Early Intervention and Mechanical Engineering (EIME): Balancing stakeholder expectations in an engineering educational environment

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Abstract: The mission of the Early Intervention and Mechanical Engineering (EIME) project is to provide real-world engineering design experience to undergraduate engineering students while significantly enhancing the services provided to children with special needs in the region surrounding Tennessee Technological University (Upper Cumberland region). These enhanced services are provided through a mutually beneficial collaboration between early intervention and engineering at Tennessee Tech. Engineering student engage in design project activities as part of their curriculum to design, develop, test and deliver new and novel applications of adaptive and assistive technology to facilitate transitioning of children from early intervention to preschool programs and inclusive environments. The project serves the engineering program by providing real-world design experiences as well as resources to develop and test projects. The project simultaneously leverages the significant engineering potential in our engineering students to meet specific needs of children served by the TEIS (Tennessee Early Intervention System) as well as the state school systems. The project provide a value-added initiative to our State educational system.

The primary objective of this paper is to describe the EIME model that has been implemented at TTU since 2001 and replicated at other institutions in the state of Tennessee. The EIME project is based on a close collaboration of multiple partners, each with specific motivations and expectations from the project. Success and sustainability of this program depends on meeting partner's expectations. Thus, the paper will identify the major stakeholders participating in this program and will define the primary objectives of each stakeholders. Historical evidence and assessment data of how the EIME program is meeting the objectives will be provided. The paper will conclude with lessons learned and recommendations for future implementation of this project.

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1. Introduction:

There has been a significant emphasis in engineering education programs to enhance students' learning experience through a focus on the context in which learning takes place [1]. The idea itself is not new, and in fact, may have been a more typical way of learning an advanced technical trade in earlier times. However, the approach is being revisited in many ways under different descriptions, each emphasizing a particular aspect of how providing a realistic and motivational environment for the teaching process can enhance learning. Some examples include open ended design problems [2], service learning activities [3], problem-solving-based learning [4] and multi-disciplinary teaming [5]. These programs suggest and reinforce the notion that contextual learning is an effective and important tool. This paper will discuss a contextual learning environment that has been evolving in the college of engineering at TTU. This project, called merging Early Intervention and Mechanical Engineering (EIME), has evolved as a partnership between a state early intervention group and the department of Mechanical Engineering that pairs engineering student teams with education and medical professionals to develop specific technology needs for children with disabilities. This project fits well within the roles of service learning and multi-disciplinary project activity for our students. Like most service-learning projects, the EIME project is based on a close collaboration of multiple partners, each with specific motivations and expectations from the project. Success and sustainability of this program depends on meeting partner's expectations. Thus, the paper will identify the major stakeholders participating in this program and will define the primary objectives of each stakeholders. Historical evidence and assessment data of how the EIME program is meeting the objectives will be provided. The paper will conclude with lessons learned and recommendations for future implementation of this project.

2. Overview of the EIME project at TTU

The mission of the Early Intervention and Mechanical Engineering (EIME) project is to significantly enhance the services provided to children with special needs in the region surrounding Tennessee Technological University (Upper Cumberland region) while simultaneously providing an environment for engineering student to work in multi-disciplinary teams to develop unique assistive technology. These enhanced services are provided through a mutually beneficial collaboration between early intervention and engineering at Tennessee Tech. The project leverages the significant engineering potential in our engineering students and the benefits of collaboration with the college of education and TEIS (Tennessee Early Intervention System), all located on the University. Through this collaboration, a number of innovative and creative assistive/adaptive projects (examples provided herein) have been undertaken to improve self-determination, independence, and quality of life for many young children with special needs and their families. Approximately 150 infants or toddlers with special needs have benefited directly from the work done through EIME. Further, for many of the children benefiting from the EIME effort, their transition to preschool classrooms in public education settings has been enhanced. Beyond the direct benefits to these children, their families, and the professionals serving them through the Upper Cumberland District TEIS office, the EIME program has had a spread of effect statewide to other TEIS district offices where similar needs for helping children with various disabilities function more independently and successfully in play, mobility and daily living skills are found. This has been accomplished though meetings and networking with other district TEIS offices located on university campuses around the State.

