From Club to Classroom, an Enterprising Integration of Student Interests and Industrial Involvement

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Abstract *¾ The conversion from quarters to semesters presents a unique opportunity to revamp the curricula. In the fall of 2000 this is exactly what occurred at Michigan Tech. The conversion involved overhauling much of the engineering curricula. One major change in the engineering curricula was the implementation of the Engineering Enterprise Program. Prior to the calendar conversion students had only one pathway toward graduation. This pathway involved the students taking technical courses in one of three flavors: theory, application, or design. Little interconnectivity was ever established between these courses. Additionally, student design projects, while of high quality were often completed with minimal student interest. To help build student interest and interconnect the theory, application, and design courses, a novel pathway was developed. This pathway, the Enterprise Program, takes students on a three-year educational journey using topics of self-selected student interests. Students in this program join a pseudo company or "enterprise". From day one, entering sophomores start working with juniors and seniors from multiple disciplines as well as with as with people from industry. This allows the younger students to immediately see the application of their theory course and reinforce "just learned" topics. This further allows the juniors and seniors to excel in design as they have self-selected to join a particular enterprise. This paper elaborates on the Enterprise Program and details the process of turning a well established club organization into an enterprise using the example of Michigan Tech's SAE Mini-Baja Team / Enterprise.*

INTRODUCTION

One of the biggest challenges we face as educators is to get students interested enough in a topic to want to grow past the "plug and chug" mentality so they can learn the theory behind the phenomenon. One way of doing this is to find a topic which holds high student interest and help guide them on a path of discovery. Unfortunately the classroom tends to limit our ability to lead such a journey. One tool which has proven to be successful are student design challenges. Student design challenges, especially national competitions, allow students to apply newly learned skills and engineering tools. This timely application of knowledge has been shown to help improve the retention of material and increase understanding of the engineering topics. However, many of the students involved in the design challenges lack effective organizational skills, have limited oral and written skills, and involve only a small number of dedicated students. This exactly describes Michigan Technological University's (MTU) SAE Mini-Baja team prior to transitioning from a club organization to an enterprise within MTU's Enterprise Program.

The Enterprise Program at Michigan Tech was developed to allow flexibility in a student's curricular path as well as answer many of the short falls in a traditional curriculum. For years industrial assessment of engineering degree programs from across the national have identified the same shortcomings of new engineering graduates [1]-[2]. In a paper by Plichta and Raber [3] these shortcomings include a lack of:

- Strong communication skills
- Team leadership and followership skills
- A sound understanding of non-technical forces that affect engineering decisions
- Awareness of global markets and competition
- Demonstrated management skills and a strong business sense

With a review of this list one can easily identify the business flavor of which these topics are being asked to address. These topics are often hard to incorporate into a classroom setting and when attempted, may receive little student "buy-in" [4]. To increase buy-in and participation "enterprises" were developed. These enterprises incorporate many aspects of a real business as well as serving as a vehicle of immediate technical re-enforcement of "just-learned" theories. Enterprise also included corporate sponsors which further help with student "buy-in". This in turn helps answer the shortcomings of a traditional education as well as serving as a tool to increase student retention and acquisition of knowledge. Another resently presented paper covers the details of the enterprise program, its development, and industrial involvement [3]. This paper outlines the overall strucutre of the Entrprise Program and focusses on the challenges of converting a well established student group into a model enterprise.

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ENTERPRISE STRUCTURE

The Enterprise program is a three year curricular jouney starting the sophmore year. It consists of a total of 16 semester credit hours. Students in the Enterprise program take the same required courses to build the foundation on which most engineering degrees are built. The difference comes in the elective course selection. Table 1 shows the comparison of the traditional and enterprise curricula [3]. It is important to note that the majority of the elective cedits are focused around teamwork, business planning, and communications untilizing examples from the students self selected enterprise team. This focus helps answer many of the deficiencies cited by industry [1]-[2].

TABLE I
COMPARISON OF TRADITIONAL AND ENTERPRISE CURRICULAR PATHWAYS

Engineering Program	Traditional	Enterprise
Required		
Basic Mathematics	19	19
Basic Sciences	15	15
Eng. Science / Design	48	48
Core General Education	13	13
Major Design Requirement	6	7
Elective		
General Education-		
Distribution Courses	15	12
Required Enterprise Modules	-	3
Technical Electives	12	6-8
Elective Enterprise Modules	-	6
Free Electives	3	0-3
Total Credits	131	131

The sixteen credits are fairly evently distributed over the sophmore, junior, and senior years. Table 2 shows the ideal curricular schedule for students activily participating in the Enterprise program [3].

TABLE 2
IDEAL CURRICULAR SCHEDULE FOR THE ENTERPRISE PROGRAM WITHIN A N ENGINEERING DEGREE PROGRAM.

