Early Intervention and Mechanical Engineering: Balancing Stakeholder Expectations in an Engineering Education Environment

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Abstract – The mission of the Early Intervention and Mechanical Engineering (EIME) project is to provide real-world design experiences for undergraduate engineering students while simultaneously enhancing adaptive and assistive technology services provided to children with special needs in the Upper Cumberland region surrounding Tennessee Technological University. These enhanced services are provided through a mutually beneficial collaboration between early intervention programs and the College of Engineering at Tennessee Tech. As part of their curriculum, engineering students engage in team projects to design, develop, test, and deliver new and novel applications of adaptive and assistive technology to facilitate transitioning of children from early intervention programs to preschool programs and inclusive environments. This paper describes the EIME model that has been used at Tennessee Tech 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 the project depends on meeting partners' expectations. The paper identifies the major stakeholders and defines the primary objectives of each. Historical evidence and assessment data of how the EIME project is meeting its objectives are provided.

Keywords: design, EIME

Introduction

There has been a significant effort in engineering education programs to enhance students' learning experience through a focus on the context in which learning takes place [McKeachie, 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 [McGraw, 2], service learning activities [Oakes, 3], problem-based learning [Duch, 4] and multi-disciplinary teaming [Mourtos, 5]. These approaches suggest and reinforce the idea 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 Tennessee Tech. The Early Intervention and Mechanical Engineering (EIME) project is a partnership between early intervention programs and the College of Engineering that pairs engineering student teams with education and medical professionals to develop adaptive and assistive technology for children with disabilities. This project fits well within the roles of service learning and multi-disciplinary project activity for the 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 partners' expectations. This paper describes the EIME model, identifies the major stakeholders participating, and defines the primary objectives of each stakeholder. Historical evidence and assessment data of

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how the EIME project is meeting the objectives are also provided. The paper concludes with lessons learned and recommendations for future implementation of the project.

Overview of the EIME Project

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 Upper Cumberland region surrounding Tennessee Technological University while simultaneously providing an environment for engineering students to work in multi-disciplinary teams to develop unique adaptive and assistive technology. These enhanced services are provided through a mutually beneficial collaboration between early intervention programs and the College of Engineering at Tennessee Tech. The project leverages the significant engineering capabilities and potential in the engineering students and the benefits of collaboration with the College of Education and the Tennessee Early Intervention System (TEIS), all located on the University campus. Through this collaboration, a number of innovative and creative assistive/adaptive technology projects have been undertaken, resulting in improved self-determination, independence, and quality of life for many young children with special needs and their families.

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 Department of Education. Local support organizations have also contributed. To date, approximately 150 infants and toddlers with special needs have benefitted directly from the work done through EIME. The project has helped children with a variety of disabilities to function more independently and successfully in play, mobility and daily living. 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 spread across the State to other TEIS district offices where similar needs exist. 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 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 adaptive and/or assistive technology to the child.

Specific details about individual projects and outcomes are too numerous to mention in this brief paper. However, two typical projects that capture the spirit of EIME are included here. One project, by four students in ME 4640 – Dynamics of Machinery II, developed a batting mechanism to allow all children to play T-ball in an inclusive environment, even those with cerebral palsy or in wheel chairs. The linkage-based mechanism, shown in Figure 1, is used on a regular basis by many children during T-ball season. Another project from the same course, shown in Figure 2, 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.

For the past two years, freshmen students in an introductory engineering course have participated in the EIME project. Projects for these students have been carefully chosen, as both the capabilities of the freshmen students and the fabrication resources available to them are limiting factors. During the fall semester of 2008, several projects related to the design and fabrication of custom eating utensils were available. These projects were assigned to teams of four to five students. Resource persons from the TEIS Office provided instructional presentations concerning the various disabilities associated with the children, as well as suggestions on how to best communicate with the children and their parents. It was determined that all of the prototype utensils could be fabricated using rapid prototyping and liquid plastic molding techniques, so students were provided instruction in these technologies. It should be noted that the use of common fabrication methods for all design teams saved considerable time and money. These projects provided an educational environment in which all aspects of the design process could be readily experienced by the freshmen students and the results were very positive.

