</td>
<td>30.91%</td>
<td>30.91%</td>
<td>23.64%</td>
<td>9.09%</td>
<td>56</td>
</tr>
<tr>
<td>Drawing on a napkin is a real-world situation.</td>
<td>0.00%</td>
<td>9.26%</td>
<td>16.67%</td>
<td>42.59%</td>
<td>33.33%</td>
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<tr>
<td>Designing a rake for a disabled person is gratifying.</td>
<td>0.00%</td>
<td>5.45%</td>
<td>14.55%</td>
<td>52.73%</td>
<td>29.09%</td>
<td>56</td>
</tr>
</tbody>
</table>
3. What skills did you use in order to complete the project? Check all that apply.

![Bar Chart showing skills used]

<table>
<thead>
<tr>
<th>Skill</th>
<th>Bar</th>
<th>Response</th>
<th>%</th>
</tr>
</thead>
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<tr>
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<td>Planning</td>
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<tr>
<td>Giving feedback</td>
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</tr>
<tr>
<td>Receiving feedback</td>
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<tr>
<td>Writing</td>
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<td>89%</td>
</tr>
<tr>
<td>Drawing</td>
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<td>98%</td>
</tr>
<tr>
<td>Others? State below.</td>
<td>0.07272</td>
<td>4</td>
<td>7%</td>
</tr>
</tbody>
</table>

55 responses

4. How was the brainstorming difficult for you?

I didn't really have a problem.
Might stuck in the normal situation and cannot think of many concepts.
It takes time to come up with ideas.
No.
It was hard to come up with many ideas once I thought I had a good one.
It was difficult to quickly think of an idea that would not only work, but be cost efficient for the user.
In a testing environment, we are taught to think quickly. The hardest thing was feeling rushed during brainstorming. Coming up with multiple designs in the time limit was difficult.
It was difficult deciding between the different aspects of each design and deciding on the best parts and ideas for the final design.
It made me be more creative.
It was hard to think of stuff.
The brainstorming wasn’t difficult for me.
I am not a very creative person, so it took me a little while to come up with some ideas.
It challenged you to be put in someone else's shoes.
It wasn’t really, it just took time to come up with the multiple design ideas.
It showed that some problems that seem simple can actual be fairly difficult to solve.
It was not that difficult for me. I have done so much raking in the past, coming up with an idea was relatively easy.

It was in a field I have never really considered before.

The brainstorming was difficult because it forced me to think about something that I never had before.

It was challenging to think of how to meet the needs of the disabled person when the person lacked key motor skills to complete the task.

I felt that is was not difficult at all.

You have to prevent yourself from giving up on ideas while still brainstorming.

Brainstorming was difficult only because of the time constraint.

The brainstorming was difficult since you were asked to come up with ideas on the spot and this requires a person to do critical thinking which at this point in my life I have not done a lot of.

Brainstorming was toughest when try to determine the overall height and area of the rake that would be effective.

A lot of factors had to be taken into account such as leverage.

The brainstorming stage was a little challenging because I had an idea already in my head that I wanted to use, but through brainstorming I thought of other ideas that eventually came together and made my original idea so much better.

It is always difficult to brainstorm for new challenging idea that you never thought of before.

Hard to think outside of the box.

It was hard to think of ideas on the spot especially in a test situation.

It was not that difficult for me, it just took time to think of something creative.

The brainstorming was difficult for me because I was not prepared for the situation, and my mind does not think like that.

It was hard trying to come up with three concepts and trying to make them worth even brainstorming. I was able to get two concepts but the third was hard to come up with.

It was new concept.

It was hard to come up with several concepts after coming up with the first one.

It was hard for me to visualize what made a rake work.

It was difficult to both think of a new innovative product, while trying to remember what it will be used for.

It was difficult to think of all of the limitations of a handicapped person.

The brainstorming was difficult because I was unable to truly visualize many of the problems associated with a stroke victim.

It was difficult to come up with an idea that satisfies the customer needs. Starting is always the hardest part.

