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Case Study: Developing Innovation Skills of Engineering Students

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Abstract

The purpose of this paper is to report a case study that develop the skills necessary to compete in a global economy by going through the cycle of product development. The best way to equip students with good skills to survive and thrive in a global economy is to teach innovation. Students can develop their skills by working in small teams to generate, evaluate, develop, and market their innovation. A formal presentation must be done at the end of the semester to develop their oral communication skills. Each team must also submit a final report outlining the development of their product and ideas for future development of the product. Another component of the final work is the product prototype. At the end of the semester, all groups should submit peer evaluations. This will allow students to comment on the behavior, contribution, and people skills of their teammates.

Keywords: *Innovation, Product Development, Teams, Problem Solving.*

1. Introduction

Universities can provide students with knowledge, and serve as the fuel for innovation [1]. Problem solving develops complex thinking ability in students [2]. In many industries, technological innovation is now the most important driver for competitive success. Firms in a wide range of industries rely on products developed within the past five years for more than one-third of their sales and profits. Foreign competition has also put pressure on firms to continuously innovate [3]. Innovation is the exploitation of change as an opportunity for a business or service. Innovation can be taught and learned [4]. On the average about sixty percent of all jobs in the U.S. are generated by firms with twenty or fewer employees. Large firms with over five hundred employees generate less than fifteen percent of all new jobs [5]. The Engineering Design/Analysis course at the University of Nevada at Reno provides an example of what one course in entrepreneurship can accomplish [6]. Student teams work during one semester to design and to build an electronic device of some sort. Several of the designs were turned into real products that were sold to existing companies or formed the basis for new startups. Engineering students have to learn to engineer in a way that is ethical, socially conscious, environmentally sound, and globally aware [7]. Engineering education must make an active learning the predominant engineering student learning mode [8]. Economic wealth is created through the creation, production, distribution, and consumption of products [9]. Most engineering and technology programs concentrate on building new products, whereas most business programs concentrate on the survey of potential customers and the business plan. This course emphasizes the product as well as the business plan, to develop a product that is feasible, profitable and meets customer expectations.

2. Research Method

Students can develop the skills to identify new business opportunities and develop the tools to capitalize on these observations. Faculty members should be encouraged to participate as student team mentors. At the beginning of the semester, students in the innovation course

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will generate ideas for a large number of potential products. The product ideas will then be presented to the class and their peers will rate the ideas based on various factors given by the faculty. The project has to be at the skill level of the students. The project cannot be too expensive, as it has to fit the budget of the school. Several other criteria can be added, depend on the limitations of the school. Students will then form teams based on product interest, compatibility, skills, and other factors. The teams will work together to generate marketable product concepts. Each student team will then perform a preliminary market analysis and patent search. Within a few weeks, the team must persuasively present their product concepts to their peers. As part of this presentation, each team must specify objectives to be met by the end of the semester. These objectives will be used as grading criteria for the project. The objective of every team and every project will be create, prototype, and market a new product. Once the team has decided on a project concept and objectives, they will work on developing their product. This will involve product specific development using engineering and business concepts. Product protection and marketing will depend on the schools existing policies and procedures. Problem solving, real-world experience, and designing artifacts develop complex thinking ability of students. Designing artifacts involves planning, inventing, assessing, and revising a product [10].

3. Product Development

The process of taking an idea from initial conception to market is called product development. It includes idea generation, market research, product evaluation and selection, design and development, product protection and commercialization [11]. Traditional research methodologies are applied to developing a product and learning from the development experience. Developing a product demands the integration of content/basic thinking, creative thinking, and critical thinking [12].