The EIME program obviously provides benefits to the children and families of the Upper Cumberland region. It also benefits the engineering students, not only by providing them with a real-world design opportunity, but also by providing an opportunity to see how their career can make a significant impact on the lives of others and how they can use their technical skills to contribute to society in a significant way.

Figure 1: Example Project – T-Ball Batting Mechanism

Figure 2: Example Project – Hand-Powered Playground Ride

Description of EIME Model and Stakeholders

Figure 3 provides a general description of the EIME model and identifies the various project stakeholders. The process begins with a collection of adaptive and assistive technology needs, and pairing of those needs with student teams. It continues through design, development, testing and implementation phases. 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.

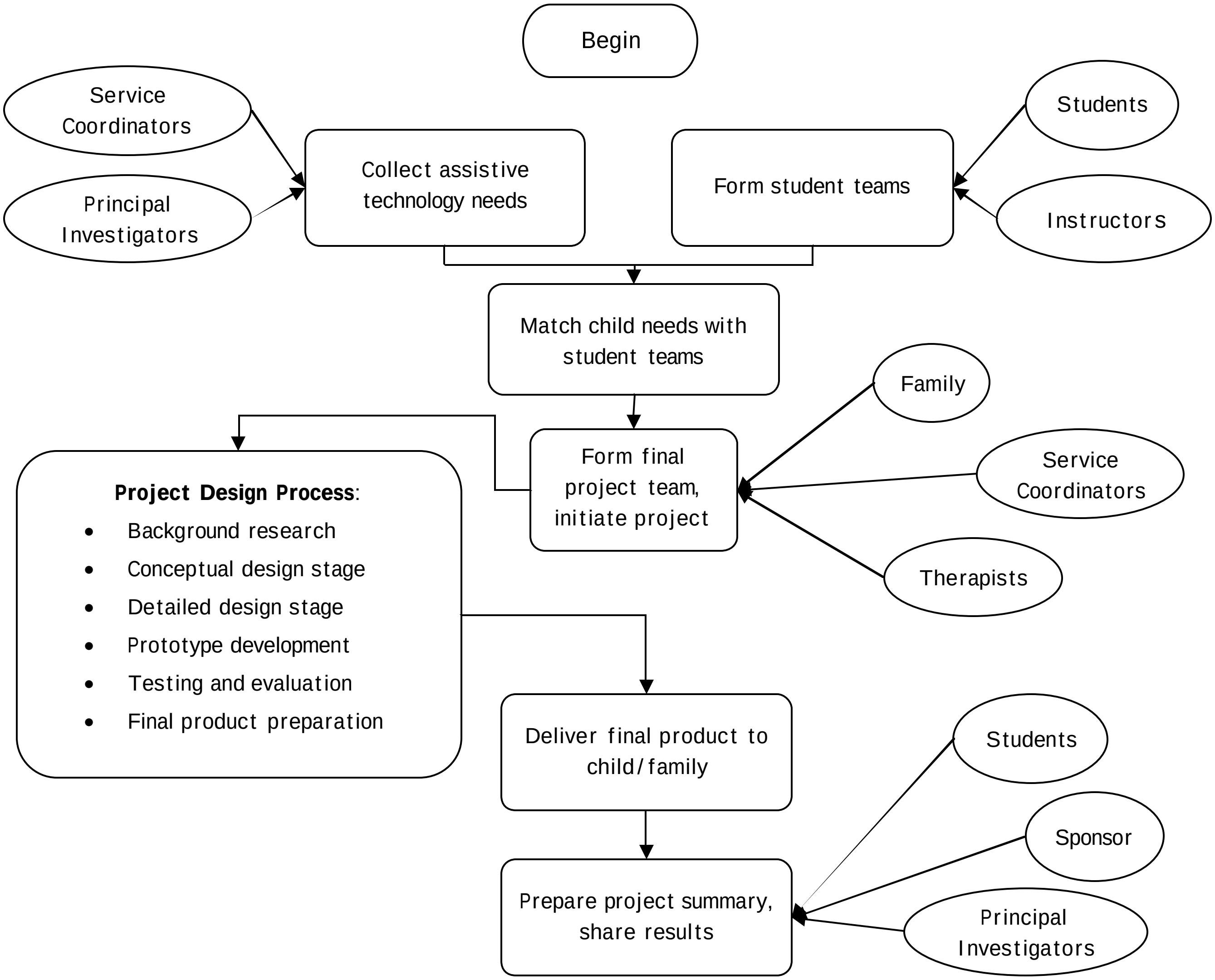

Figure 3: Outline of the EIME Model

Collect assistive technology needs.