It wasn’t hard at all.

It challenged me to come up with a concept that I haven’t previously thought of.

There were many concepts that were in my head and not many of them were innovative enough without removing the needs of the customer.

Very hard because I cannot think of any creative ideas.

It was difficult to understand the problem faced from the perspective of a disabled person.
It was difficult because I have never thought of making something for a one handed person before so it was obviously hard trying to make up for that one hand's function. It was difficult because I did not understand the product I had to design at the beginning. Finding creative or new ideas is hard. Each idea had to include a way that would compensate to the fact that the person only has one arm, which is difficult to create.

To put myself in the shoes of a disabled is difficult. The fact that I am not handicap, made it real hard to imagine the things they go through. That being said, the brainstorming was difficult. It was difficult because I had never imagined an object like this and that to for a disabled person. So I had to brainstorm ideas without any flaws because it was for very critical subjects. I had trouble first starting with ideas for the rake. It took me at least 15 min before I could start writing down concepts. Usually I came up with the idea I think is the most important and then got stuck with nothing as worthy to be mentioned. It wasn't. It wasn't bad. Ideas for this specific use came easy. It was figuring out which fit the needs that was the tough part.

5. How was the brainstorming easy for you?

I worked landscape and was a medic so I had a pretty clear idea of the limitations of the equipment to the symptoms of the user. I just thought of a couple ways I thought might fix one of the problems and then flowed from there. Can think without constraints. I can think whatever I want. Because I enjoy brainstorming. The idea for my design came to quickly.

I was able to understand the issue of only using one hand while raking fairly quickly. Because of that, I was able to create a design implementing the solution to the problem in my design. The requirements were fairly well explained. I felt I had a good idea what I needed to create. I had made three designs so there were a lot of aspects to pick from and I work well with options. I have had to brainstorm for projects and papers in the past. It wasn’t easy for me. It was easy for me because I was able to visualize the task and how to do it easily in my head. It was easy because I knew it was for a good cause and it was going to help someone. I felt like I knew the process well, so that really helped out. There were ample amounts of ideas that you could use, it wasn’t limited at all. It was easy to come up with ideas, but difficult to come up with any practical ones. From my experience as working as a summer maintenance man, coming up with a rake was easy. I like thinking of new ideas. I had raked leaves so I was familiar with that subject. With time, I could think of a good concept. I was able to visualize what I wanted to build, because everything was explained clearly.
The situation was not overly complicated or difficult to think about.
It was easy because I am natural a creative person so once I got some ideas flowing they just continued to build.
I had practiced it a little bit in the class before, and it was a little bit familiar to me.
The brainstorming was easy for me because I could practice the motions in the classroom to develop ideas.
It was easy because it was very clear what was required from the product.
The challenge was clear and interesting to think about.
I can think whatever I want.
Once one idea came they all started coming and it became easier.
It was easy in the fact that we were dealing with a simple concept.
The only way that the brainstorming was east for me was because I was able to picture the motion of raking leaves with one arm.
The brainstorming was easy for me because I was able to thinking of ideas that helpful to the customer even if it wasn't the best idea.
NA
Once I thought of a few concepts I was able to open up my mind more.
Once I figured how a rake worked i was able to come up with at least one design easily.
Because it was a simple system that had not been made yet it was easy to come up with new systems because there weren't any old ones to try and model off of.
It was not too easy. It was easy to come up with one idea but not two more.
Once I had an initial concept, the others came as a natural expansion of that.
It was easy once I came up with an idea. The second one was easier than the first one.
It was kind of easy.
Since we did the process for our projects in the class like ZEH or ALCOA."
It just required creativity, which I have to a certain extent.
It was not easy.
It was easy in the fact that it was very open ended with countless possible designs.
It wasn’t at all.
It was easy because I got the chance to move around and simulate the movement of the rate considering the persons disability.
The brainstorming was easy for me due to the setting of the quiz. The quiet environment allowed me to brainstorm easier.
Once I started getting into the project (got the ball rolling in my head) it was easier for me to come up with ideas different than the ones I had already thought of.
I can list a numbers of ideas regardless of the helpfulness of the idea.
I understood the problem better.
I actually spent most of the test brainstorming. I feel that is how it should be. Once I had some solid ideas down in my head, the rest was a breeze.