Project needs are gathered throughout the year from numerous sources, but predominantly from early intervention service coordinators and professionals working with children with special needs. The projects are reviewed by the program investigators (Stephen Canfield, ME, Ken Hunter, Basic Engineering and Dean Richey, C&I) and topic-appropriate projects are presented to students early each semester in engineering classes with design content that could be enhanced with real-world challenges. The projects then may become a design problem for a team of students in the class. Once involved in a project, the students collaborate with professionals in medical, therapy, education, and other fields and provide the engineering technical component to develop and deliver assistive technology to the child.

2.1 Project History and Current Status:

The program began in 1998 and has grown to the point where 20-30 technology development needs are met each year by the engineering students. Funding for the project has been sought from many sources, with the predominant funding coming from the state level and local support organizations.

2.2 Typical Project Outcomes:

Specific details about individual project outcomes are too numerous to mention, many significant needs are met by our students each semester. However, two typical projects are mentioned that capture the spirit of the project. One project completed last semester by four students in ME 4640, developed a mechanism to allow all children to play T-ball in an inclusive environment, even those with CP or in wheel chairs. The linkage-based mechanism was delivered to and is used on a regular basis by many children during T-ball season. Another project modified a piece of playground equipment to allow children with spina-bifida or other lower-body mobility issues equal access. This project redesigned two of the tricycles on the ride to be powered by the hands rather than feet. The modifications were so popular that all the children now want to take a turn on the new rides.

The program provides benefits to the children of the upper Cumberland region. It also benefits the engineering students through the opportunity to see how their career can make a significant impact on the lives of others, and how they can contribute in a significant way to society using their technical skills.

3. Description of process and stakeholders:

Figure 1 gives a general description of the EIME project and identifies the various project stakeholders. The process begins with a collection of assistive technology needs, and pairing those needs with student teams. It continues through design, development, testing and implementation processes. Along the way, various project partners (stakeholders) interact with the process. This section will briefly review each project phase and indicate how the various partners participate.

