Penn State Sustainable Campus and Living Classroom

Siemens AG Corporation

Team 6

Engineering Design 100
Section 011
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The goal was to design a means to increase the sustainability of the Penn State University campus. Our solution includes an outreach effort to children of the surrounding communities in order to expand their horizons into learning the basics of engineering and sustainability. The program will encourage children to participate in critical thinking, leadership, teambuilding and communication skills, as well as use of the design process – all while learning all about energy efficiency and sustainability. The students will be instructed to build a model sustainable house. Through this effort we will be increasing diversity, workforce competence, and creating a more positive mindset towards STEM careers.

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Introduction

Siemens AG is an international corporation headquartered in Munich, Germany focused on electronics and technologies in the fields of energy, industry, communication, transportation, healthcare and lighting. Partnering with Penn State for research, recruitment, etc., Siemens presented a challenge to engineering students: Considering Penn State's University Park campus as a small city, research elements of the "Sustainable Cities" concept to design or redesign elements of the campus to be sustainable and how your concepts might be implemented. This project provides the opportunity to make some aspect of Penn State campus sustainable to encourage thinking and acting with an inter-community and global perspective in order to make a profit and gain positive publicity.

Problem Statement

Partnering with Siemens to continue their initiative, along with the University's Sustainability Strategic Plan, the goal is to develop an innovative solution to make the Penn State campus more sustainable.

To meet the expectations of Siemens, as well as the university's, general guidelines were decided upon. The solution must be sustainable, not only environmentally, but socially and economically, too, and appropriately use technologies available. The design can be associated with any part of campus,

whether that be buildings, transport, water, waste removal, energy, healthcare or communal happiness.

Sustainability

Penn State's University Sustainability Council defines sustainability as "the simultaneous pursuit of human health and happiness, environmental quality, and economic wellbeing for and current and future generations." Sustainability, in coordination with the design, will include and deal with environmental care, competitiveness and quality of life. Using the right technologies, Penn State will become more environmentally friendly, will help their local authorities and businesses to cut costs and will improve the community's quality of life. Sustainability can be implemented within the areas of buildings, transport, water, energy and healthcare with respect to social, economic and environmental factors in addition to the use of appropriate technology.

General Specifications

In general, the solution should, as much as possible, fulfill each of the following specifications. The design should make money, reduce waste, produce food, produce energy, make the community happier, reduce energy use, reduce emissions, create positive publicity for the university, and/or create a positive future in the community.

The team will work on making the community happier by creating a model to improve K-12 education of engineering. This will create a

positive future in the education of the community and help improve education and engineering awareness.

Directed Specifications

To further the concept, Team 6 created a list of specifications to guide the design. Two subgroups were then developed: required and preferred/optional. The program must use the campus as a living lab for children to learn about engineering and STEM professions, educate children on engineering processes, explain and explore sustainable and modern technologies, be a safe and enjoyable environment for children, have approval from administration and be paid for entirely by donations and business partners like Siemens, leaving no cost to participants. These requirements were chosen as the core qualifications that the project should be formed around. Other, less necessary specifications considered were having volunteers to run the program-staff and students, large enrollment with individualized help, a total cost of less than $500 per week, competition and awards incorporated, and having a simple course structure. These are still important, but the program could succeed without meeting every one.

Schedule of Project

The project spanned over approximately a month and a half. Time was divided into three main periods – each approximately 2 weeks long – as laid out in Figure 1. The majority of the first period was spent understanding the problem at hand and drawing connections between our goals and constraints. Most of the initial information gathering and brainstorming occurred during this time as well. During

the next two weeks, potential solutions were evaluated and the preliminary report was produced. Final detailed research and idea refinery was done during the last period. This is also when the final report and presentation were completed.