6. How did the product challenge help you learn how to brainstorm better?
I learned to draw or write all of the possibilities. It might seem like a crazy idea by itself but used with something else or seeing the fault and slightly adjusting could make it brilliant.

It helps me to think in a real situation and consider in the customers' position.

It helps me to practice creative thinking.

I have no clue.

I had to quickly come up with this idea and sketch it on a napkin; just like you would have to if you were at a restaurant and had to present an idea. This forced me to focus on the task at hand and really lay out all of my ideas onto paper to then organize them.

While hard, it did help me visualize my designs quicker. It is easier for me to imagine my designs now.

Yes, making me think outside the box.

I was able to collaborate with others to make my brainstorming more efficient.

It made me be open to any idea that pooped in my head no matter how dumb.

It helped me by giving me more tools to use for brainstorming new ways to tackle problems.

It helped me to really focus and come up with several ideas that I normally would not have.

I just felt overall more confident in being creative in my brainstorming.

It forced me to use the matrices and need statements that ultimately lead to a better brainstorm.

It made me realize how important identifying the problem and creating customer needs is in developing a product.

It made me do it on a time constraint was helpful.

It taught me to think of fields that I never thought of before.

It made me think creatively.

I have never been asked to do this in anyway before so it was a completely new experience that I enjoyed.

Just that I need to keep a more open mind to ideas that may not be all they could be yet.

I learned that not all of my ideas would be good but if i followed the process that wouldn't matter because in the end I would have choices.

By thinking under a time constraint, you become a better brainstormer when you have more time to think; at least that’s how I look at it.

I now know to use every sense I have when establishing ideas and I can expand my brainstorming capabilities.

It put me on the spot and gave me time constraints so I had to think hard which I believed improved my ability to brainstorm in a short amount of time.

The product challenge gave me a real world situation to think about and enabled me to actually get excited about the ideas I was creating. It gave me motivation to come up with the best possible idea I could think of.

Writing down all the ideas you come up with always helps, I had to be fast and creative in short period of time, so that pushed me for sure.

It helps me to practice my creative thinking.

The product challenge made me use the engineering process which helped me come up with multiple ideas. i like how it was set up.

It helped me to brainstorm under pressure.

The product challenge helped me learn how to brainstorm better because it was good practice.

Meaning I usually do not have to think critically about certain spontaneous situations, so this challenge was a good scenario for practice brainstorming.
The product challenge helped me to expand my creative side and to learn how to brainstorm in a short amount of time and on the spot which could be a real world application.

It helped me because different thought arise in mind.
It gave me more experience in trying to brainstorm.
It helped me think more critically about how a system works as a whole.
It helped me to think from a different perspective as well as come up with a product I had not seen before.
It forced me to think critically.
The product challenge taught me that there are many considerations that aren't realized until once you're actually drawing the product. My initial brainstorming didn't fully address the needs of a stroke victim and I missed many components.
The product challenge helped me to come up with an idea in a certain amount of time. It allowed me to brainstorm faster and regarding to the needs.
I practiced the imagining the situation and completing the task in a given time.
It challenged my ability brainstorm and improved my ability to come up with solutions in a faster paced manner.
The product challenge made the brainstorming process more structured and it encouraged out of the box ideas.
I can use brainstorm to figure out what kind of product I need.
Make me asses the validity of ideas, and the plausibility of them.
It helped me think deeper.
It helped me to think fast and efficiently leaving aside unnecessary features and focusing only on the really crucial ones that would benefit my design the most.
Because it force you to came up with good ideas.
It made me think on the spot with a limited of time. It made me pick and remove ideas fast.
The product challenge helped me learn how to brainstorm better by having to look at a matter from different angles. Also the product challenge showed me that a lot of time has to be allocated for brainstorming.
It made me have a natural approach towards all the objects. It made my brainstorming better as for this project I had to think very critically, taking all the intricacies into consideration. From now on wards I will always try to think out of the box for all the future designs that I will make.
Given a direction is always helpful.
I know to understand the problem at hand and clarify it before you proceed.
It gave parameters to think inside (or outside).