The project cycle begins with collecting appropriate adaptive and 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 Tennessee Tech, 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 factor in the success of this project.

Form student teams.

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 to five students.

Match child needs with student teams.

In general, teams choose their project from the list of possible assistive technology needs. 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 stakeholder, primarily the Tennessee Department of Education, and maximizes the use of the limited resources attached to each project.

Form final project team, initiate project.

This phase involves the greatest number of project stakeholders. The primary stakeholders here 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 between the student team, the family, the service coordinators, and medical/therapy 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.

Design and develop the product.

Design and development activities are 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/therapy professionals, or service coordinators. At the end of the design stage, the design is presented to the instructors and family for approval. Following approval, development, fabrication and testing begins. At this point, the project sponsor (Tennessee Department of Education) is particularly notable since they provide a materials budget for each project. Typical projects work with a budget of $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. This typically occurs in more than half the projects.

Deliver final product to child/family.

At the end of the project design cycle, 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.

Prepare project summary, share results.

At the completion of the project phase, the results are shared with the project sponsor (Tennessee Department of Education) and placed on the project website. The projects result first in delivery of specific technology for the individual child and family. Then, the 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. Information regarding the fabrication and assembly skills needed to replicate the project is provided.

Expectations and Outcomes for EIME Stakeholders

Four primary stakeholders are associated with the EIME project at Tennessee Tech: engineering students, early-childhood intervention organizations, the Tennessee Department of Education, and the families served by the project. The project impact, expectations and outcomes for each stakeholder are considered in the following discussion.

Engineering students as stakeholders

Engineering students provide the primary engineering effort for design, development and delivery of the adaptive/assistive technology products. In return, the students satisfy course requirements in design components of their curriculum. Further, they tend to gain 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 the next section.

Early-childhood intervention organizations as stakeholders

The early-childhood intervention 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, particularly TEIS. Through the EIME project, TEIS is able to significantly enhance the existing service delivery system to meet the national mandate for using technology to serve infants and toddlers with special needs and their families. For TEIS, this project provides a formal process of sustainable collaboration with a university-level engineering program to serve as a resource to help meet the assistive technology needs of children with disabilities and their families.

State of Tennessee as a stakeholder

The Tennessee Department of Education has served as a vital team member since 2001, providing project funding through the Department of Special Education. As a stakeholder, the State receives benefits at two levels. First, the EIME project provides a cost-effective means to meet some of the adaptive and assistive technology needs for children with disabilities, particularly in more rural, underserved regions of the State, such as the Upper Cumberland. 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.

Families in the Upper Cumberland 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 lifecycle. The student design teams meet with project AT 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 adaptive and assistive technologies that are designed to work within their lifestyle 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 engineering field at a later point to help others.

Student Outcomes

Approximately 100 students participated in the EIME project during the fall semester of 2008. These students fell into two groups, freshman engineering students and junior mechanical engineering students. These students are predominantly traditional, full time engineering students taking between 12 and 17 credit hours a semester. On average, these students are employed ten hours per week and spend an additional six hours per week in non-academic, school related activities. Approximately 1.5 hours per week are spent in non-school related, volunteer activities.

A two-stage, service-learning survey instrument was used to assess the impact of the EIME project experience on student learning and attitudes, as perceived by the students. This survey instrument was developed by the service learning office at Tennessee Tech for general use with undergraduate students. A summary of the responses to selected survey questions are shown in Figure 4 below, with the selected questions provided in Table 1.

Table 1: 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.