3.1. Idea Generation

Idea generation refers to generation or identification of potentially marketable product ideas. Highly motivated enterprising students are an ideal source of potentially marketable, creative product concepts. The opportunity to learn real business and engineering skills, while working on one's own idea, should appeal to many students. Even if student's concepts fail due to weak market analysis, existing products, or for any other reason, failure can often teach much more than success. The process most often used for idea generation is brainstorming [13]. This involves students who suggest anything that comes to their mind, and feed off one another's ideas, and seeks to create a large list of potential products in an environment free of criticism. Students will then form teams based on product interests, personal relationships, skills, or other factors. These teams will then work together to generate potentially marketable product concepts. Surveys or interviews with potential customers could be useful in generating relevant product concepts. Students must also be taught to keep an accurate log book and document their work carefully to protect their intellectual property rights. Once the list of potential products is developed, each product or concept should be evaluated, considering student interest in the project, strengths and weaknesses of the concept, feasibility of execution, etc. By the end of this process, each team should have a potentially workable project. Once this process has been completed, the student teams can begin their market and product research, preparation of prototype, and preparing to present and to defend their ideas before their peers.

Our case study involves extending the life of light bulbs. The first light bulbs were invented using direct current as its main energy source [14]. These bulbs used energized carbon filaments to produce light inside a controlled vacuum. This type of light bulb was very inefficient and costly for production. It was only until the discovery of ductile tungsten did the light bulb become a viable instrument for light production [15]. The first bulbs that utilized tungsten filaments were produced by General Electric in 1907. Tungsten was found to be a good conductor of electricity while also having a high melting point and low evaporation rate which helped the filament withstand the heat created by light production. Later, inert gasses were used to reduce filament evaporation by transporting heat away from the filament and it was discovered that winding the filament helped reduce convective heat loss. This was all necessary because direct current had not become the energy of choice, alternating current had, and alternating current produces more heat in an incandescent light bulb than direct current resulting in faster filament loss [15]. The main reason current incandescent light bulbs use alternating current is its availability; even though direct current can still be utilized by an incandescent light bulb to produce light. Currently, many organizations produce products that utilize this principle for the conservation of light bulbs by the consumers who own their product. The only problem is that the type of energy conversion used by the organizations is not fully rectified. They use what is referred as a half wave rectification to reduce heat and lengthen the life of the bulb they are trying to protect [16]. This type of system reduces the luminosity of the bulb which makes it less functional even though the life-span of the bulb is lengthened a reported 27% to 93% [17].

Energy rectification from alternating current to direct current is relatively simple. Through the use of a half wave or full wave rectifier diode alternating current comes into the system and direct current comes out [18]. Ron Stoner [19] displays these processes in his physics PowerPoint lecture of the winter 1999. What has not been done is the use of full rectification of alternating current to produce a light bulb that still has the same luminosity of its alternating counterpart but a reduced heat production extending the life of the bulb.

3.2. Market Research

During this phase, students will perform searches to make sure they are not duplicating products already on the market. They should also consider demographic factors, identify competing products, establish timelines, and get a better estimate of the resources needed to complete their project.

Currently, all efforts to provide rectified power for incandescent light bulbs are based on half wave rectification of alternating current to direct current. The objective of this study was to provide research on the viability of a product utilizing full wave technology in the rectification of power for a system of light production. This was to be conducted through testing of a prototype system and a marketability survey of potential consumers for a product using the above technology.

The survey used in this study consists of various questions designed to retrieve feedback from possible consumers about the marketability of the product. The survey also collected information about these consumers and was designed to help the researchers' forecast possible retail pricing and target populations. The survey used in this study and the results are shown in Appendix A.

3.3. Product Evaluation and Selection

Once potentially feasible ideas have been generated and market analysis has been performed, student teams must present their concepts to their peers. Their peers will evaluate their concepts according to some established criterias. The evaluation criteria should include consideration of the product such as manufacturability, manufacturing costs, raw material availability, size, shape, material, color, price, projected sales volume, profitability, market strategy, adaptability to customer needs, and estimated cost of marketing. External factors to consider are market size, potential customers, competition, and demand. Internal factors include available resources, financial, equipment, time, and fit to program. This step is a filtering process in which only the ideas with greatest potential are allowed to proceed.

The data provided by the research showed the researchers that a product meeting the designed criteria is viable and marketable. The product is able to meet the criteria of extending the life of a normal incandescent light bulb. The research also shows that these attributes are in relatively high demand by the consumer. The product marketability survey was designed to identify the demographic segment, most likely to purchase product that extends the life of an incandescent light bulb by using direct current as an energy source. This survey was also designed to allow the potential consumer to target the possible retail price of the product. The product marketability survey of potential consumers revealed that married individuals and females would be the ideal target demographic for a product which extends the life of an incandescent light bulb by using direct current as an energy source. Both of these groups were not only inclined to purchase such a product, but also willing to purchase the product for a larger retail price.

