The Incredible Edible Car: An Instructive and Fun Design Exercise for Engineering Freshmen

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Abstract

First semester freshman engineering students taking the one-credit Introduction to Biological Systems Engineering (BSEN) and Agricultural Engineering (AGEN) 100 class at the University of Nebraska – Lincoln are assigned teams and the task of designing and testing a vehicle made entirely of edible food products. The task culminates in a graded poster presentation, competition, and the eating of the teams' cars on "E-Day," where freshmen, senior, graduate students, faculty, and alumni industry representatives participate in an open house at the end of the semester. Parents, high school students, and the community provide a diverse audience for the students and alumni. Networking is encouraged, and freshmen are required to visit at least three alumni, senior or graduate student displays. This paper focuses on the role of the Edible Car design competition in achieving the course objectives by uses team-based learning to engage the students in the engineering design process, and providing hands-on experience with problem-solving, biological materials, teamwork, communication, and professional ethics in an engineering setting.

Introduction to the Course

Introduction to Biological Systems Engineering (BSEN) and Agricultural Engineering (AGEN) 100 is a one-credit course required of all BSEN and AGEN majors at the University of Nebraska-Lincoln. This course is designed to introduce students to careers in biomedical, environmental, water resources, food and bioproduct, and agricultural engineering. It also covers the human, economic, and environmental impacts of engineering in society; as well as communication, design, teamwork, and the role of ethics and professionalism in engineering work.

The course objectives are to prepare students to:

1. Demonstrate understanding of the functions and societal impacts of engineering, and the defining characteristics of the biological systems and agricultural engineering disciplines.
2. Comprehend the meaning and importance of problem-solving, teamwork, communication, and professional ethics in an engineering setting.
3. Articulate a design solution for a problem of a biological or agricultural nature that demonstrates comprehension and application of the engineering design process.

Structure of the Edible Car Design Exercise

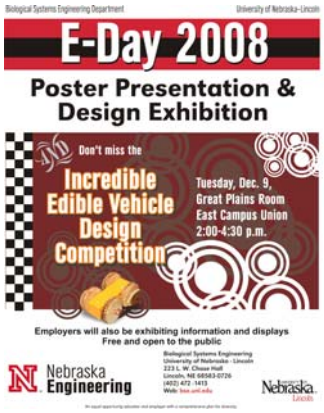
The Incredible Edible Car design exercise is intended to bring together many of the topics covered throughout the course and allow students to apply them hands-on in a fun competition. It specifically addresses course objectives 2 and 3.

Students are assigned to 3 or 4 person teams and given the task to "build a car that is fast enough to roll a great distance, withstand two test runs, and be completely edible," as defined, for

example, by student team Theta[1]. The following assignments are given to help guide their effort (the Edible Car instructions and guidelines can be found in the Appendix):

- Indicate through a memo how their personality type (MBTI) will enable them to positively interact with those of their teammates.
- Develop a professional email indicating their team name, problem statement, and design objectives give a team-based oral PowerPoint presentation on their car design and give a "rally cheer."
- Give a team-based poster presentation to a diverse audience.
- Compete in the Incredible Edible Car Competition for points based on: distance, durability, design, creativity, edibility.
- Write a team-based Executive Summary of their design project.

The Edible Car Competition occurs during "E-Day," an open house at the end of the Fall semester where freshmen, senior, graduate students, faculty, and industry representatives participate. BSEN and AGEN alumni are present with their company/agency displays, seniors show their capstone design projects, and graduate students present posters on their research projects. Faculty, staff, parents, high school students, and the media provide a diverse audience for the students and alumni. Networking is encouraged, and freshmen are required to visit at least three alumni, senior or graduate student displays.



Engineering design process

The main objective of the Edible Car competition is to help students to understand the engineering design process and gain experience using it. Freshmen are typically unfamiliar with the open-ended nature of engineering design. The Edible Car exercise challenges students to define their own problem statement, objectives, and design using "client-driven" constraints.

