

## **2006-2392: THE INFINITY PROJECT: ON THE DESIGN AND IMPLEMENTATION OF A HIGH SCHOOL ENGINEERING CURRICULUM**

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# The Infinity Project: On the Design and Implementation of a High School Engineering Curriculum

## 1. Introduction

The Infinity Project is a joint effort between university educators, high school teachers, administrators, and industrial leaders to establish an engineering curriculum that is taught within the regular high school day. The curriculum teaches students about the design of technology-driven systems and motivates them to learn fundamental concepts of mathematics, science, and engineering. The curriculum consists of (1) a course text, (2) integrated laboratory exercises with real-time signal processing hardware, (3) summer teacher training institutes, and (4) a web community portal for information sharing ([www.infinity-project.org](http://www.infinity-project.org)). Started in 1999, the Infinity Project is in over 150 high schools across twenty-five states and is garnering some interest in other countries across the world as an innovative educational intervention to promote and increase awareness of engineering and technology education in young people today.

While careful assessment and tracking of pre-college student populations on a large scale is challenging – see the comments in Section 4 of this paper – the Infinity Project attracts both students and teachers towards the study and education of pre-college and college engineering. In a small population study taken during the second year of the program’s implementation, 65% of all students who completed the Infinity Project pre-college curriculum plan to pursue engineering in college. Only about 2% of all students who graduate from high school are interested in pursuing such degrees<sup>1</sup>. Teachers who complete a one-week-long training seminar designed to prepare them for teaching the year-long course have also given positive comments towards the program – some of these comments include “Best training I have ever seen” and “My state needs this curriculum now.” Additional details regarding the structure and outcomes of the Infinity Project can be found in several papers<sup>2-7</sup>.

The implementation of a high school engineering curriculum that is taught by teachers with limited exposure to engineering curricula and concepts represents a particular system design challenge. In this paper, some of the knowledge that has been learned in establishing such curricular activities in varied educational environments is shared. In particular, the following topics are discussed:

- The role of and importance of partnerships with engineering and educational technology providers,
- The curriculum design process and its relationship to technology development,
- Issues related to curriculum design that affect teacher professional development and training, and
- The process of community building for widespread adoption of an educational intervention at the high school level.

In each case, the focus is to provide information on best practices that would be useful to anyone who seeks to implement a new educational intervention widely at the pre-college level.

## 2. Development and Implementation of the Infinity Project Curriculum

The Infinity Project, an initiative developed as part of a non-profit organization at the non-profit academic host institution, was the brainchild of Prof. Geoffrey C. Orsak, faculty in Electrical Engineering at SMU in Dallas, Texas, and Torrence Robinson of Texas Instruments. Like many who worked in technology fields, Mr. Robinson observed the discrepancy between the technological boom occurring in the economic marketplace and the decline in numbers of engineering graduates being produced by U.S. engineering schools. He met with Prof. Orsak, known as an innovator of college engineering curricula and teaching methods, during a technical meeting, where the pair recognized that as in most physical systems, a “larger input leads to a larger output.” Thus, the creation of a pre-college engineering curriculum was planned.

With initial funding from Texas Instruments, Prof. Orsak built a curriculum design team that included authors from engineering programs in universities across the U.S., high school teachers from Texas, and civic/educational leaders and advisors. The initial outline and design of the curriculum elements occurred in face-to-face meetings held in 1999 and 2000 of this group. During those meetings, decisions on several issues were made: the curriculum structure, overall goals, level of mathematics and science to be taught and used, and technology issues related to curriculum instruction.

Several critical design and implementation choices led to a successful launch of the curriculum in high schools:

- 1) *High school teachers were given the opportunity to describe the constraints of the classroom teaching environment prior to most every curriculum and technology decision and were kept advised of and provided feedback on the curriculum throughout its development.* Obvious issues such as the typical high school teaching schedule and its relation to other school events such as assemblies and state testing requirements affected the development, as did non-obvious ones such as the number of available electrical outlets in a laboratory or classroom.
- 2) *Laboratory technology was chosen and developed based on a number of factors, including ease of teacher training, relevance to the chosen classroom subject material, and design flexibility.* The Hyperception Visual Application Builder design environment, part of the suite of graphical design and programming tools offered by National Instruments, gives both teachers and students the ability to simulate and implement complex signal processing systems without a significant training overhead – a critical issue for curriculum adoption and dissemination.
- 3) *Curriculum design was performed iteratively.* Three different versions of the Infinity Project text have been used by high schools: a spiral-bound text<sup>8</sup>, a softbound text<sup>9</sup>, and the current hardbound text<sup>10</sup>. In each case, feedback from the teachers and students using the materials helped in improving the quality of the text. Feedback on the laboratory technology, as obtained through telephone

conversations with and web-based discussion group postings from teachers, helped to identify common problems in the typical classroom environment.