	Text1	Duration
1	1.1 Discuss Potential Needs	1 day
2	1.2 Discuss Project Goals	1 day
3	1.3 Understand team abilities	1 day
4	1.4 Discuss the meaning of sustainability	5 days
5	1.5 Discuss how to incorporate sustainability into potential need	6 days
6	2.1 Recognize the opportunity	5 days
7	2.2 Read project background and specifics	5 days
8	2.3 Identify specific customer needs	1 day
9	2.2 Choose Approach to fufill needs	1 day
10	2.3 Identify Stake Holders	1 day
11	2.4 Write questions to ask Siemens	1 day
12	2.5 Email Siemens	1 day
13	2.6 Survey potential customers	2 days
14	3.1 Think about what needs should be met	1 day
15	3.2 Write down all specs	1 day
16	3.3 Quantify Specs	2 days
17	4.1 List general focus ideas	1 day
18	5.1 Research ideas	2 days
19	5.2 Make final general decision	1 day
20	6.1 List general ideas	1 day
21	6.2 Add details to ideas	1 day
22	7.1 Make screening matrix	2 days
23	7.2 Make pairwise comparison matrix	2 days
24	7.3 Make weighted decision matrix	2 days
25	7.4 Choose best option from matrices	2 days
26	8.1 Create PDR	11 days
27	9.1 Research	2 days
28	9.2 Develop visual representation	5 days
29	9.3 Reform original details	1 day
30	10.1 Create PowerPoint	2 days
31	10.2 Practice	1 day
32	10.3 Oral presentation	1 day
33	11.1 Create FDR	5 days

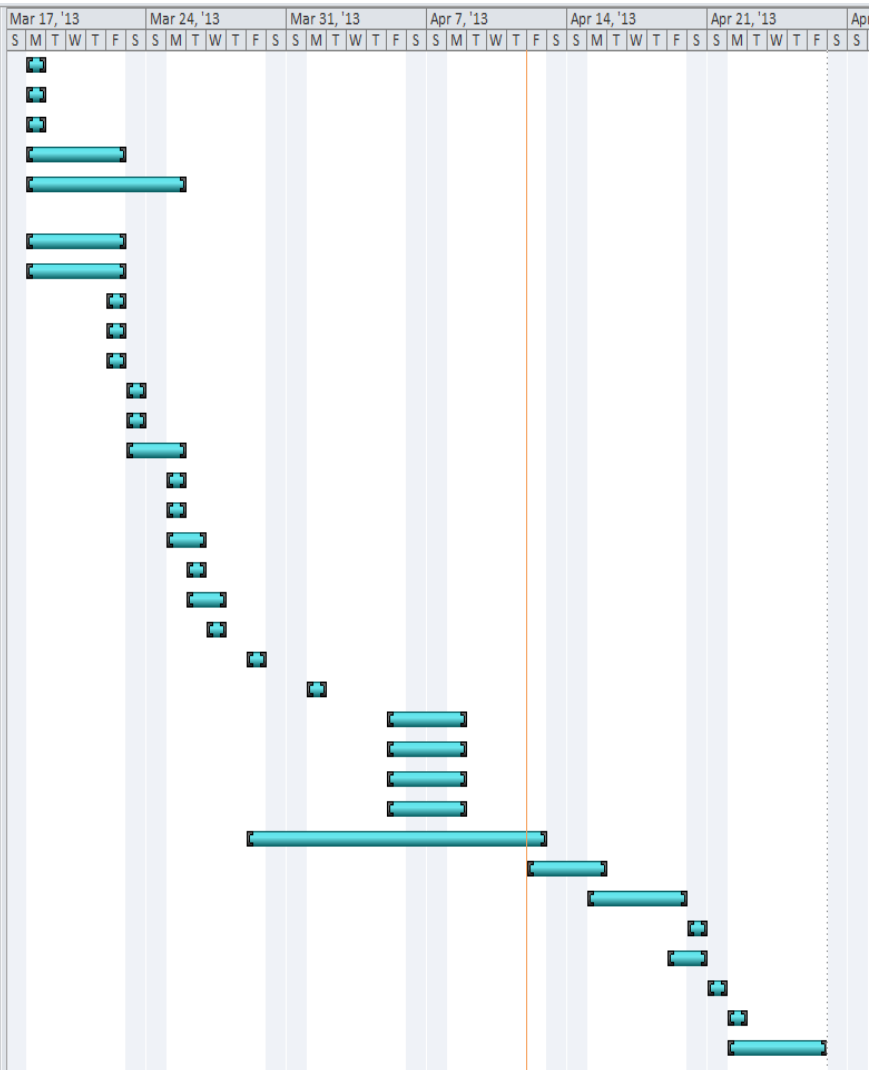

Figure 1 – Gantt Chart

Concept Development

Possible Solutions/ Concepts

After analyzing the results of the survey, the team developed six possible solutions. Each of the following programs would be run on the Penn State University Park campus, utilizing resources and space provided by the university.