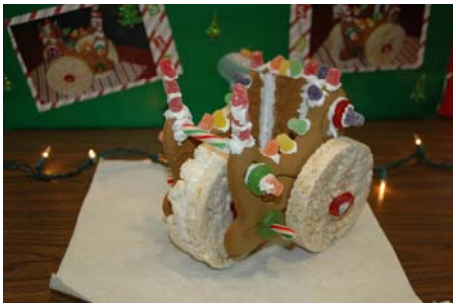
Through the Edible Car exercise BSEN/AGEN 100 freshmen experience how a final design is only the best selection from a group of alternatives that combine the principles of engineering with economics, safety, ethics, and aesthetic considerations. They also begin to see how problem-solving fits into the engineering design process, and hopefully gain an appreciation of how their required fundamental courses will give them the tools they need to solve complex designs in advanced classes and the practice of engineering.

The students also experience the iterative nature of design as they brainstorm ideas, experiment with designs, and refine their designs during competition. As one team noted in their Executive Summary, "We had problems during the construction process, so we had to adjust our design."[2] Even those who did little experimenting discovered it might have improved their design's performance, "We did not consider many alternatives, but it might have been a good idea to use different materials."[3]

Experience with Biological Materials

As agricultural or biological engineers the students will need a keen understanding of how biological materials will perform in an engineering design. The Edible Car Competition allows them to begin to experience this by thinking though the properties and interactions different food materials will have and then experimenting with them. As Catherine noted, "There are plenty of resources out there that nobody thinks about."[4] Each team is required to design and build a vehicle made from a minimum of three edible materials, with bonus points for more, and then they must eat the entire car in less than five minutes.

The teams estimate how different biological materials will withstand the stresses placed on the car by the competition and then experiment with different materials to withstand those stresses. Key considerations for a sound design include considering the biological materials' performance and durability, e.g., how to get components to spin, how to get materials to stick together, how some materials hold up when transported, and what happens when the materials are allowed to dry out.



The constraint of eating the materials used in their design at the conclusion of the competition, allows them to discover unanticipated interactions with human systems, adding in unexpected constraints: for example not all foods taste well together, how to store the car so that the materials will be safe to eat, is the food too dry or too solid to eat quickly, does the design look appealing?

Plus, watching a food eating contest is just plain fun!

Teamwork

Another objective of the Edible Car exercise is to allow students to experience the dynamics of team projects. Early in the course students complete the Myers-Briggs Type Indicator (MBTI) personality type assessment (See Appendix). They are asked to compare their personality to that of the others in their team and to examine how each can best contribute to the project. For example, Stephanie noted, "I can try to make the working environment as conducive to each personality type as possible, while taking into account my own needs."[5] (Stephanie's full response can be found in the Appendix)

An end of semester team evaluation (see Appendix) is used to show how each member of a team had a stake in the final product and contributed to the design teams' success. As explained by Team 'Rho', "Our team collaborated and delegated tasks well, which resulted in an efficient and high quality final design that we all agreed on."[6]

Engineering communications

Students learn and practice engineering communication skills throughout the Edible Car exercise. They use guidelines learned in class to send properly written and formatted emails, memos, posters, presentations, and executive summaries.

The students discover the value of clarity in individual assignments, and the importance of communication within their team. Presentations given before the whole class allow practice with public speaking. E-Day provides experience presenting to their "clients," the judges of the competition. They also explain their design and answer questions for the general audience during the poster presentation portion of the competition and then introduce themselves and their car to the entire audience at the beginning of the race.

Networking is also a key skill they begin to develop during the E-Day portion of the exercise. Biological Systems Engineering departmental staff and faculty serve as judges throughout the competition. Time is allowed for high school students, freshman, upper-class, graduate students, alumni, faculty, and industry representatives to all network and visit projects and displays. The freshmen are required to visit at least three displays. This gives the freshman an opportunity to talk to engineers at all stages of their careers, get ideas for internships and courses they are interested in, and start to develop a network of colleagues, all in a fun environment.