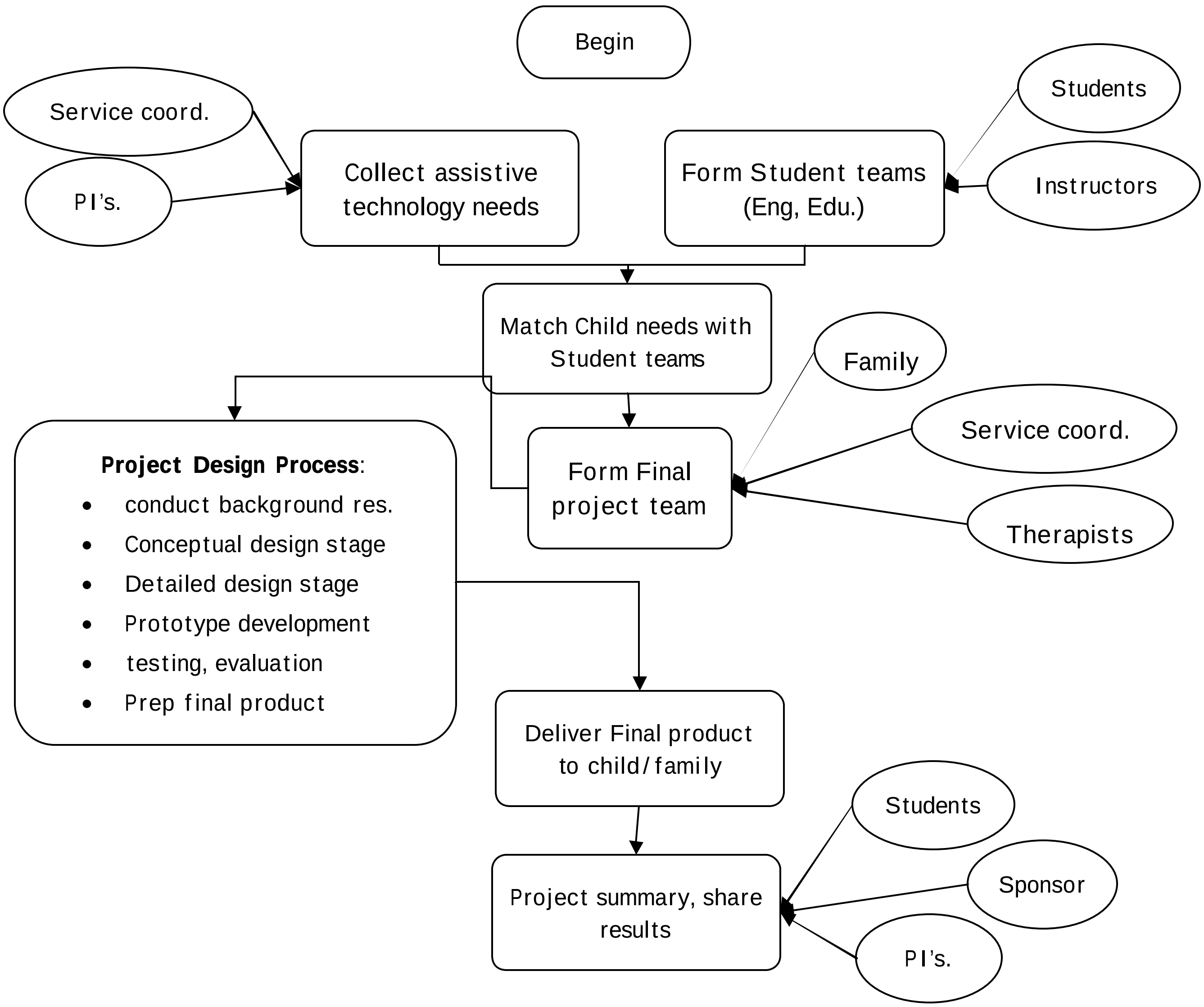

Figure 1: Overview of the EIME model

<u>3.1: Collect Assistive technology needs:</u> The project cycle begins first with collecting appropriate assistive technology needs (appropriate for the desired levels of student design projects). Our project has shown that this phase is most successful when an ongoing partnership is developed and maintained with professionals/organizations that work daily with children with special needs. For the EIME project at TTU, the three primary partnerships have been with the Tennessee Early Intervention System (TEIS),

the Children Special Services (CSS) organization and the special education department in the local school system. In the state of Tennessee, these programs have regional offices, often with close ties to the state Universities. The ongoing relationship with these organizations has been an important part of the success of this project.

<u>3.2: Form Student Teams:</u> Instructors in participating classes form student teams at the beginning of the semester. Both formal team assignments as well as self-selection for team groupings have been used. Team sizes are typically four students.

<u>3.3: Match Child needs with Student teams:</u> In general, teams choose their project from the list of possible assistive technology needs (3.1). This tends to personalize the project, increase team motivation in the project, and serve as an initial decision-making activity for the team. In this process, the instructor tends to mediate in the process to limit overlap of project efforts. Avoiding overlap enhances the project's ability to meet the needs of the funding stateholder, primarily the TN department of education, and maximizes limited resources attached to each project.

<u>3.4: Form final project team, initiate project:</u> This phase involves the greatest number of project stakeholders. The primary stakeholders hear are: the student teams, service coordinators, the child and his/her family, and medical/therapy professionals related to the project. These various members collectively form the Assistive technology (AT) team that will meet the child's need. While the student group performs the majority of the legwork on the project, all members of the team meet at least once. The project is initiated by a meeting with the student team with the family, the service coordinators, and medical professionals as appropriate. This meeting is generally organized by the service coordinators. As an outcome of the meeting, the AT team will provide problem definition and necessary data input for the engineering student teams to begin their design phase. This phase of the project is most critical; here students generally enter a role of calling on their engineering skills to provide a piece of technology that would improve the child's life.