Year	Fall Semester	Spring Semester
Year 2	Enterprise Orientation - 1cr Teamwork Module – 1cr	Communication Context – 1cr Project Work – 1cr
Year 3	Elective Modules – 2cr Project Work – 1cr	Communication Strategies – 1cr Elective Modules – 1cr Project Work – 1cr
Year 4	Elective Module – 1cr Project Work – 2cr	Elective Module – 1cr Project Work – 2cr
		Total Semester Credits - 16

The elective modules are an integral part of the entperise program. They allow the student to develop a sense of the world outside of engineering. An abridged list of elective modules include:

- Economic Decision Analysis
- Enterprise Market Principles
- Strategic Leadership
- Project Management
- Global Competition
- Writing about Engineering in a Societal Context
- Conceptual Design
- Design for Manufacturing
- Entrepreneurship

These courses are developed to be active collaborative learning sessions. The assignments have been developed to work within the framework of each enterprise. So while a student might not be excited about project management in a broad sense, she or he may be excited about managing the project found in their enterprise.

BAJA CHALLENGE

Michigan Tech has a long history with the Society of Automotive Engineers Mini-baja challenge. Dr. William Shapton, a Professor in Mechanical Engineering at MTU is one of the founders of this competition. Over time the challenge given to students has changed from merely a performance based competition to include more business and manufacturing applications. These changes help to make the competition more like the "real world". The current challenge posed to the students is to develop a vehicle capable of being raced off-road. Student are asked to develop a cost analysis report based on 4000 units, a design report, and a safety report. At the competition site, student give presentations focused on sales, manufacturablilty, and design. The competition also includes several aspects of performance:

- acceleration
- top speed
- braking
- sled pull
- hill climb
- maneuverability and
- endurance

The scores of the static competitions are combined with the scores of the dynamic competition to determine the final total score.

The challenges of the club

In 1999, I was offered the role of faculty advisor to MTU's Mini-Baja Team. The first year served as a chance for me to learn and understand the team dynamics. The basic structure involved a strong leader who single handidly designed the vehicle, a talented welder who built the frame, and three semi-talented fabricators who focused on building the machined parts. In early fall, student interest ran high and

the team had as many as 16 people showing up to weekly "shop" meetings. However, due to the poor division of labor, new students were not given the opportunity to participate and quickly stopped attending. Only a few students stuck around long enough to be incorporated into the club. These same few students also complained about how much work they had to do and wished other students would help. This dysfunctional approach to membership ensured low numbers and a large amount of work per student. Students that remained involved were initiated into the "build it first, design it later" mentality. The required design, cost and safety reports were often written the day prior to the due date and had to be shipped express mail to the judges. Not only was little effort placed on writing these reports, the basic report content had not changed in several years. The team was ready for a major reorganization.

In January of 2000, we were invited to join the Enterprise Program with the understanding that things would have to change. With poor teamwork, communication, and engineering practices I had my work well defined. In the spring of 2000 the team made the decision to become an enterprise. Two tasked had to be accomplished durring the first year, development of a business plan and development of tools for assement of student work.

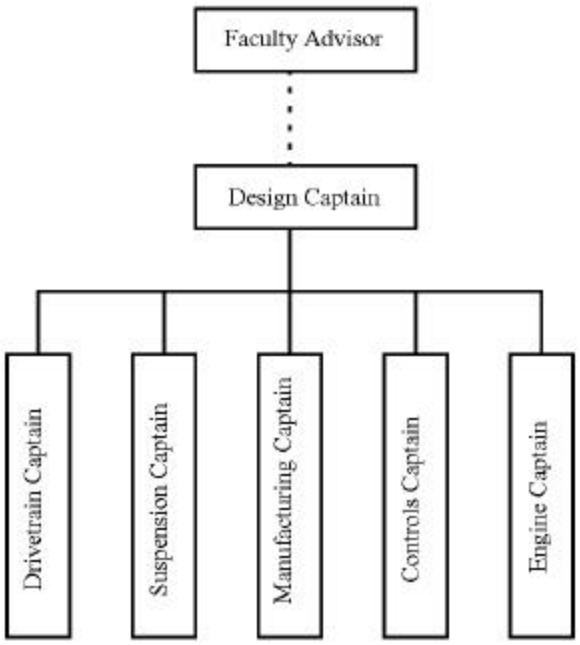

FIGURE. 1
THE WORKING STRUCTURE OF BAJA TEAM PRIOR TO THE CONVERSION TO THE ENTERPRISE PROGRAM.

Changes in the team structure – "if it don't work, fix it"

Two major tasks had to be accomplished in order to become an Enterprise. The first was the development of a business plan. This task included a complete restructuring of the team from a "build" focused hierarchy to a "design and document" focused organization. Figure 1 shows the pre-enterprise structure of the team.

The design captain had nearly dictatorial control of all aspects of the vehicle design and construction. This person often exercised veto power over the smallest detail. Others were given tasks to accomplish, but these tasks required little thought or engineering principles. Communication to the faculty advisor was often filtered through the Design Captain. This historically kept the advisor from "interfering" with the team's operations. To further strain team communications team meetings where often held in the "shop", a great location to build a car but a less than suitable location to hold an effective group meeting. Notes were seldom if ever taken or archived, agendas were not developed, and no hint of project timeline produced. To change the direction of the team I empowered the lowest level of the enterprise students (sophmores) to develop a business plan and new corporate structure.