Ethics and Professionalism

Students experience hands-on application of ethics and professionalism that are discussed in class. Team evaluations and assignments highlight the importance of personal and team ethics. The E-Day environment allows them to practice presenting a professional appearance through their communication and attire. They also have the opportunity to learn from the demeanor, dress and communications skills of the professionals they interact with at E-Day.

Evaluation

Overall, the course has received positive evaluations as seen in Table 1. Since the Edible Car Competition is a significant portion of the course, it is felt that these evaluations positively reflect on the Edible Car exercise itself. Also favorable were specific comments relating to the Edible Car from the course evaluations: "The car design project is useful" and "Liked the group projects."[6]

Table 1. Course/Instructor Evaluation Results, 2008.[7]

	Mean score† (possible 4)	Standard Deviation
General Attitude	3.40	0.43
Method	3.28	0.43
Content	3.32	0.41
Interest	2.87	0.51
Instructor	3.66	0.32
Total	3.32	0.33

† 71 responses

The Incredible Edible Car exercise has been a valuable addition to Introduction to Biological Systems Engineering and Agricultural Engineering at the University of Nebraska – Lincoln. It plays a vital role in achieving the course objectives by using team-based learning to engage the students in the engineering design process, and providing hands-on experience with problem-solving, biological materials teamwork, communication, and professional ethics in an engineering setting. Having the competition portion of the Incredible Edible Car exercise as a

part of E-Day allows students to network with practicing professional engineers, helping them understand the functions and societal impacts of engineering, and the defining characteristics of the biological systems engineering and agricultural engineering disciplines.

"It's not whether you win or lose; it's how you eat the game."[8]

References

1 Team Theta, 2008, Assignment 7.1, Problem Statement
2 Team Mu, 2008, Assignment 8.3, Executive Summary
3 Team Alpha, 2008, Assignment 8.3, Executive Summary
4 Catherine, 2008, Real Nebraska interview
5 Stephanie, 2007, Assignment 6.1, MBTI personality and your team.
6 Team Rho, 2008, Assignment 8.3, Executive Summary
7 AGEN/BSEN 100 Course/Instructor evaluations, 2008
8 Timothy, 2008, Real Nebraska interview

Biographical Information

Crystal A. Powers
Ms. Powers is an Extension Engineer in Biological Systems Engineering at the University of Nebraska, and Engineer in Training. She has helped teach several courses in agricultural and biological engineering including Introduction to Biological Systems Engineering and Agricultural Engineering since 2007.

Donald M. Edwards
Dr. Edwards, ASEE fellow, is Dean Emeritus of the College of Agricultural Sciences and Natural Resources and a Professor of Biological Systems Engineering at the University of Nebraska, and registered Professional Engineer. He is former Associate Dean of the College of Engineering at UNL and has received numerous college, national and international teaching awards. Dr. Edwards has taught Introduction to Biological Systems Engineering and Agricultural Engineering since its inception in 2004.

Dennis D. Schulte
Dr. Schulte is a Professor of Biological Systems Engineering at the University of Nebraska and registered Professional Engineer. He teaches undergraduate and graduate courses in environmental engineering, and has received many college and national teaching and advising awards, including being the Holling Family Distinguished Engineering Educator at UNL. Dr. Schulte has taught Introduction to Biological Systems Engineering and Agricultural Engineering since 2004.