7. How did the product challenge help in your learning of the engineering design process?

It made me do all the steps. I had to dissect the symptoms of a stroke to create my costumer needs. I had to use those needs and the purpose of a rake to generate matrixes. I then had to brainstorm ways to achieve those matrixes. Had to rate them based off of how I felt they would work and make each new drawing more improved. We had to do it all. I also feel that if you read the instructions on those it pretty much pieced it all out.
It helps me by letting me design a product and experiencing the design process.
It helps me to follow the steps of engineering design.
Because I have to go through every engineering design process.
It provided a real world example that we had to attack step by step.
Having the engineering design process in mind, it was easier for me to come up with this product because I knew what the correct procedure in creating a product entailed. Then, by using this process, I gained a further understanding of it.
It simply reinforced the steps of the process.
It made me think and process in differently.
I had to follow all the steps and it made me learn how to go about a project using the specific process.
It made me quickly try and think of something on the spot which was pretty realistic I think
It made us do it over and over again to build repetition.
I had to go through the design process for the product challenge so I knew what it was like to do the whole process.
I felt like more than anything it proved to me I actually knew what was going on.
It forced me to utilize all of the concepts that we learned in class.
It helped me put what I had learned into use in a real world situation.
It made you go through the steps, whether you realized it or not.
It was short and to the point which really put the whole process into perspective.
It encouraged us to apply the skills and concepts that we learned in class.
I learned the complete process from this exercise.
It was a step by step application of it, which is very useful.
It did.
By making me practice the whole process under a time constraint, it will help me to use it later, when I have more time.
I now know what goes into developing a product and the ideas that need to be created to make the product.
It helped me learn the engineering design process because it allowed me to put in into practice rather than just talking about it or reading it off of a slide.
The product challenge laid out the engineering process perfectly. It made you go through every step and made you create every matrix. The product challenge made me feel like I was actually engineering something. I went through all of the steps of the engineering process and even was able to bring my idea to life by sketching it out and describing it.
It helped me practice and use the engineering process in a real-world situation.
It helps me to practice engineering design process.
The whole Product Challenge was a backbone of the engineering process. It outlined the necessary steps you need to take.
It helped me learn it because I actually had to do it in order to come out with a product for the test.
It helped me apply the steps in the engineering process so that my final product would be a clear cut choice.
The product challenge helped me to reinforce my knowledge on the engineering design process that was taught in class. I was able to go through the challenge and go through the process step by step even if it was not in the correct order.
It helped me to learn some basic idea of thinking about the problem.
It helped to reinforce what I learned in class.
It made me go through the engineering design process one step at a time.
It helped me to critically think through the process on my own for the first time.
It helped me think like an engineer.
The product challenge taught me the significance of continually improving the product design.
My initial design was continually changed as I progressed through the process in order to address problems that arose.
The product challenge helped me to experience the real life situation.
I had a chance to practice the process which I learned in the class.
It tested my knowledge of the engineering design process by incorporating it into a real life situation.
I received practice using the matrices.
I followed the 8 steps to do the work.
It allowed the development of my own idea, helping relate the design process to my thought process.
It challenged me.
It helped me actually see how the engineering design process helps you think and organize your ideas in order to come up with a good and efficient design.
It helped me in learning the engineering design process as a whole. Because the engineering design process functions as a tool, it really helped me to organize my work better.
It helped me a lot as it was a challenge to make a completely different product that I had never made till now. As a result of which I had to apply all my engineering design knowledge to come up with the best idea. Thus it directly or indirectly helped me with my engineering design process making.
It was one of the first times I had to use the entire engineering design process to create a product concept from start to finish. It took the concepts that I had learned from lecture and made me apply these concepts to real life.
I learned to think critically.
It brought everything together.
It incorporated every part of the course, which was good.