<u>3.5: Design and development stage:</u> The project design and development is conducted over the course of the project duration (a significant portion of the semester). The primary active participants are the student team, with inputs as needed from the family, medical professionals or service coordinators. At the end of the design stage, the design is presented to the instructors and family for approval, and development, fabrication and testing begins. At this point, the project sponsor (State department of Ed.) is particularly notable since they provide a materials budget for each project. As an aside, typical projects work with a budget between $200 - $400. It is not uncommon for student teams to acquire contributions or donations from other sources, such as vendors or members of the community, typically in more than half the projects.

<u>3.6: Deliver the project to the family:</u> At the end of the project lifecycle, the student team delivers their project to the child and family. This meeting is often accompanied by a medical or therapy professional to provide final project adjustments and recommendations on use.

3.7: Project summary, sharing results: At the completion of the project phase, the results are shared with the project sponsor (TN Dept. of Education) and hosted the project website. The projects result first in delivery of specific technology for the individual child and family. This design is also made available on the project website, with the intent that another family with a similar need may make use of the design work conducted, and provide the fabrication and assembly skills needed to replicate the project.

4. Input and outcomes for EIME stakeholders

Four primary stakeholders are associated with the EIME project at TTU: Engineering Students, Early-childhood organizations, Families, State of TN. The project impact, expectations and outcomes for each stakeholder are considered in the following discussion.

4.1. Engineering students as stakeholders:
Engineering students provide the primary design and engineering input for design, development and delivery of the assistive-technology products. In return, the students satisfy course credits in design components of their curriculum. Further, they show positive or improved attitudes and performance in several areas considered to be indicators of student success in undergraduate engineering. These outcomes are discussed in more detail in section 5.

4.2. Early-childhood organization as stakeholders:
The Early-childhood organizations play two key roles in the EIME project. First, they serve as the primary source for collecting project ideas from the families. Second, they serve as the primary point of contact between the project team and families and generally provide one or more members to be part of the inter-disciplinary project design team.

The EIME project meets an important need for these organizations, in particular TEIS. Through the EIME project, TEIS is able to significantly enhance the existing IDEA Part C service delivery system to meet the national mandate for using technology to serve infants and toddlers with special needs and their families (ref.). For TEIS, this project provides a formal process of sustainable collaboration with university-level engineering education to serve as a resource to help meet the assistive technology needs of children with disabilities and their families.

4.3. Families in the middle Tennessee Region as stakeholders:
The families and children serve as the recipients of the developed technologies. They also serve as a key part of the project life-cycle. The student design teams meet with project teams two or more times over the course of the project. From these interactions, the children and families provide both project data and motivation to the student teams. Outcomes for the families are assistive technologies that are designed to work within their life-style in as normal manner as possible. As an added benefit, many of the children get to experience the engineering design process, and express interest in entering the STEM field at a later point to help others.

4.4. State of TN as a stakeholder:

The State of Tennessee has served as a vital team member since 2001, providing project funding through the department of special education. As a stakeholder, the State of Tennessee receives benefits at two levels. First, it provides a cost-effective means to meet some of the assistive-technology needs for developing children, particularly in more rural, underserved regions of the state (for example the Upper-Cumberland region were TTU is located). Second, several indicators show that the EIME program serves to improve student motivation, interest, retention and overall performance. This contributes to an improved engineering workforce available for the State.

Student Outcomes:

Approximately 100 students participated in the EIME project during the fall semester, 2008. These students fell into two groups, freshman engineering students and junior mechanical engineering students. Some basic statistics that characterize the out-of-class room activity are given as follows. On average, these students are employed 10 hours per week, and spend an additional 6 hours per week in non-academic, school related activities. Approximately 1.5 hours per week are spent in non-school related, volunteer activities. These students are predominantly traditional, full time engineering students taking between 12 and 17 course hours a semester.

A two-stage, service-learning survey instrument was used to provide a measure of the impact on student learning and attitudes, as perceived by the students. This survey instrument was developed by the service learning office at TTU for general use with undergraduate students at TTU. A summary of the response to selected survey questions are shown in figure 1 below, with the selected questions provided in table 1.

