Examining Students' Graphic Representations of the Undergraduate Research Experience: Toward Developing a Framework for the Design and Evaluation of Student Experience[1]

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Abstract

The current paper examines the process, the intended and unanticipated outcomes of the undergraduate research experience as represented in graphic form by students who have participated in an intensive and extensive introduction to the process of research, mentoring, and teamwork. This paper examines BEST PRACTICE in light of students' experience by focusing on the ideal research experience in relation to the actual research experience. Based on the analysis a framework is developed for the design and evaluation of research experiences. The challenges of socializing students into a research community and developing culturally responsive evaluations when the diversity of students is increased are addressed.

I. Introduction

Increasing the number of students in engineering and science have become growing concerns for engineering and science programs across the nation. There is a strong movement in science and engineering education to include all undergraduate students in research. Participation in an undergraduate research experience in science, engineering and mathematics holds the promise of increasing student interest in pursuing graduate degrees and research careers in these fields.

According to an advisory committee to the National Science Foundation, an undergraduate research experience provides students with the opportunity to attain high levels of competence and confidence in the their field of interest. Students develop an understanding of the methods and process of research and learn to make informed judgments about technical and scientific matters and develop a strong set of skills to communicate and work in teams to solve complex problems[1]. In addition, students are provided an opportunity to interact with faculty and graduate students who socialize them into a research community. Interaction with a faculty member can provide a student with the desire and motivation to persist toward graduation and consider graduate school as a viable option after graduation. As the undergraduate research experience is expanded to include all students and funds from private and public institutions increase to support such an effort, the need to evaluate and assess the effectiveness and impact of these programs also grows[2].

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No one design, method or instrument can adequately address all outcomes and processes, therefore this paper provides one framework for developing a plan to systematically examine programs designed to provide research experiences to undergraduate students[3]. Although this paper only touches briefly on clarifying program goals and developing a program logic map, these steps are essential in the design of an evaluation plan. The evaluation plan is designed with the "ideal program and implementation" in mind and with an understanding of the context in which the program is implemented and its stage of development. Dependent on the purpose or purposes of the evaluation, an evaluation or the systematic collection of information about an undergraduate research program should provide evidence to either (1) render judgment about the overall merit or worth of the undergraduate research experience project; (2) improve the ways in which students engage in the research experience; or (3) generate knowledge about the essential elements of an undergraduate research experience than enhances the effectiveness and impact of these types of experiences for undergraduates.

As undergraduate research experience programs proliferate to include all students, the need to design, monitor and evaluate these types of programs also grows. This paper provides an examination of students' graphic representations of the research experience as a strategy for developing a framework for the design and evaluation of undergraduate research programs. Rather than focusing exclusively on student outcomes, this paper examines students' representations of the research experience as process. Comparing Best Practice for undergraduate research experiences[4] as a description of the "ideal undergraduate research experience" to students' representations of their research experience will shed light on the development of a framework for evaluating and assessing these types of educational experiences. The issues guiding this analysis are these:

- Can evaluators and researchers use students' representations of the research experience as a way to discover critical or essential elements of the research experience?
- What is learned from an examination of students' representations of the research experience?
- Are these elements represented in Best Practice?
- Is this strategy useful in leading to culturally sensitive evaluations of undergraduate research experiences?

II. Evaluation

The field of evaluation distinguishes two major types of evaluation: formative evaluation and summative evaluation. Each type or function is conducted for specific and intended uses. Each can contribute to the knowledge base about the issue(s) being addressed by the program. One the one hand, formative evaluation is designed and implemented to support improvement of the program, and is normally commissioned, done by, and delivered to someone who can make improvements. The focus of the evaluation is on gather information about key aspects of the program, such as depicting the strengths and limitations of the program and intended and unanticipated processes and outcomes. On the other hand, summative evaluation is done for decision makers who need a judgment of value or worth. Both strive to contribute to an understanding of the project. With this in mind, the purpose of this paper is to examine students' portrayal their experiences as participants in an REU program and to assess if and how the

program impacted them. In order to accumulate sufficient evidence about the REU program, we developed and implemented an instrument and several activities that would lead us to come to a better understanding of students' perceptions of and experiences during their research experience.

Subjects and Method

Students who participated in the Research Experience for Undergraduates program (REU) for the spring and summer 2000 semester were the participants in this study. 50% of the subjects were males and 50% to be females (n= 52). Subjects' classification was reported to be 11.53% sophomores (n= 6), 32.70% juniors (n= 17) and 55.77% (n= 29) seniors.