8. How did you feel about using a pencil and napkin as your design tools?

I was fine with it. Didn't have a hard time writing on it. I was talking to my dad the other day and he told me he has a guy he works for who always writes on napkins and scrape paper and he always gets upset with him. I didn't even mention the project to him he was just that upset about it. He thinks it's very unprofessional. However, in the context of the situation I feel it was fine. The ability to be adaptable to a unexpected situation and achieve a task is a necessity in life.
Not too bad.
It is interesting and helpful.
Kind of interesting.
The same thing could have been accomplished on paper. I thought using the napkin was pointless because it wasn't really any harder than drawing on paper.
It certainly added another challenge to the quiz. I did find it interesting in the fact I am sure many designs of products were first drawn on a napkin at a restaurant and presented quickly.
I didn't think it was easy. It was challenging to create but I enjoyed the creativity at the same time.

It was an unorthodox experience making me feel uncomfortable at first but eventually I warmed up to the idea.

It was very difficult to convey what I was thinking using those materials.

It was a bit weird but I liked it.

Very good real world example.

It was cool because it is a real life situation.

I understood the application idea behind it, but it wasn't hard.

It was very interesting; it was an eye opening experience that allowed me to see how one must convey information using different types of medium.

I thought this idea was useful because it helped me learn to explain my ideas using only the minimal tools I had on me.

It at first seemed rather dumb, but then the idea that you may need to one day do that sunk in.

It was interesting.

I really didn't affect me too much; I was just worried about ripping the napkin.

I think that was going a little overboard. There are very few places in the world today that a napkin is readily available but not a scrap of paper (including restaurants).

It was a real world application.

I thought it was a different way on how to introduce us into the design process.

It really did not hinder me in any way.

I thought it was an interesting idea but was a little bit challenging.

It was very realistic to a real life situation, which is what happens in real life.

I did not feel this was a good idea as I had already drawn the picture on the test.

It was kind of difficult to draw on the napkin.

This was originally quite an odd idea, but when I actually sat down and started drawing on it, I understood why we were doing it. It brought other factors into play such as the sharpness of the pencil. If we were giving a pitch in a restaurant and had to use a napkin and a pencil, you do not want your pencil piercing through the napkin and ruining your design. I truly loved the idea of using the napkin after I figured out why we were doing it.

That was different to say the least, but it was interesting as well.

It is hard to write and it will be easily distorted.

I thought it was very creative and a good real world application. It could actually happen.

I thought it was weird at first, but then I realized that there could be actual real world applications of it.

I was uncomfortable because the pencil kept ripping the napkin, and distorting the image of my design.

The pencil and napkin made the challenge practical and like it could be a real world possibility.

It was difficult to do because the napkin could easily rip but the idea of using what is given was a good idea.

I feel like this is new idea, and new experience.

It was very difficult.

I thought it was strange however I found it very easy to do.

I thought it was an interesting way to convey my idea, but it was effective if the tools were used correctly.
It was annoying. I thought that it was a unique experience. Obviously not something that I do on a regular basis, but it made the project more interesting.

I thought I was really creative that one day I might have an opportunity to be in the same situation.

It was an interesting experience but I liked it!

It made drawing the model difficult.

It was interesting to be limited by the tools in our immediate surroundings.

It is very cool.

It was novel, but I do not feel strongly either for or against it. I would understand those who thought it added an unnecessary aspect to the test.

I felt like a real engineer, trying to get my view out there even if all I had was a napkin and a pencil.

I would have preferred to use a pen because the pencil kept taking the paper apart making it harder to sketch on it.

It feels great because as an engineer you want to find anything to keep your ideas.

I disliked it only because I press hard when I write and draw, so I was trying my hardest not to rip the napkin.

I felt more like a real-world engineer, as it is more realistic, and sometimes we are not given what we desire. Thus, we as engineers have to be trained to work with what's given.