3.4. Product Design and Development

The details related to the design and development of a particular product depends on the nature of the product. Students should develop a timeline to guide the development of the product against which the team can be evaluated and graded at the end of the semester. This will also satisfy ABET (Accreditation Board for Engineering and Technology) Criteria 2000 [20]. Developing product prototypes will require the use of discretionary funds to cover the cost of materials, parts, and equipment usage.

The design for this experiment was to test the longevity of the rectification system versus the industry standard, for the utilized light bulb [21]. This test against time showed that our system allows a normal incandescent light bulb to outlast the industry standard and due to the time constraints of time allow the researchers to assume that the system increases bulb life. The tested bulb was energized by a fully rectified system and not turned on or off until the industry standard has been surpassed or the bulb life had expired. Figure 1 shows the prototype aluminum mould that was built in our lab for this project.

Figure 1. Prototype Mould

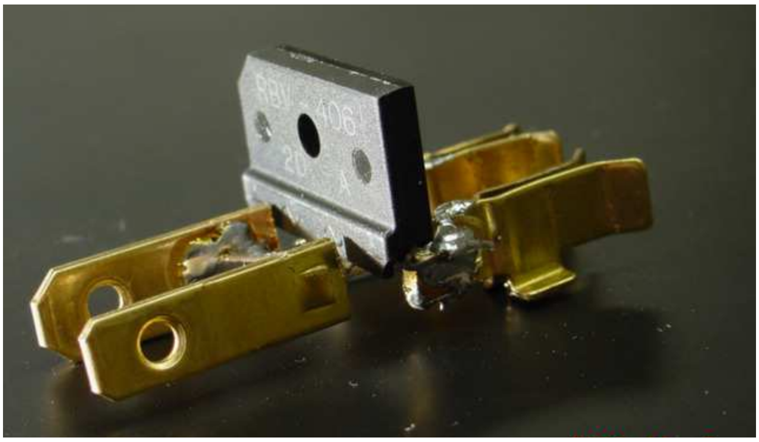

Figure 2. Prototype Components

Figure 2 shows the prototype components that were used in this project, and Figure 3 shows the final prototype with the components. The product testing, shown in Figure 4, concluded that the system we implemented met our expectations. The light bulb used, which was rated at 1000 hours, surpassed the industry standard utilizing full wave rectification. The system succeeded in lengthening the life of the tested light bulb past its expected life span. The light bulb used was not tested to failure because of time limitations, so generalizations could not be established about how long our system lengthened the life of the light bulb, only that it had lengthened it past the industry standard.

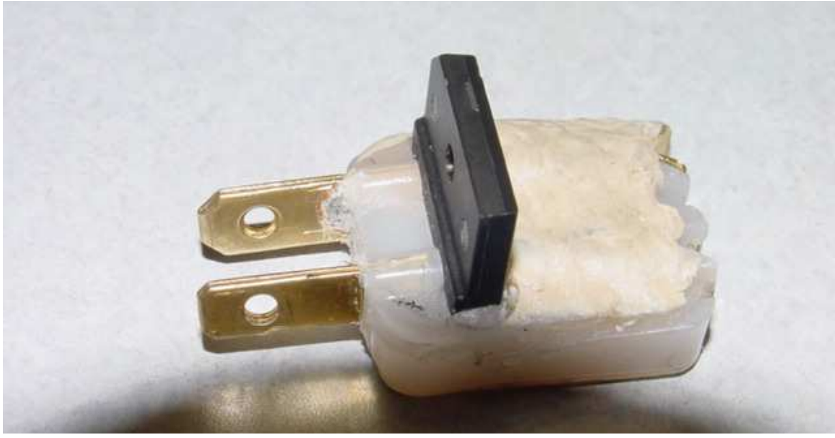

Figure 3. Final Prototype

Figure 4. Product Testing

3.5. Product Protection

Protection of products and intellectual properties by patenting or copywriting of new products are essential for long term survival and growth. However, securing a patent can take up to two years and cost up to $10,000 in legal fees. Intellectual property policy protects the rights of all co-inventors. All participants must keep careful records of their activities in the form of engineering log books. Our product could easily be duplicated and we did not see the advantage of patenting the product.

