Undergraduate Entrepreneurs: Novel LED Taillight Assembly Design, Prototyping and Market Tests

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ABSTRACT

Rowan University's Engineering Clinic courses have made it possible for motivated undergraduate entrepreneurs to take their creative ideas and turn them into prototypes. Spaghetti Engineering is a start up company whose short-term goal is to design and fabricate a high performance line of automotive taillights. It consists of a multidisciplinary team of five electrical and computer engineering and mechanical engineering students from two universities. Market studies completed by the students as part of this internal grant award show that the concept's potential for success would be sufficient to justify the development investment in prototypes and do further test marketing research. The project was undertaken as part of Rowan's Innovative Engineering Clinic which all junior and senior engineers must participate in. The student team competed in order to receive the award of $2,500. Funding for the award is made possible from the National Collegiate Inventors and Innovators Alliance (NCIIA). Rowan and NCIIA has created a Venture Capital Fund, specifically ear-marked for the development of original inventions by multidisciplinary student teams within the Junior and Senior Engineering Clinics. This arrangement gives the project team several extremely helpful benefits. In addition to the obvious benefit of monetary backing from the University the team also made use of many of the other university assets, the most important one being many laboratory and faculty resources. An entrepreneurial clinic project requires the support of two faculty advisors, an engineering advisor for technical design and a business advisor for the business start up and product to market techniques. Having these advisors brings years of knowledge and experience to the clinic team and greatly helps them increase the probability of success for the new venture. The team uses the Rowan College of Engineering's prototyping facilities, which include a comprehensive machine shop, a stereo-lithography machine, 3D wax printer, high-pressure water jet, and a host of other CAD/CAM and computer resources. With these combined assets and a motivated entrepreneurial team of undergraduate students the Rowan Engineering Clinic provides a hands-on, minds-on educational experience that helps students go from concept to prototype and from colleagues to business partners.

BACKGROUND

Since the Autumn of 1998 professors from Rowan University with funding from NCIAA, NSF and regional business have funded over a dozen student originated, developed, and designed business ideas. The Rowan Venture Capital Fund has helped students explore in real ways what it means to attempt entrepreneurial activity. The efforts of these students has led to two patents pending and three start-up companies. The Engineering Clinic at Rowan University College of

Engineering is rather unique across the country[1-2]. From the freshman year students are exposed to hands-on and minds-on project experiences in engineering where they must make work with their hands what they have thought through in the design portion of their course. These clinics include reverse engineering experiences, introduction to product design, developing actual commercial products for industry as well as research for major state and federal agencies (NSF, NASA, NIH, DOE, DOD, NJDOT, etc.) While many students work on the research projects of their professors, the interest areas of their departments or the needs of local businesses for real world problems to be satisfied, the Venture Fund is rather unique. It has been set up specifically to provide the necessary resources (financial and educational) to enable students to develop a unique and proprietary idea or invention they have conceived of while pursuing their studies at Rowan. While the Clinic experience is mandated, applying for Venture Capital Funds is totally voluntary. The specific requirements for participating in the Venture Capital Fund include: the completion of an application by a Junior or Senior engineering student, submission of a well thought out business plan, a commitment to a prototype concept that will be built and proven as part of the semester long effort, the creation of a multidisciplinary team (including at least 2 engineering disciplines) of students excited about the innovation, and the support of an engineering faculty advisor. The original Rowan University Venture Capital Fund was endowed by contributions gathered from research grants from essentially two sources: the National Collegiate Inventors and Innovators Alliance (NCIIA) and the Lemelson Foundation[3]. Since its origins in the Autumn of 1998 it has also been funded by other sources including the Henry Rowan Family Foundation. Over the last five years more than 50 students have participated in these types of projects in the College of Engineering at Rowan. Some of the student inventions include: the SnoRhino, a machine head clutch, portable mp3 player, 3com palm® rs232 protocol analyzer, automated synchronized spinning exercise cycle, coating thickness monitor, linear combination guitar effects processor, hybrid rocket motor demonstrator, dorm-sized air conditioner, hurricane roof vent, enhanced four-wheel drive suspension, and this latest work on designer led taillight assemblies.