Appendix:

Edible Vehicle Design Competition (Materials Given to Student Design Teams)
Problem: To be defined by your team
Objective(s): Also to be defined by your team
Constraints:

1. The vehicle must utilize at least three (3) different food items.
2. Each vehicle must be entirely edible. No toothpicks, tape, glue, etc.
3. The vehicle must have at least:
    a. A body
    b. 3 wheels (the wheels must rotate)
    c. 2 axles
4. The vehicle must travel down a 20-degree, 1-m long x 0.3-m wide inclined plane, and onto a flat plane.
5. All parts must be dry at the time of competition.
6. For the eating of the vehicle, each "team" will consist of three people. A portion of the vehicle must be eaten by each member of the team. No more than 5 minutes may used to eat the vehicle.

Scoring:
Each vehicle will be judged on the following criteria (see last page for point distribution):

1. Distance
2. Durability
3. Design
4. Creativity
5. Edibility

Rules:

1. Vehicles will be released by a competition official at the top of the ramp. The front end of each vehicle will be placed on the start line and released with a hand-held device.
2. There can be no outside influence on the vehicle after its release. However, for vehicles that leave the ramp or jump the guard rails on the deceleration surface, teams are allowed to "catch" the vehicle to prevent damage.
3. Any vehicle that does not make it down the ramp will not receive distance points for that run.
4. The maximum of two runs will be used to determine the points awarded for distance.
5. Vehicles that leave the deceleration surface (e.g., jump the guardrail) will receive one-half the distance from the point where it left the surface.
6. Teams may not disassemble the vehicle prior to the eating portion of the contest.
7. Three members from each team will be asked to eat their vehicle upon completion of the distance trials of all teams.

Prizes - UNL Bookstore Gift Certificates for the top three teams
All decisions by judges are final

Overall Sequence of Events

1. Use the design process to create the plans for your vehicle
2. Prepare PowerPoint slide(s) for a oral presentation the week before the competition
3. Prepare a poster presentation for competition day
4. Construct your vehicle and bring it to class on race day (don't forget to bring extra materials in case your vehicle falls apart!)
5. Have fun, win the competition and the audience!!
6. Turn in your final written report on Friday of competition week

Reimbursement
Up to $16/team reimbursement is available. Included in this are funds to build the vehicle and materials needed for the poster presentation. For reimbursement of up to $10 of expenses incurred outside of Chase Hall, present your receipts to Ella Carson, 220 L.W. Chase Hall (no later than Friday afternoon, December 12).

- One member of the team should collect/present receipts for the entire team.
- Only one reimbursement per team. (Be sure you have all the receipts).

- When collecting reimbursement, be sure to bring your student I.D.

For color laser printing in Room 248 Chase Hall each team has been given a budget of $8.00. This only includes color laser printing and limited supplies such as velcro dots.

A record will be kept by Gail Odgen in room 249 for each team, indicating printing cost incurred. Do not wait until the last minute to do your printing.

Supplies for mounting the color laser prints, such as poster board, foam core backing, and glue, must be purchased outside the department. If you wish reimbursement for these outside supplies, save the receipts and include them with the receipts above for the edible car.

Judging Criteria and Scoring (50 total points)

Distance (10 pts)
This is the performance part of the design. The vehicle which rolls the furthest (parallel to the rails) on the flat plane will receive 10 points. Distance is determined at the part of the vehicle closest to the ramp. The second place vehicle will receive 9 points and so on.

Durability (5 pts)
- Vehicle:
  - slides down incline (does not roll) but stays intact (1 pt)
  - makes one run down incline, unable to make second (2nd point)
  - makes two runs down incline, requiring minor repairs (3rd point)
  - makes two runs down incline with no repairs (4th & 5th points)

Design (15 pts)
- Edible Materials (up to 5 pts)
  - the minimum number (3) of edible materials (2 pts)
  - four edible materials (1 additional point)
  - five or more materials (2 additional pts)
- Wheel/Axle Design (up to 10 pts)
  - does not start on its own or slides (2 pts)
  - rolls down incline, but with assistance (4 pts)
  - rolls poorly down incline, but without assistance (6 pts)
  - completes run down incline without assistance, but hits the rails on the way down (8 pts)
  - completes run down incline without assistance and without hitting the rails (10 pts)