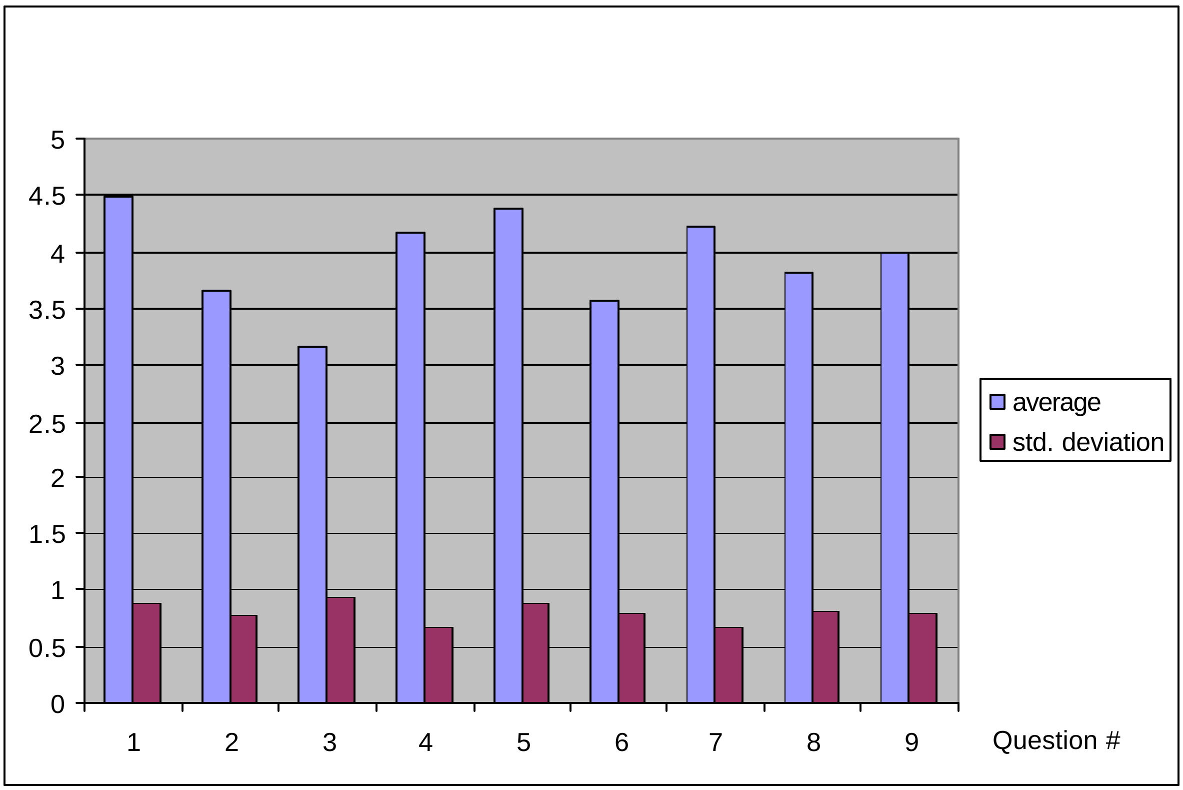

Figure 4: Student Responses to Service-Learning Survey (ME 3610)
(Scale: 1=strongly disagree, 2-disagree, 3=neutral, 4=agree, 5=strongly agree)

The survey responses show several interesting trends. First, the Tennessee Tech 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 thru 9 indicate that students gain a sense of improvement in several key skills in the engineering profession, skills that are often more difficult to obtain froma traditional lecture session.

Conclusions

The EIME project has proven to be an excellent vehicle for providing real-world design experiences for undergraduate engineering students, while simultaneously enhancing adaptive and assistive technology services provided to children with special needs. The success of the project is due to the collaborative partnership that has developed between the Tennessee Tech College of Engineering and early-childhood intervention organizations located on the campus. Careful consideration of the expectations of all project stakeholders has contributed to the sustainability of the project. All stakeholders contribute and all stakeholders benefit. Students provide the engineering effort required to complete the projects. They receive real-world design experience, meet course requirements, and gain valuable insights and skills related to the engineering profession. Early-intervention organizations provide the projects and coordinate meetings with the families served by the project. They benefit from the additional resources that can be used to address the adaptive and assistive technology needs of their client children and families. The children and families served by the project provide the engineering students with a very real and personal design experience by serving as the clients. In return, the needs of children with disabilities are addressed. And finally, the State of Tennessee provides financial resources for the project. In return, the State receives enhanced services for its citizens with special needs and an enhanced education for its future engineers.

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