Table I: Selected questions from Service-learning survey (ME 3610)

#	Question
1	I learn more when courses contain hands-on activities
2	Courses in school make me think about real-world situations in new ways.
3	When I am put in charge of a project, I sometimes wonder whether I can succeed at it.
4	I learn course content best when connections to real-world situations are made.
5	The community participation that I did through this course helped me to see how the subject matter I learned can be used in everyday life.
6	The work I accomplished in the course has made me more marketable in my chosen profession.
7	The work I preformed helped me learn how to plan and complete a project.
8	Participating in the community helped me to enhance my leadership skills.
9	The work I preformed in the community enhanced my ability to communicate my ideas in a real-world context.

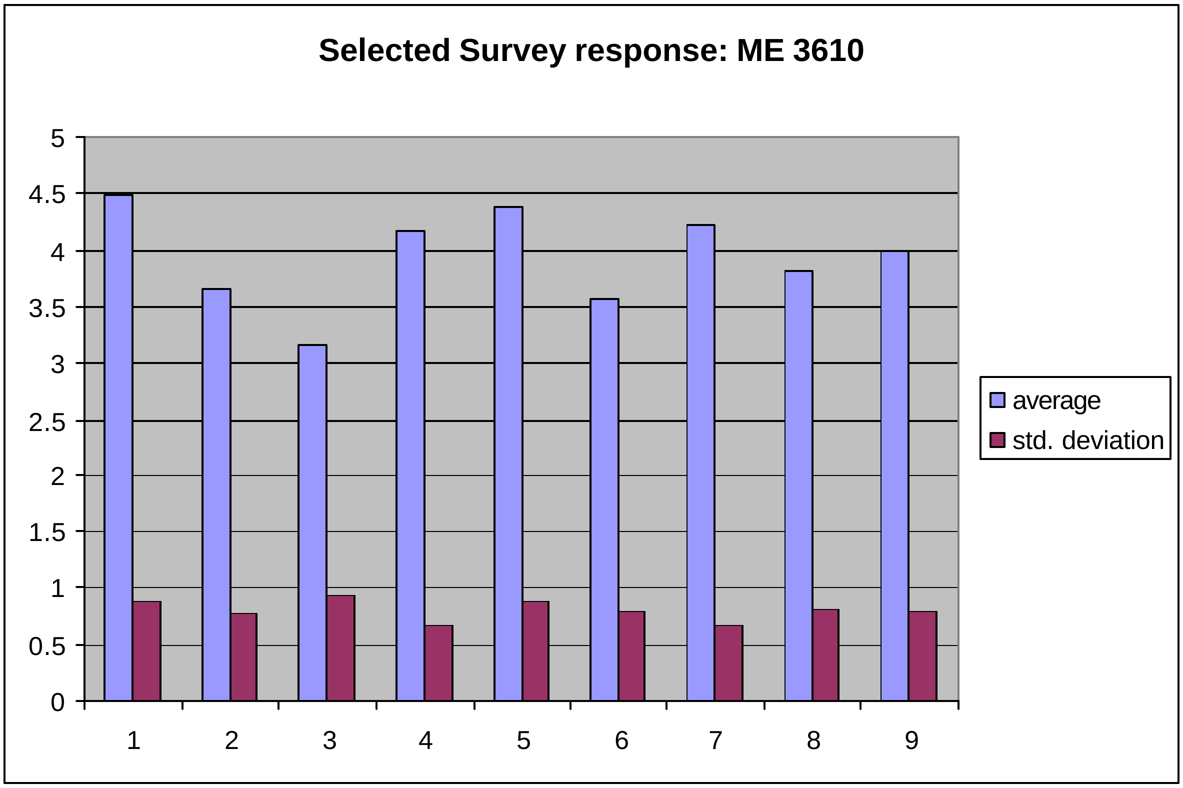

Figure 1: Student response (1 = strongly disagree, 5 = strongly agree)

The Survey response shows several interesting trends. First, the TTU students seem to bring a desire and interest to service-learning type activities. The students in general feel like they have a reasonable knowledge of future job expectations, and feel well prepared for their future career. Questions 6-9 indicate that students gain a sense of improvement in several key skills in the engineering profession, often skills that are more difficult to obtain in a traditional lecture session.

Results and Conclusions:

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