Creativity (10 pts)
- use of a theme, slogan and team and vehicle identity (2 pts)
- use of a clever idea or material (2 additional pts)
- use of different colors or textures (2 additional pts)
- vehicle-like appearance (2 additional pts)
- unique uses of materials for special effects (2 additional pts)

Edibility (10 pts)
All members of the team must consume a portion of the vehicle. The entire vehicle must be eaten within 5 minutes to receive the full 10 points. Two points will be deducted for the next minute and two additional points will be deducted for going over 6 minutes (e.g. <5 minutes = 10 points; 5 - 6 minutes = 8 points; > 6 minutes = 6 points). No team will be allowed to eat for more than six minutes. Judges will be permitted to stop a team from eating if a problem arises. It is suggested that each team bring a couple bottles of water for the eating portion of the competition.

MBTI Personality Test

One of the several methods of assessing personality types is the MBTI Personality Test. MBTI stands for Myers-Briggs Type Indicator. It has been used widely by companies, colleges and universities, and institutions where an individual's personality type may influence the overall performance of the organization. The MBTI is especially useful in highlighting the strengths and gifts each person brings to life and work. It also helps one identify the primary sources of motivation and energy that people rely upon to get through the day. The MBTI can help one identify new possibilities in interpersonal relationships with loved ones, friends and colleagues. For teams, it can facilitate ease problems and issues that may stand in the way of completing tasks.

Example personality assignment

To: Dr. Dennis Schulte
From: Stephanie
Re: Assignment 6.1
Date: November 6
c: Kristen, Austin, Ryan

My knowledge of the MBTI personality types and that of each of may teammates and myself will be beneficial in the Edible Vehicle Competition in that I know what environment the others like to work. I can try to make the working environment as conducive to each personality type as possible, while taking into account my own needs to in the working environment.

As introverts, Kristen and I prefer to work alone rather than in groups. Therefore, it might be best to delegate parts of the project to each of us to work on individually. Austin and Ryan are extroverts and prefer to work with others rather than individually; they could work together on part of the project while Kristen and I work individually and we could eventually meet to combine and review information. Since my three teammates are all "sensing" and I am "intuitive," I many need to adapt to a more "sensing"- like personality in order to work with them most productively. While Kristen, Austin and I prefer and very organized, structured work environment, Ryan may need a more flexible way to work, but will probably be very helpful if any unplanned circumstance should come up in our project.

Team Evaluations

Below is a form that BSEN/AGEN 100 uses at the end of the Edible Vehicle Competition. The results are used to adjust the individual grades in the project.

I did my fair share in all of the team projects. 1 = Way more than the others, 2 = More than most of my teammates, 3 = Most of the time, 4 = Not nearly as much as I should have.

The other team members were reasonably prepared and brought constructive criticism to group meetings. 1 = All the time, 2 = Usually, 3 = Somewhat, 4 = Seldom, 5 = Never

Some of the other team members **did not** attend meetings as they should have. 1 = Strongly agree, 2 = Agree, 3 = Neither Agree nor disagree, 4 = Disagree, 5 = Strongly disagree

Some of the other team members **did not** make a sincere effort to contribute to the project. 1 = Strongly agree, 2 = Agree, 3 = Neither Agree nor disagree, 4 = Disagree, 5 = Strongly disagree

Some of the team members **did not** effectively communicate and cooperate. 1 = Strongly agree, 2 = Agree, 3 = Neither Agree nor disagree, 4 = Disagree, 5 = Strongly disagree

Certain team members were undependable, did not complete tasks as promised, or were not on time. 1 = Strongly agree, 2 = Agree, 3 = Neither Agree nor disagree, 4 = Disagree, 5 = Strongly disagree

Based on your answers to Question A - D, which of your teammates (there may be more than one) did not perform up to your expectations in the project-related aspects of this course?