Ethnographic Research Based Education Model Development

Kushal Abhyankar and Subhashini Ganapathy

***Abstract*—Due to the decreasing number of engineering graduates, there is a strong need for the betterment of the education customs. A model-based education approach is extremely useful application with an opportunity of the technology integration. There is a need to understand the barriers that the students have in order to successfully complete the curriculum. This ethnographic research presents the foundation for a deep dive research into the pain points of the students in the engineering curriculum. This research also presents the human-technology integration points in the overall modular education system. The future research is to provide an Augmented reality based technology on small form factor devices to provide a scaffolding support in the education system.**

***Index Terms*—Ethnographic research, engineering education, education modeling, inductive teaching, scaffolding.**

I. Introduction

Modern educational techniques and technologies have been focused on modularizing the education system for effective knowledge acquisition and retention in the engineering students. The National Science Foundation (NSF) has reported a constant decrease in the engineering enrollment and an increasing number of engineering dropouts(http://www.nsf.gov/statistics/seind12/pdf/c02.pdf). The difficulties in the comprehension and retention of the knowledge in engineering education arise because of the abstract nature of the concepts in Science, Technology, Engineering and Mathematics (STEM) areas [1]. Due to this fact, there is a demand for betterment of the process of knowledge transfer and the development of effective educational programs, which offer a compelling experience for the overall knowledge construction process across the board. Due to the existing dormant knowledge transfer processes, the students graduating out of the universities show a constant degradation in the quality of the output at the industry level [2]. As the educational challenges are becoming prominent, the methods and techniques to tackle these challenges are also becoming more sophisticated. Though there are examples of technology assisted didactic practices, there are many issues which are unanswered [3]-[5].

Among the criteria for successful engineering programs (Criteria for Accrediting Engineering Programs, 2012 – 2013), the student needs to demonstrate not only an ability to apply knowledge of mathematics, science, and engineering, but also the need to effectively understand the impact of engineering solutions in a global, economic, environmental, and societal context and apply them in a multidisciplinary team. These needs are forcing the educators and the administrators rethink about the viability of the traditional teaching mechanisms employed in the engineering schools. These concerns also put a spotlight on understanding and aiding engineering students with wide learning curves and facilitate them with the technology that can help them go the next level both professionally and personally. In order to design the curriculum effectively it is important to understand the areas where technology integration can aid their learning process. There is currently a lack of research to identify these areas of difficulty or pain points in an undergraduate engineering program. This paper focuses on conducting ethnographic research to collect the data on the major pain-points across the different disciplines of science and mathematics courses taken by undergraduate students. The findings from this paper will also help to conduct a deep dive to get granular details of the roadblocks in the program. This research will identify integration points of technology that increase the effectiveness of information presentation in situations where it can support and enhance learning. Understanding and aiding courses with appropriate technology can help faster concept acquisition and longer retention.

A. Teaching Methods

There are different teaching methods that are currently practiced in academia. The main highlight of all these teaching styles is to challenge or drive the students in unfamiliar learning environments and allow them to struggle to build meaningful knowledge. Most of the engineering educators still employ the classic deductive method of knowledge transfer. There is a strong need for the educators understand the importance of inductive learning and application of the same in their curriculum designs [5]-[11]. In the deductive teaching practices, the fundamentals and the principles are taught to the students with the help of derivations and the theorem proofs. The learners then try to make the connections with the taught principles with the help of some of the examples demonstrated in the class by the instructors. The students are then given additional exercises to work on the problems based on the principles and the theorems taught in the classes in the form of homeworks, assignments, labs and projects. The students passively try to make connections with the theorems taught in the classes with the real world problems at the last stage of the knowledge transfer. If the students are unable to maintain the connection between the concept and the real world

Manuscript received October 20, 2012; revised December 12, 2012.

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application, the entire process goes around in the loop. The deductive teaching may better promote short term retention of factual information [7]-[13].

On the other hand, the inductive process of knowledge transfer on the other hand starts from a case or a real world problem or a challenge. Starting from a wide concept, the students start filtering the problem to the components of the problem by defining the concepts, problem statements in different learning environments. The students work on the problems or in the unfamiliar learning environments individually or with the help of their relative groups. Together, the students are engaged in addressing the questions in a collaborative or cooperative effort. At this stage, the instructors shift their teaching modes to the different teaching techniques and there is a vast scope for the application of the teaching models to come to the effect. Following is a highlight of different inductive teaching models which are commonly employed:

Inquiry Based Instruction (Inquiry based or challenge based learning): Teaching begins with an introduction of the problem or a challenge. The instructor provides the content guided to answer that problem. The instructors can provide with the content which is guided towards finding the solid answers or none.