It was pretty intriguing to draw on a napkin with a pencil. It was actually easier to draw on a napkin rather than a paper. So it was very exciting and fun.

I thought it was a great idea. It is definitely a real life scenario for an engineer.

It the first time I heard of it and I think this is a real life situation and people should be ready to do it because it may occur at every moment.

It was understandable but unnecessary.

I would prefer to use as an alternate media or engineering tool; instead of the pencil and napkin for making the drawing?

If I was still at the restaurant I would have asked for a kids coloring menu. I would have gotten a bigger sheet then loose leaf and at least three colors.

Paper or computer.

No clue.

I would prefer paper.

Obviously it would have been easier to draw my design on paper, but I found it very applicable that I had to draw it on a napkin, just as discussed previously.

Simply normal pencils and paper for that step in the process, more substantial materials that are more common.

I believe that napkins are an unorthodox but good medium.

I thought that the pencil and napkin idea were perfect tools.
I can’t really think of anything, I thought the napkin pencil thing was good enough. No, the pencil and paper showed that sometimes you will need to be able to use next to nothing to do a task. Perhaps Solidworks because it is more accurate. I am indifferent to what was used. I would prefer to be able to draw the design out on a normal blank sheet of printer paper using a sharp pencil. it would have been a lot easier and allowed for erasing. the ultimate best tool would be to utilize a CAD software such as Solidworks.

I thought the napkin was good. A golf score card would be a good idea that is a real world application for sure. Perhaps a tablet or some form of technology.

Maybe a business card and a pen, or a dollar bill and a pen (fake dollar bill for sake of the project). Pencil and a quarter sheet of paper or golf scorecard. SoldWorks, but with limited time the napkin was the best. If I had time and anything I wanted sure, but the napkin is good for creating a potential situation.

An iPad would be cool. Just a normal piece of paper and pen, but I like the napkin and pencil idea, I think it applies to real world situations.

I would just say use a program on a cellular device that would accomplish the same task. A paper and a pen.

Personally, I liked the napkin and pencil combination due to its real world feel. It made me feel as though I actually was giving a pitch in a restaurant. If another media could create this feel, then by all means use it, but the napkin and pencil combo is a great one.

Business card or note paper.

A pencil and napkin was very hard to use to try and get your design across. If you could use a tool like an iPad your design would be much more clear. I would prefer to use an actual piece of paper maybe from a small notebook or something, like those a waitress would use.

Yes I would prefer to use pencil and paper, because it wouldn’t rip, and I would feel more comfortable conveying my ideas on paper rather than napkin.

I would use an I-pad or another kind of device that would allow me to draw my picture more accurately since I am not very artistic and it was hard to understand my drawing.

Anything that is available near me.

A computer program or paper.

Yes, I would prefer to simply use a pencil and normal piece of paper because you don’t have to be as careful.

I would prefer to use a Solidworks model, a regular pen or pencil and graph paper.

I would prefer pencil and a regular piece of paper. Perhaps some sort of computer design that could better capture the raking motion that I wished to implore in some of my designs.

Pen and hand.

I think pen and pencil was just the tools we needed to use. Because we might get a chance to use improved tools all the time.
Doing a minute speech about the model and how it would benefit the customer.
Actual writing paper or even a computer.
Pencil and napkin
Maybe a modular construction kit, (lego type product).
I think it’s a great idea to have us draw on such everyday materials, maybe next time it can be on a piece of cardboard.
It would have been interesting to make the quiz into two different quizzes and actually get to build our design on SolidWorks.
I would have preferred the common pencil and paper.
Generating simplified/rough concepts and perhaps scoring them, on a tiny pocket sized notepad.
I would prefer a working model on Solidworks or cad to make the drawing.
A gridded drawing pad with a pencil would be good but you are not going to have that in a real life scenario so I still prefer the napkin.
It's easier to draw on and may not restrict my drawings to simple sketch and I can provide more detail with the drawing which may help me with my communication.
Yeah paper.
Actually no. Drawing without limits is a good start to any thought process.