1. Create a non-competitive after school program in which children are involved in creating vehicles out of an assortment of provided materials. The vehicles have to be designed to overcome certain obstacles and withstand the stress of use.
2. Run a non-competitive two week summer camp based around constructing a model sustainable house after the children are taught about all current available technologies to build a house as such. The children will be provided all the usable materials and they may use whichever ones they'd like to choose based on what they learn about.
3. Run a two-week summer camp based around constructing a model sustainable house after the children are taught about all current available technologies to build a house as such. There will be a so called 'store' where the children can use their allotted 'money' to buy the materials that they feel are the best suited for energy efficiency and cost efficiency. They will be awarded points for their choices in materials and use of money. There will be winners.
4. Run a two week summer camp that combines all of the subjects in engineering into a brief overview of the opportunities in the engineering field. No hands on- saves materials, demos and explanations only.

5. Develop a program run on weekends (two days) that will allow children to participate in a competition that had rounds and advancements. Each weekend will be a separate round and to get to the next weekend you have to pass a series of specs and challenges with your design. Different materials and objects will be designed every week. This program will be based mostly upon the ability of the students to iterate their designs to fit new specs depending on the challenge of the weekend. Through the competition, the original designs will constantly be running through the engineering design process and be improved every time.
6. Develop a once a weekend workshop-type expo. Kids will be able to sign up for the programs that they want to participate in every weekend. Every workshop will offer different opportunities and be keen to different interests.

After evaluating each potential solution- after also looking at survey results (see appendix A)- through the concept screening matrix (Table 1), options 1, 3 and 5 were considered the best to following up on, but none seemed to warrant removal from consideration. After all the possible solutions were rated again using the weighted matrix (Table 3) (determined by the pairwise comparison (Table 2)), the team decided to continue with development of option three. Based on the previously stated specifications, this option was rated the highest after being subjected to the matrices.

Detailed Concept Development

The program we are choosing to develop is option three as stated above:

Run a two-week summer camp based around constructing a model sustainable house after the children are taught about all current available technologies to build a house as such. There will be a so called 'store' where the children can use their allotted 'money' to buy the materials that they feel are the best suited for energy efficiency and cost efficiency. They will be awarded points for their choices in materials and use of money. There will be winners.

This program will be offered as a free two-week summer camp for students in the State College area. The program will cost under $500 to run by the university and the leadership of the program will volunteer based only. Costs must be covered by monetary or material donations. Children must sign up for the program and either be entering, or exiting grade eight in a local public school. There will be a limited number of spots for applicants and if there are too many applicants, enrollment will be determined solely by a lottery. The camp will run from nine AM until two PM everyday and there will be a break for lunch provided for campers from eleven AM until twelve PM. The camp location and all materials used will be based primarily out of Hammond building and the engineering department at Penn State University.

During the first week of camp, the students will be educated about what a sustainable house is and various systems that are considered when constructing a sustainable home. The systems they will learn about include energy production and savings, water and wastewater treatment and heating and cooling with the addition of material options for building structurally sound sustainable homes. The education of these components will be introduced through presentations, demonstrations and on-

campus field trips to different facilities available for exploration and knowledge growth about the components involved in construction. The students will then be educated on how to properly utilize the engineering design process. They will go through a series of situations in which they will have to use the process in order to get accommodated with the steps involved and the way it works to weed out the best design solution for their problem.

During the second week of camp, after the basic instruction and education of the campers, the students will be split into random groups. Within these groups, the students will get to know each other and understand each other based on problem solving activities and icebreakers.