- 4) *Methodologies for growing and scaling professional development and training processes for teachers were identified and pursued.* The model adopted – the designation of the most successful high school instructors as Infinity Project Master Instructors for the summertime teacher training institutes – is scalable to meet a fast adoption rate, and it can be easily expanded geographically.
- 5) *Technology partnerships were leveraged both for financial assistance and laboratory technology development.* Texas Instruments and Hyperception, Inc., have been regularly involved in the development of the curriculum, and the latter entity provided significant amounts of technical support for the Infinity Project in exchange for growth in its market opportunities and improvement of its products' interfaces.
- 6) *Ease of implementation and use has driven the packaging and delivery of the curriculum.* Although the Infinity Project materials are professionally-produced, the reasons for the effort to make the curriculum as professional as possible are not simply to gain adoptions. Rather, the most important issue is the robustness of the implementation, which is a by-product of having good business practices in place. One of the goals of the Infinity Project has been to provide a consistent educational experience in every classroom in which the course is taught, independent of other factors that might affect its delivery. This goal not only makes rollout easier; it also is well-received by potential funding sources such as government entities, corporations, and philanthropic organizations.
- 7) *Constant improvement of curricular offerings is performed.* Just like methods technology corporations use to drive growth in engineering product fields, the developers of the Infinity Project continue to work and innovate within the classroom to maintain the relevance and improve on the curriculum offerings. One of the ways in which these improvements are tested is through offering a one-semester introduction to engineering course at the college level within engineering schools. Today, over 30 different colleges and universities have adopted part or all of the Infinity Project curriculum as part of their first-year course offerings, and in several institutions, this adoption creates a base of engineering talent that can support engineering outreach programs to local high school students and teachers.

The above discussion points do not give details on the content of the course, testing and assessment, and ways to adopt the curriculum; for additional details on these ancillary issues, please see the Infinity Project website at <http://www.infinity-project.org>.

### 3. Identifying Best Practices in Pre-College Engineering Curriculum Implementation

Best practices are methods that lead to desired results, usually through experience, and

that have some measure of transferability to similar problems or contexts. Our past experiences with implementing the Infinity Project curriculum have helped us to identify several best practices that are potentially useful for anyone who is developing pre-college engineering curricula and whose main barrier to effectiveness is widespread adoption.

*Best Practice #1: Garner the interest of high-quality, committed pre-college teachers and instructors.* A pre-college curriculum must have in-classroom proponents at the high school level to be successful. Presentations at teacher conferences sponsored by the National Science Teachers Association, the National Council of Teachers of Mathematics, and Teachers Teaching with Technology –Worldwide, among others, are important to “get the word out” and obtain feedback on the curriculum itself. In addition, a web-based discussion board is highly recommended to give instructors an opportunity to share ideas and give feedback on the curriculum.

*Best Practice #2: Choose a technology platform for any laboratory components carefully, considering all issues relevant to the rollout of the curriculum.* Besides overall cost, other important factors in the choice of classroom technology include reliability, extensibility, the ease of teacher training, the support provided by the technology partner, and interface issues with existing classroom technologies such as computers and calculators.

*Best Practice #3: Develop and provide teacher training experiences for adopters.* Pre-college instructors are almost always required to teach multiple subjects, and the amount of time that each instructor has to prepare for these courses is quite limited. The Infinity Project uses week-long summertime professional development institutes taught at different college campuses across the country to train teachers to offer the Infinity Project course, and every teacher who offers the Infinity Project course completes one of these institutes before beginning instruction at her or his high school.

#### 4. Common Goals and On-Going Challenges in Pre-College Engineering Curriculum Implementation

What are some of the common challenges that developers of pre-college curricula face?

*Challenge #1: Developing sustainable practices.* An innovative educational initiative is relatively straightforward to offer once or twice in a few classrooms where the extent of the impact is limited, with significant involvement of the initiative’s creator(s) and developer(s) invested. To have truly lasting impact, however, one needs to develop educational initiatives that can be transferred from expert to novice, that have appropriate documentation procedures in place, and are economically viable for all partners involved.

*Challenge #2: Placing a curriculum in an environment that is over-prescribed in terms of content and resources.* Adding new educational content to a pre-college curriculum inevitably means that existing educational content must be removed or altered to make room. Moreover, students’ choices also drive course adoptions at some educational

levels (e.g. high school), and to be successful, engineering curricula must be attractive to and fit the overall educational and career goals of these students.

*Challenge #3: Getting political and social organizations to support pre-collegiate engineering initiatives.* Such support is not necessarily monetary. In fact, the political support provided by state Boards of Education and other educational associations can be critical to widespread adoption of an engineering curriculum. In the State of Texas, the Infinity Project was given course catalog numbers as both a math and a science elective – required by all high school courses offered in the state - less than one month after the required paperwork was requested by the Texas Education Association.

*Challenge #4: Assessment and tracking of pre-college student populations.* Because of privacy concerns, it is more challenging to determine and track the impact of educational innovations on pre-college student as compared to college students who can and do typically give consent to such studies. Sample-based studies are one strategy for obtaining such data.

## 5. Conclusions

This paper discusses implementation issues facing designers of pre-college engineering curricula in the context of one particular curricular innovation, the Infinity Project, a high school engineering course in over 160 high schools across the U.S. The focus of this paper is to provide information on best practices that would be useful to anyone who seeks to implement a new educational intervention widely at the pre-college level. Both best practices and challenges to implementation of such curricula are discussed.

## References

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