10. What would you suggest as a future product challenge that consists of a real world example?

A bike rack that can hold multiple bikes in a manner that is not bad for the rims and doesn't feel or appear to be too congested.
Just kidding I just hate Hammond's bike racks and wanted it in writing. A system to write with a cast on. It is pretty easy to grasp the limitations with grip and dexterity. Everyone knows how to use a pencil which levels the playing field and puts no one at a disadvantage. Also you can use your actual pencil to brainstorm and figure out matrixes.
Automation house.
Design a shovel for people with only one hand.
Yes, as stated previously, I believe the product challenge is very applicable to real world engineering, and that real engineers probably have to do this all the time. I believe that the product challenge would be beneficial for future students as well.
Creating a "leg" for wheelchair-bound kids to play soccer.
I believe that this concept mirrored a real world example well.
Create a product for handicapped athletes.
Maybe design some sort of prosthetic limb for someone who needs it, like a more efficient and aesthetically pleasing one.
Using the napkin again but doing a different overall design so not the rake but something different.
A portable wheelchair device to use the stairs.
I can't think of anything right now.
A shovel or something that makes the engineer step into the shoes of the person needing the product.
Designing a slingshot.
Disabilities give a human perspective, which was rewarding. Perhaps some other tool or utensil for a handicapped individual.
A person with no use of his hands needs to write.
A soda can opener for someone with severe arthritis.
No idea.
Communication methods for the deaf.
Yeah another random concept would be good.
I thought it was a good way to help people learn both time management skills and how to use the engineering design process.
A product that makes getting out of bed easier. Maybe a mat alarm clock that forces you to stand up to turn it off.
Designing a way to eliminate the amount of food wasted in the dining commons. E.g. think of a way to put it to use.
The restaurant example with the napkin was truly I great one. I would definitely recommend it for next year.
Design a car for people with no legs.
Something that has to deal with a disease so no one will have an advantage
I would just pick something that you do not need a lot of background information on, something simple, so that everyone can just focus on the engineering process instead of the dynamics of a complex item.
I do not have any good suggestions.
Another tool that is seen as simple but can be impossible or hard to use by someone with a handicap. The tool could be a snow shovel.
Creating accessible home for disable people. means they don't have to depend on others for simple help like going to bathroom etc.
Designing a new energy system to propel cars.
Designing a football helmet that protects against concussions
A computer system for someone who cannot see.
Anything related to alternative energy.
I feel as though having a group come up with the basic design for a prosthetic leg would be a fun project. There are a lot of components to consider in something such as that.
Cleaning shoes would be perfect I guess, for people who have difficulties kneeling or bending down.
Designing a new way to heat the dorms on campus.
I believe the rake worked pretty well. Other similar situations and products should be used.
Table.
Relatable topic, such as a alternative way to prevent cellphone screen from cracking.
I think getting people to think about disabled people is a great idea, maybe continue giving them object that can be accessible to everyone, like a bike or a knife.
Something more technological that modern generations could relate to.
Drawing a blueprint on a large paper.
Design a non-electric (Manual) wheelchair that can be operated with one hand.
Cars for people who don't have legs.
Eye communication software for injured peoples at the hospital.
Maybe a water bottle for a person with one arm. It's tough to get the disability theme off my mind now.

11. Regarding design of the product...
Question 11. Responses

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<th>#</th>
<th>Question</th>
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<th>Disagree</th>
<th>Neither Agree nor Disagree</th>
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<td>10</td>
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<td>3</td>
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<td>4</td>
<td>The brainstorming activity was challenging.</td>
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<td>10</td>
<td>25</td>
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<td>5</td>
<td>The concept screening or concept scoring matrix were difficult to create.</td>
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<td>17</td>
<td>22</td>
<td>2</td>
<td>55</td>
<td>3.2</td>
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<tr>
<td>6</td>
<td>I was able to practice the raking motion during brainstorming.</td>
<td>2</td>
<td>7</td>
<td>10</td>
<td>24</td>
<td>12</td>
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Question 11. Statistics:
Creating the customer’s needs was easy for me. The needs metrics matrix was difficult to create. The needs/metrics matrix was familiar to me. The brainstorming activity was challenging. The concept screening or concept scoring matrix were difficult to create. I was able to practice the raking motion during brainstorming.