The students who worked on this new innovation had personal interests in assisting hobbyists who were interested in creating high performance detail taillights for import cars. Their market was specifically targeted toward these individuals. Over the coursef the project the team conducted patent research, market research and had many business conversations with companies already in the marketplace with respect to opportunities for joint venturing. The team developed three unique prototypes using LEDs[4] that would satisfy their desire for aesthetic uniqueness while meeting highway requirements for illumination and coloring (DOT, SAE), completed a preliminary market study and developed their first significant business plan.

Once the idea for the taillight has been conceived, it was decided by the team to develop ideas that will be marketable to the specified target market. A proof of concept design was created in two stages. First an existing after-market taillight enclosure was modified to accommodate LEDs. Next an elementary controller circuit was designed and implemented to create the desired effects. This was a decided necessity because before the group heedlessly poured money into research and development a demonstration of the desired effect can be attained within the DOT and SAE safety regulations. After it was determined that an effect would be possible within the required restrictions, a base enclosure was selected. This selection was made with the following considerations: selection of a car that was popular in the target market and easy to work with.

With the selected enclosure in mind, several mechanical design concepts were generated and that which had the highest potential was selected. Once the desired mechanical design concept was selected, it allowed the group to create an effect that best complimented the mechanical design. A controller circuit was not only designed to create the desired effect, but also to keep modularity in the event that the effect needs to be changed. The project goal was to build three levels of prototypes: from the simple → more complex. This prototyping was made possible by use of the prototyping facilities here in the College of Engineering; machine shop, a stereo-lithography machine, 3D wax printer, high-pressure water jet and our CAD/CAM and computer resources.

SYSTEM INNOVATION

The design process for each of the three prototypes followed similar steps. Once a concept design was chosen, a controller circuit was developed on a bread board as a proof of concept. From the bread board it was entered into a CAD program, and a printed circuit board (PCB) was designed, laid out, and fabricated. Parallel to the PCB design, the mechanical insert was designed to meet the concept's specifications. Once the PCB and mechanical inserts were fabricated the PCB was populated with the LEDs and controlling circuitry. The final aesthetic steps were taken and the prototype was ready to undergo a market analysis. These steps were repeated three times to generate simple, intermediate, and complex tail light prototype. Figure 1 shows the final prototype of the intermediate design.

Figure 1: Complete intermediate design.

Throughout the design and fabrication process of the three prototypes, the students learned and improved on many skills. The process allowed the students to utilize the concepts and theory learned in previous classes. Furthermore, the students learned additional skills such as printed circuit board design, layout, and fabrication; surface mount pick-and-place population; and mechanical CAD design and CNC fabrication. All of the previously mentioned skills will be used again in other designs and possibly in future work experiences.

The intermediate design (Figure 1) was presented to colleagues of Spaghetti Engineering and a market survey was taken, and the results can be seen in Table 1.

Table 1: Market response to intermediate Design

Evaluation 1: 31 Responses	**Responses**
Impression	
Awesome, Great, Excellent	14
Exciting, Wow	6
Interesting	3
Different, Original	4
Fancy, Bright, Gets Attention	3
Alright	1
Idea	
Awesome, Great, Excellent	19
Gets Attention	1
Creative, Unique, Innovative	7
Interesting	1
Alright	3
Street legal?	1
Design	
Awesome, Great, Excellent	23
Professional	2
Creative, Unique, Innovative	3
Alright	4
Cost	
Too high	9
Reasonable	19
Questionable	3

Initial review of the market response has encouraged the team to place the design in a field market trial at a local merchant location which markets similar products. During this market test in 2004, input from potential buyers will be collected and the market price finalized. The response of manufacturers and retailers has been favorable to the active LED matrix concept, the appearance and performance of the initial prototypes, and the prototypes' marketability from an aesthetics viewpoint. The team formed their company to develop and market their prototypes, negotiate a potential joint venture with existing firms that make replacement taillight assemblies,[5-6] and work with patent attorneys. The company is on the web[7] and has developed its logo (see Figure 2) and business cards. Spaghetti Engineering is a small business whose main goal is to supply innovative designs to the automotive industry. Currently the company's main focus is developing and selling licensing for an advanced high performance tail light design. More information about the company can be found on the web. At the present state the company is composed primarily of electrical and mechanical engineers, along with a graphic artist, Mark Ratzlaff, from Central Missouri State University. Currently, the company is working to obtain a broader market analysis. To accomplish this, the intermediate design will be put on display in a high performance automotive shop for a period of a few weeks. This will allow for greater feedback from the target market. A lawyer hired by Spaghetti engineering is finalizing a pre-drafted non-disclosure/non-compete agreement. (The non-disclosure/non-compete agreement allows for confidentiality between the inventor and the manufacturer. It gives a general description of Spaghetti Engineering and vaguely describes the circuitry and pattern sequences of the brake and blinker lights in order to sell the product to the manufacturer.)