Problem Based Learning: The focus is to address the problem that is authentic or open ended or not well defined. The students work in coordinated teams and the instructor support is minimal. Students are pushed to learn new concepts in problem based learning.

Project Based Learning (Abbreviated as PBL) and Hybrid (problem/project based learning): Students are assigned some kind of project or design to build. In the project based instruction, students are free to apply their previous knowledge to work on the projects.

Case-Based Learning: Students study case studies similar to the professional settings and involves the concepts and the methods instructor needs to teach. Students work out the problems involved in the case and compare with the real solutions or they analyze the case critically.

Discovery Learning: Students are exposed to the real world scenarios directly with minimal or no instructor support. They are observed in the process.

Just-In time teaching: This method uses the technology support and just before the class begins, the instructor allows the student to answer few questions and submit the answers electronically. The instructor responds in the same way and sends out the comments on the answers [9]-[15].

Many of the modern educators are dynamic in their teaching styles. Some of them are natural and some of them are trained on the deliberate application of these styles into their curriculum to help the students understand the concepts better in an active way. They do employ several dynamic hybrid teaching styles in their courses. Though their percentage in the education domain is low, but the numbers are picking up. The professors who encourage active knowledge building among students are not only successful but they also show the quality output of the students from their classes. In an engineering education domain, there are evidences of detailed research on the application of collaborative and cooperative learning environments [7]-[23]. In the project or problem based learning environments, the instructor can assign the group with the project and the expected outcome. The instructor can provide the students with the peripheral information about the project and let the students actively participate in solving the problem. The struggling zone or the region of students actually working to build the knowledge and the instructor helping them to understand the concepts is called as the zone of proximal development (ZPD). In the ZPD, the students struggle to build the active knowledge and try to make some sense out of it. The students can use several self educating sources in this zone and this technique is called as scaffolding. Effective scaffolding can help students build an active knowledge around themselves and make some integral and constructive sense out of it [24]-[26].

Scaffolding is a technique which could be employed by providing the references to the active knowledge building sources. A solid technological support could be introduced for the students to get hands on convenience to the educational tech-tools. Our efforts are guided towards providing a model for human technology integration. Students who are active knowledge builders can serve as target customers for such technologies. Technology integration is one of the solutions the educators can provide for the creating compelling education experience for the students but it cannot be looked as the only scaffolding mechanism. All of the students need the classical instructor-classroom interactions with the additional tech support. With the students' approach towards the assisting technology, and the set of interactions it can support, the technology use becomes ideal for all the non-standard styles and patterns of teaching [20]-[31].

II. Methods

A. The Ethnographic Research

The ethnographic research began with informal and documented 1:1 interviews and web polls. The interviews and the polls are guided to understand the major pain points of the students in the undergraduate engineering education program. These interviews are designed and guided to understand some of the most difficult topics in engineering undergraduate program especially in the areas of Science, Technology, Engineering and Mathematics (STEM). The research was carried out on the random sample of 37 students with mixed genders and races.

The entire ethnographic research was split into two phases. The first phase was to carry out a high level survey of courses to form a classification of log of pain points. The second phase is to carry out the future research which is to incorporate the findings from phase I into an intensive deep dive research into these pain points to get the granular details of the pain points. The description and the significance of these phases are described below:

Phase 1: The purpose of phase 1 was focused on collecting the high level list of the pain points and guide the system development. We interviewed 37 individuals from a population of engineering students. The interviewees were selected from a random mixed pool of genders, races, ethnicities and with diverse engineering majors. The interviews were guided specifically to understand their overall difficulties in the engineering undergraduate education. Fig. 1 shows the results of the survey which displays the overall result as a list of several pain points highlighted by the students.