As a requirement of the Enterprise program, students had to present the business plan and corporate structure to the Dean of Engineering and our corporate sponsor, Ford Motor Company. This task was strategically assigned, get the youngest students to develop a new way of doing business and in three years we will have an entirely new corporate culture. The structure developed by the students is shown in figure 2. This is a much more communication based structure. The advisor, team captain, and design captain form the hub triad. This triad works together to guide the overall direction of the team. Sub teams are now listed in terms of a corporation. These teams include the business team, design team, prototype/manufacturing team, research and testing team, and competition coordination team. Each team had to meet together at least once a week, and then report to the faculty advisor their accomplishments and action items developed for the next week. The captains of each team then met with the advisor as a group once a week. This helped foster communication and ensured we all had a common direction and timeline. All official meetings were held in a conference room, notes were taken and archived.

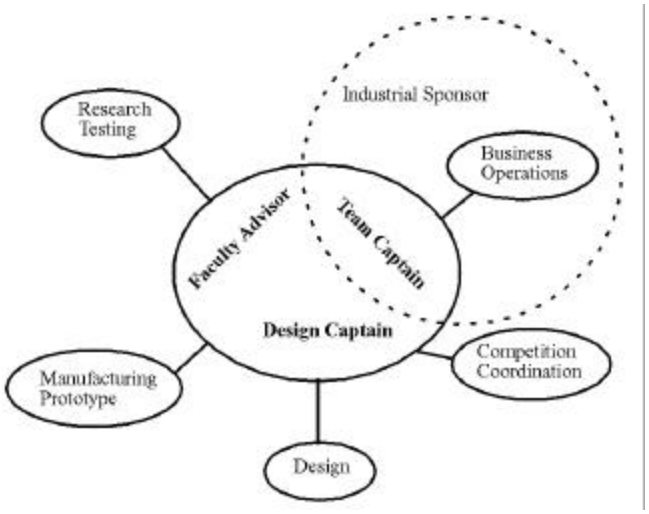

FIGURE 2
THE STRUCTURE OF THE BAJA ENTERPRISE FOLLOWING REORGANIZATION.

To help keep the big picture in focus we utilized corporate sponsors. This was perhaps the single most important tool used to gain student participation. The purpose of this sponsor was to serve as a resource for technical question, a mentor to the help guide the students, and a client for whom we were to report project performance. Students were required to submit progress reports and give technical to presentations to the sponsor. This face to face interaction allowed the students to fully understand the relevance of both the engineering and non-engineering forces which drive the action of the corporate decision makers. This communication was usually initiated by the team captain and the business team.

The second major task in the conversion from club to enterprise was the development of assessment tools. Prior to the conversion, this was a club activity, no assessment was ever developed because no grades or other performance measures were given. However, under the Enterprise Program students would be taking up to 9 credits within the mini-baja organization. To gain student buy-in within the program we started out easy, students would be required to develop a portfolio of their contributions to the team, submit weekly activity reports, keep a research journal, and meet individually with me for their semester review. The students baulked at the first set of assessment tools. So initially we reduced the load to weekly activity reports and a regular meeting with the advisor. Ironically, during the first semester under this new system the students wanted to re-initiate the portfolio and research journal. They were all starting to see the big picture.

RESULTS

After the first year of our enterprise experiment we can already see some success. From the student perspective the team has already performed better than in the past 20 years with a 5th place finish at the Western Regional SAE competition held in Manhattan, Kansas. The students improved their scores for their reports and presentations as well as dynamics performance. From a faculty perspective, I see great success. Students realize the need for organization, assessment, timelines, and project reviews. Students also see the need for a division of labor and the harm that micro-managing can do. Most importantly the excitement level has driven the students to want to learn more advance topics than are normally covered in undergraduate level courses. Students have taken it upon themselves to develop a required seminar series which includes topics of advance vehicle dynamics, shock absorber design and modification, and roll cage safety and construction. While the data is not available at the time of publication, I feel these students have increased the knowledge base and performance in their other classes. These students also have a much better understanding of corporate structure and fully understand the need for designing before building.

Positive results are noticeable in other ways. Previous to becoming an enterprise, the Mini-Baja team has between 4 and 6 active members. We currently have 20 active members who contribute to the success of the team. The integration of students between classes (freshmen to seniors) has helped the lower classmen see the application and importance of what they thought were previously unimportant classes (yes, calculus does have real world applications).

RECOMMENDATIONS

A similar approach can be developed for any design oriented student organization. Some key aspects for success should include:

- Student buy in - the students must identify the need for change and decide to reorganize.
- The inclusion of a corporate sponsor - What the advisor says often falls on deaf ears, when an engineer from Ford Motor Company says it, it is heard loud and clear.
- Recommend a structure for student assessment, but be flexible and willing to change. Most of the students came back around to the original assessment policies and have suggested more ideas.
- Develop and continuously revise a working timeline.
- Include younger students in the decision making and strategic planning of the organization.
- Require presentations be made to the Deans and Department Chairs. This helps prepare students not only for competition but also improves their self confidence.

Other factors for success included:

- A dedicated person continuously seeking corporate involvement
- The ability for the students to receive credit for their involvement.

REFERENCES

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