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<td>Mean</td>
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12. Would you be willing to invest time to develop a working concept?

Responses:

Gratitude of helping amputees and others
It is interesting
because I enjoy doing that
I found this quiz interesting and would enjoy further developing a working concept.
Yes I’d like to see if my design is truly helpful.
It is for a good cause and will help someone in need.
I think it would be interesting to work on this project.
It would be useful in learning more about the engineering design process.
It interests me.
Yes, I enjoy challenges.
I want to make sure that what I create will work in the end.
If the project had a future it could do good probably
It helps people learn the engineering design process.
That is what engineering is about. Taking a concept, running it through the process and making it work.
Because it is challenging!
It can help disabled people
It is something that is interesting to me
I think my project had a decent chance of being an actual product that would work in this situation.
We are developing things for others good.
I would fine it satisfying to help the handicapped.
Because this is a product that many people may need.
The product design as a whole forced me to consider that there isn't a suitable appliance such as a rake for stroke victims
It might be interesting!
It could help someone live a better life.
It is gratifying to watch a concept become a product. Especially when it is developed to help others.
It is very cool
Experience that relates to my field for a cause I support
It’s a noble cause
I would be willing to because I would like to see a concept that I was a part of become a project.
It is worth the time investment to develop a working concept. In other words, we are engineers, our time investments in possible concepts are highly expected.
As it is a new concept and I want to see how successful I was in making a working concept.
It is very satisfying to take a concept on paper and see it become a reality.
It sounds fun.
Important an engineer

Why not?

Responses:

Disabled should not rake leaves as it is too tiring
I’m not sure what it entails
It's hard
Because I won’t be able to think of anything useful probably
I don’t have much time on my hands
I don't have the time
I will not be a Penn State in the near future.
Don’t understand the question
A rake can be replaced by a piece of machinery to get the job done faster.
I do not have a lot of time to invest right now.
I am not interested in making a working concept.
I would like to but it would be time consuming
I did not like my initial idea
I would do it in a more advanced part of my engineering career because i have not been able to come up with a good enough idea or product yet.
I don't have time
Appendix D

Focus Group Protocol

Perceptions of Student Learning

The purpose of this focus group is to get feedback from students that will help us improve the Product Challenges Project for future semesters.

1. To start off this conversation, please tell me your name. This will only be used for my coding purposes. This conversation is voluntary and confidential. Your instructor will not know if you are participating. A summary of the focus group will be shared with the instructor after the semester is over and will not contain any identifying information. This focus group will be audio recorded. Only the facilitator will have access to the recording.
   a. What is your name?
   b. Do you agree to be audio taped? If not you will have to leave the group.

2. Can you tell me about how you felt when the project was introduced?

3. Can you describe how you initially approached the project?

4. Prior to this course, have you been involved with designing a product for a disabled person? Can you tell me about that experience?

5. How was it different from this experience?

6. Would you please tell me about having to use a napkin and pencil to draw your design?

7. How was this difficult for you? Please describe.

8. What other devices would you prefer to use as an alternative to a pencil and napkin? Why?

9. How did the project help most in the development of your technical skills? Drawing, planning, design, development, any others?
10. How did the project help most in the development of your professional skills, for example, oral and written communication, time management, giving and receiving feedback, brainstorming, any others?

11. How did the project help you in your learning of the engineering design process?

12. What suggestions would you have for future project challenges?

13. How could your professor improve the Product Challenges Project for future students that would consist of a real-world example?

14. What about the Product Challenges Project was most helpful to your learning?

15. What could have been done differently regarding the project? What did you like least?

Are there any additional comments that you would like to share with the group? Thank you for your time.