3.6. Commercialization

Once products have been conceived, selected, developed and protected, they must be successfully commercialized. We are looking into commercialization options.

4. Results and Discussion

The evaluation of our research leads us to two major conclusions. The first conclusion is a product enlisting fully rectified energy in light production by an incandescent light bulb was marketable. Our market research showed that most individuals questioned, felt that this product was viable and necessary to their lifestyle. This shows that individuals would be interested in a product utilizing energy rectification in light production.

Secondly, a conclusion can be made that our system of energy rectification in light production by an incandescent light bulb can out last industry standards for the same bulb which uses alternating current. Our testing shows that a system using full rectification, along with an incandescent light bulb, can help the bulb expand its life span. This can be inferred to our research which states that this type of system can increase life span by up to 93%. Further research is needed to validate these findings by our initial research shows that this idea is promising.

Other possible products brought up by this research involve this system being utilized in a wall mount switch for home wiring, a breaker for commercial use to be installed in the electrical panel, and build the system within an electrical lamp. These possible products were not researched within the study for marketability but could be viable applications of the research technology.

4. Conclusion

The project will satisfy most of the skills of ABET essential summary of critical skills for engineering graduates in Criteria 2000 [20]. Motivated students from any department should be permitted to participate. Having a wide diversity of students participate broaden the perspective of students by exposing them to think differently. It develops communication and interpersonal skills.

Through our example, we have shown how a project can be taken from an idea to the design, prototype development and commercialization of the product. We hope the background information and example will be useful to other schools in innovation development.

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APPENDIX A
Product Survey Results (n=25)

Please circle the letter that corresponds to your answer.

1) When was the last time someone in your household bought light bulbs?
   a) In the last month 36%
   b) One to two months 32%
   c) Two to six months 24%
   d) More than six months 8%

2) How often does someone in your household buy light bulbs?
   a) Once a month 8%
   b) Once every two months 28%
   c) Once every six months 44%
   d) Once a year 20%

3) What characteristic most influenced your purchase of light bulbs?
   a) Price 72%
   b) Brand name 4%
   c) Appearance 4%
   d) Advertising 4%
   e) Bulb life 16%

4) What price, per bulb, did you pay?
   a) Less than $1 48%
   b) $1.01 to $2 36%
   c) $2.01 to $5 16%
   d) More than $5 0%

5) Did you know the average bulb life for standard incandescent bulbs is only 750 hours?
   a) Yes 32%
   b) No 68%

6) Have you every purchased a “long life” or “extended life” bulb?
   a) Yes -- what was the cost 44% Avg cost - $5.89
   b) No -- skip to question 8. 56%

7) How satisfied were you with the performance of the bulb when compared to the price?

Dissatisfied		Somewhat dissatisfied		Neutral		Somewhat satisfied		Satisfied	
1	2	3	4	5	6	7	8	9	10
18%	9%	9%	0%	18%	36%	9%	0%	0%	0%

8) Would you purchase a device that could extend the life of a light bulb by up to 10 times the normal 750 hours?
   a) Yes 84%
   b) No 16%

9) What would you be willing to spend on such a device?
   a) $1 to $5 56%
   b) $5 to $10 28%
   c) More than $10 16%

10) Would you buy more than one such device for your household?
   a) Yes – if yes, how many? 92% Avg # - 6 to 7 bulbs
   b) No – 8%

For demographic purposes, please answer the following:

Sex:

female	male
40%	60%

Marital status:

single	married
40%	60%

Age:

<25	26 – 35	36 – 45
32%	28%	24%
46 – 55	56 – 65	>65
4%	12%	0%

Household annual combined income:

<$20,000	$20,000 - $50,000	
20%	36%	
$50,000 - $100,000	>$100,000	No answer
32%	8%	4%