Once the students get comfortable with their group roles, they will start working through the design process in order to determine what technologies they think would be best to design their own sustainable model home. Each group will be assigned a specific amount of "money" or points that they can use to buy differently priced items- the different options available to construct the home with- in the "sustainability store". The groups are to use this "money" as cost efficiently as possible to build the best possible sustainable model home that they can build. They are not allowed to have any more "money" than originally allotted. In addition to buying the house systems, they are to create the sturdiest possible structure with the available materials.

Winners of the home construction will be chosen by rating each home with relation to cost effectiveness, sustainability ratings, and structural integrity. The cost

effectiveness will be determined by the amount of "money" left over at the end of construction along with the hypothetical payback period of the entire home. The sustainability rating will be determined by the technologies the groups chose in relation to studies on the different options available for research. The structural integrity of the home will be tested by a series of stress tests and measures used in real construction. The group with the highest cumulative score will be the winning team. This team will receive an achievement certificate and some sort of monetary based educational prize such tickets to the local children's science museum. At the conclusion of the week, children will dissemble their houses and return all materials to the "sustainability store".

Conclusions

The multi-week program focused around discovering sustainable technology and engineering the most sustainable house possible is a way for younger children to become involved in an important and fun learning environment. By providing an easy-going, yet competitive activity, children will enjoy learning and will be driven to perform well. This reinforces the idea of creating a sustainable community by keeping the younger generations driven to succeed in engineering while also incorporating sustainable technologies into their work.

This design can also easily be kept to the designated budget of $500 dollars/week as supplies can be used multiple times and students would only be attending during the day, which saves on rooming, heating and food costs. This, along with students and faculty members working as volunteers, provides the opportunity to allow a large number of

children to enroll. With a low cost, getting funding from alumni, community members and sponsor organizations such as Siemens would not be difficult. These donations will fund the entire program meaning there will be no cost to students. As a result, lower income families will be able to take part in the program, contributing to the social aspect of the program's sustainability.

Lessons Learned

During this design project, our team learned a lot about engineering processes and general team work. We were able to take the design process step by step rather than instinctively rushing through. Through working together, we saw the importance of good communication and were able to pick up the slack when one member wasn't able to keep up. Also, our ability to make swift, but rational, decisions helped our time management. Another lesson we learned was how to think creatively to solve problems we may not be familiar or comfortable with

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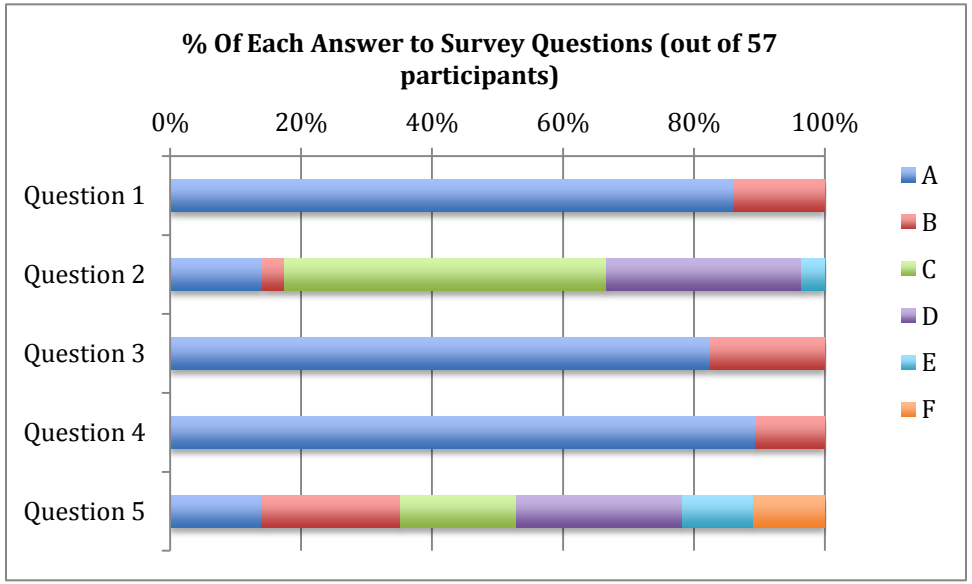
Appendix