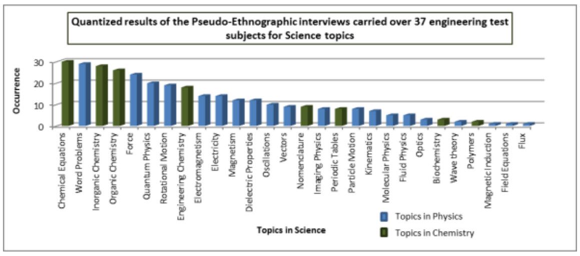

Fig. 1. Phase 1: Primary pseudo-ethnographic research to collect the pain points in the science education domain

These students were also given the open ended questionnaires and they were asked to comment generously on different topics encountered in engineering. Almost all of the students reported calculus as one of the most difficult subjects in Mathematics. As the level of calculus got advanced, students faced a colossal amount of roadblocks. The origin of these roadblocks was due to the weaker concept base from the basic calculus class. Eventually, the 85% of the students have lost their interest till they reached calculus III from calculus I. Due to the same fact, the students' struggle continued in Differential equations and matrix algebra subjects. In the science streams, similar trends are seen due to which learning of the advanced subjects in Physics, Chemistry and Biology becomes tasteless and eventually hard to grasp.

Phase 2: This phase mostly consists of the data collection through web polls and surveys. The survey question format is as shown in Table I. With this survey template, the subjects commented generously on the difficult topics they learnt in their undergraduate engineering education and the specifics of the topics learnt. The students also commented on the methodology they were trying to learn the subjects and what could have been helpful for them to learn those concepts. These surveys were distributed as campus emails in the form of a Microsoft Word document. This survey asked a deep dive questions about some of the specific reasons. The questions were guided to understand why students were disinterested in learning the subject; what could have been provided to them as a learning assistance; how learning styles could have been altered to generate the interest etc. The surveys collected were quantified as shown in the Fig. 2, 3, 4. The visual representation and the overall data, we can target the specifics of the STEM subjects to provide the assisting technological support.

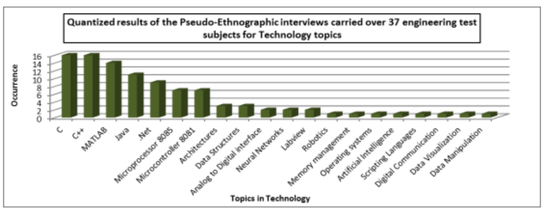

Fig. 2. Phase 1: Primary pseudo-ethnographic research to collect the pain points in the technology education domain

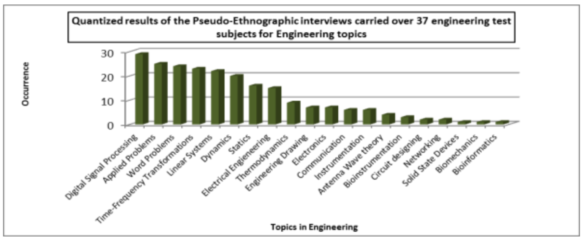

Fig. 3. Phase 1: Primary Pseudo-ethnographic research to collect the pain points in the engineering education domain

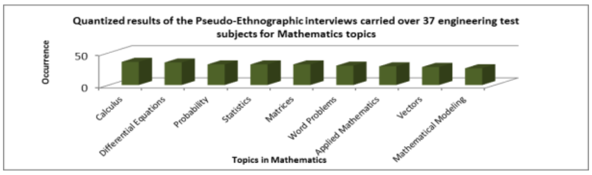

Fig. 4. Phase 1: Primary Pseudo-ethnographic research to collect the pain points in the mathematics education domain

III. Conclusion

We focused our ethnographic research to STEM areas to maintain a high level log of pain points. From the charts, it is evident that in science, the most difficult topics are the real world problems, chemical equations, force concepts. For technology subjects, students have reported serious concerns on learning programming languages. Digital signal processing, Linear systems, mechanics were the most difficult topics for the students to learn; and in mathematics, almost every one of the test subject reported their strong concern on calculus and differential equations. Apart from these difficult topics, most of the students reported that the real world application problems of the learnt concepts were the most difficult to conquer. We can conclude from this ethnographic research that there is a need to change the didactic practices which can be tailored around the real world problems. With the log of the pain points, we can focus on carrying out granular research over the high level data. Our future research includes the development of an Augmented Reality based technology over small form factor devices, with which we will be able to provide scaffolding assistance to the students. With the help of this technology, we propose that without disorienting the students from the classroom interactions we will be able to add a new dimension in the existing classroom-instructor interactions that occur around the students. With the help of this ethnographic research, we have generated the integration points for the students and the technology.

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