Figure 2: Corporate Logo of Spaghetti Engineering.

The product prototypes will be presented to the manufacturers after they agree to the non-disclosure/non-compete agreement. (The molds needed to create the base enclosures would cost well over $100,000 per car model, thus inhibiting Spaghetti Engineering's ability to self manufacture.) With this licensing agreement, Spaghetti Engineering will provide the manufacturer with additional designs for a wide range of car makes and models.

ASSESSMENT

The assessment of student performance in a Venture Capital Fund (VCF) project is challenging. At Rowan, our focus includes a review of the performance of the team against its proposed business plan. If the key elements have been successfully accomplished over the term then the performance (grading) reflects the completion of the aggressive deliverables. In the case of this and all product innovations or inventions under the VCF at a very minimum the team must develop a working prototype by the end of the semester in order to achieve a passing grade for the Clinic Course. In the case of this innovation, the assessment was not challenging. The team worked well in excess of the anticipated 10 hours per week and developed in a very short period of time (one semester) three (3) unique designs for a simple to complex taillight system. As the project moves to the next stage, the students are negotiating with manufacturers to construct their designs, continuing in-store marketing to gain a better understanding of price points and potential market size for each model, and refining their business partnership strategy. The key deliverable of the experience from the faculty perspective is the impartation of an excitement for invention, creativity, and entrepreneurship. In the experience on this project the team had a very positive experience in creating some innovative, working products that were well received by their focus groups. Our engineering clinic program is successful in providing unique hands-on, minds-on project challenges to our students for them to grapple with each semester. They can use their problem solving skills and engineering design approaches learned in our curricula. What we often lack in our research and industry driven projects is an opportunity for students to perform out-of-the-box, blue-sky thinking in the context of an engineering challenge. Many of the projects and problems posed by the students themselves when applying for the VCF funds are just the ticket required to get students to eagerly engage in innovation, invention creativity and entrepreneurship.

Perhaps the best measure of our performance is the degree to which these efforts create and instill the entrepreneurial spirit of invention and innovation that keeps the US in a technological leadership position globally. This past March (2004) we were informed that Fred Hovermann, '01,'03 and Pete Ferrara, '01 were officially issued a patent for their device entitled, "Tuning Peg Construction" US Patent #6,703,547. This was a first for our young engineering program at Rowan. They invented their device in the Junior/Senior Engineering Clinic, and were funded by the Rowan Undergraduate Venture Capital Fund for one semester. They were subsequently awarded a grant from the NCIIA to complete their work, and apply for a patent. It is our hope that many of the projects we create will instill that entrepreneurial drive which in the end can only be measured by the individual and collective performance of our graduates in business and new product development.

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ACKNOWLEDGEMENTS

This work was supported by the Rowan Undergraduate Venture Capital Fund, which is funded by the Rowan Family Foundation.

BIOGRAPHIES

PETER JANSSON is Associate Professor of Electrical and Computer Engineering at Rowan University and leads numerous Junior Senior Engineering Clinic Teams in solving real world engineering problems each semester. He teaches Networks, Sustainable Design, Power Systems and research includes renewable power systems. He received a PhD from the University of Cambridge, MSE from Rowan University and a BSCE from M.I.T.

MICHAEL MUHLBAIER is a Senior electrical and computer engineering at Rowan University and is planning to attend graduate school in 2004. He is Chair of the Rowan University Student IEEE Chapter and co-founder of his own entrepreneurial business (Spaghetti Engineering).

SEBASTIAN BLICHARZ is a junior mechanical engineering student at Drexel University. Has extensive knowledge on Automotive and Performance Engineering. He also is co-founder of Spaghetti Engineering.

GREG DIGNEO is a senior electrical and computer engineering student at Rowan University and is planning to attend graduate school in 2004.