Appendix A – Survey Results

1. Would your child be interested in participating in a **free** program in which they will use engineering in fun and creative ways to create things for play or practical use?
    a. Yes
    b. No
2. When would an ideal meeting time for this program be, if interested?
    a. After school
    b. Before school
    c. During a 1-2 week summer camp (multiple sessions offered-mornings)
    d. On weekend mornings/late mornings
    e. On weekend evenings
3. Is your child interested in competition and winning prizes?
    a. Yes
    b. No
4. Are you willing to help your child expand on the lessons of the program outside of the 'classroom'?
    a. Yes
    b. No
5. Is your child interested/do you think they will be interested in the following (check all that apply)
    a. Machinery (anything with moving parts)
    b. Vehicles (cars, planes, trains)
    c. Chemistry (making chemical reactions)
    d. Building (building things out of household items, legos, k'nex)
    e. Electricity (wiring, lighting, building circuits)
    f. Computers (making computer software, using computer programs for design)



Appendix B – Screening Matrix

*1-6 are the possible solutions explained in the report

	Concept Variants					
Selection Criteria	1	2	3	4	5	6
Cost less than $500 dollars a week	+	0	0	+	0	+
Use of modern technology to maintain sustainability	0	0	+	-	+	-
Awards and Competitiveness	-	-	+	-	+	-
Take away knowledge of sustainability and interest in engineering	+	+	+	+	+	0
Course structure is easily manageable	0	0	+	-	-	+
Fun and Enjoyable	0	-	+	-	+	-
Total	1	-1	5	-2	3	-1
Rank	3	4	1	6	2	4

Appendix C – Pairwise Comparison

	Cost less than $500 dollars a week	Use of modern technology to maintain sustainability	Awards and Competitiveness	Take away knowledge of sustainability and interest in engineering	Course structure is easily manageable	Fun and Enjoyable	Row Totals	Row total/total
Cost less than $500 dollars a week	1	5/6	5/4	5/9	5/7	5/7	5.07	0.140
Use of modern technology to maintain sustainability	6/5	1	3/2	2/3	6/7	6/7	6.08	0.168
Awards and Competitiveness	4/5	2/3	1	4/9	4/7	4/7	4.05	0.112
Take away knowledge of sustainability and interest in engineering	9/5	3/2	9/4	1	9/7	9/7	9.12	0.252
Course structure is easily manageable	7/5	7/6	7/4	7/9	1	1	7.09	0.196
Fun and Enjoyable7	7/5	7/6	7/4	7/9	1	1	7.09	0.196

Appendix D – Weighted Matrix

*1-6 are the possible solutions explained in the report

		1		2		3		4		5		6	
Selection Criteria	Weight	Rating	**Weighted Score**	Rating	**Weighted Score**	Rating	**Weighted Score**	Rating	**Weighted Score**	Rating	**Weighted Score**	Rating	**Weighted Score**
Cost less than $500 dollars a week	14.0%	3	**0.420**	3	**0.420**	3	**0.420**	5	**0.700**	4	**0.560**	1	**0.140**
Use of modern technology to maintain sustainability	16.8%	4	**0.672**	4	**0.672**	5	**0.840**	1	**0.168**	3	**0.504**	2	**0.336**
Awards and Competitiveness	11.2%	0	**0.00**	0	**0.00**	5	**0.560**	0	**0.00**	5	**0.560**	0	**0.00**
Take away knowledge of sustainability and interest in engineering	25.2%	5	**1.26**	4	**1.01**	5	**1.26**	2	**0.504**	3	**0.756**	5	**1.26**
Course structure is easily manageable	19.6%	2	**0.392**	4	**0.784**	3	**0.588**	5	**0.980**	1	**0.196**	3	**0.588**
Fun and Enjoyable	19.6%	4	**0.784**	3	**0.588**	3	**0.588**	2	**0.392**	3	**0.588**	5	**0.980**
Total Weighted Score		**3.528**		**3.474**		**4.256**		**2.744**		**3.164**		**3.304**	
Rank		**2**		**3**		**1**		**6**		**5**		**4**	