The students were recruited in two meetings at the end of the respectively semesters to assess the process, the intended and the unanticipated outcomes on their research experience. Two activities were involved in the collection of data. These were the administration of the "MIE Research Experience for Undergraduate Questionnaire Spring and Summer 2000," respectively and the "Graphic representation of their experiences in research and the listing of how the research has helped them in making the process through graduation." Students were asked to complete the survey, think about and draw a representation of their research experience, and then to get into groups and develop a picture of the research experience that took into account all their graphic representations. In addition, students were asked to list the benefits and challenges of their participation. Feedback was provided to the REU program coordinator for improvement purposes.

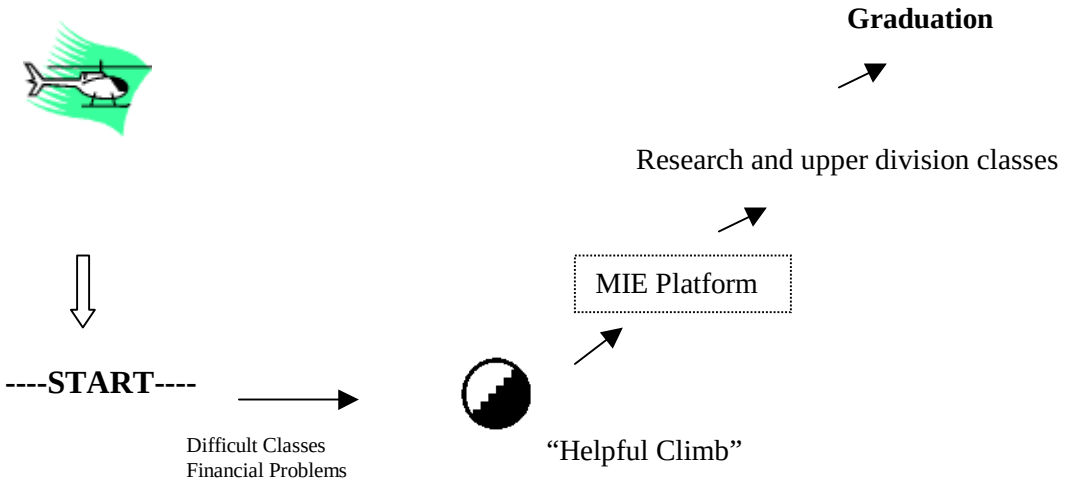
Results

This paper will report only on the analyses of the group representations of the research experience. Examination of the drawings reveal that the groups of students generally viewed the research experience as an experience that "saved them" from obstacles such as serious doubts about their ability to learn the material or difficult classes or financial problems. One group of Mexican National female engineering students viewed the research experience as a way to overcome language barriers, fear and loneliness. It is interesting to note that most of the students implicitly or explicitly referred to the "time before the research experience" as a "time filled will with obstacles, fear and a sense of floating." For most of these students participating in an undergraduate research experience was, as one group put it, "Nirvana."

Not all students represented the undergraduate research experience as a journey from "hell" to "nirvana." One group's representation viewed the undergraduate research as "work" that need to be balanced with school. Work needed to be scheduled. Work involved a mentor. It held the students' interest, that could be supported by supplies and held opportunities. Yet for this group of students work, the REU, was separate from school and had to be balanced with it.

One of the groups described the MIE research experience as the "helpful climb" to "research and upper division classes." (Illustration. 1) Students in this group represented their experience before the REU as a "drop" from a helicopter into difficult courses and financial problems. The REU provided the means to "climb above" the obstacles and make progress towards graduation.

Illustration #1:

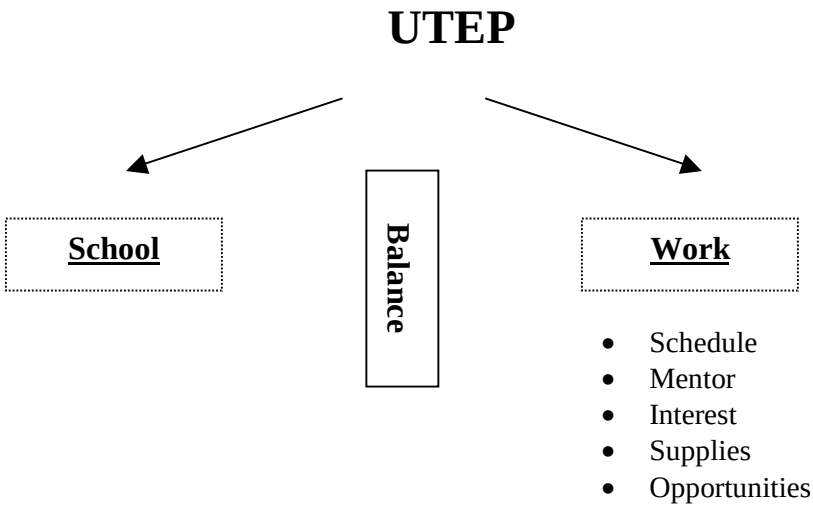


Another group represented the research experience as a time sequence bounded by summer fun and graduation. In-between these two points summer fun moved into orientation hell and a sense of fear and "floating" into hard classes and tough professors. Through student perseverance students "discovered the research experience that will lead to graduation.

Illustration #2

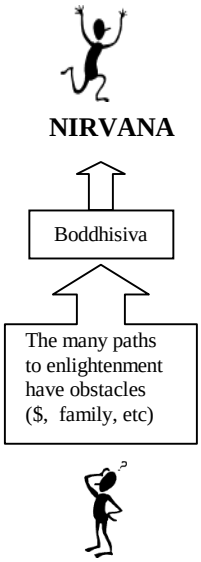
The third group, described their research as a "balance between school and work." In interviews with students continually mentioned that research was "work" and class assignments were "school. For these students, the research experience was "disconnected" from school. Their task was to learn how to balance them.

Illustration #3



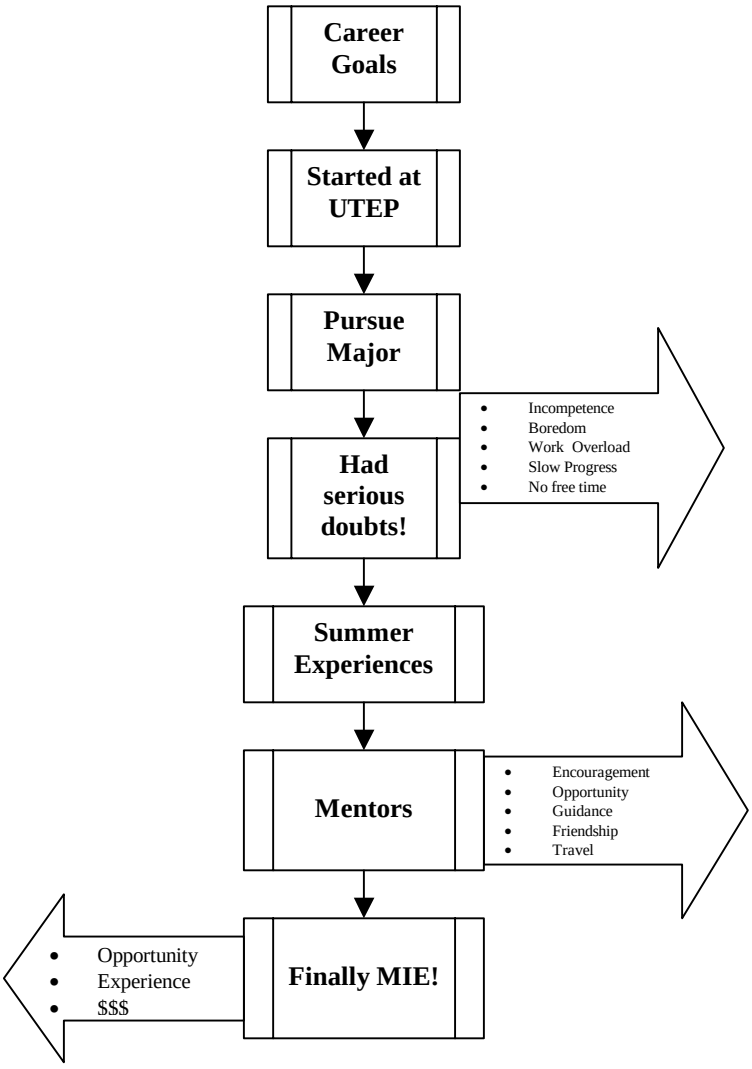
A fourth group described the undergraduate research experience as "Nirvana" – the cessation of all obstacles, such as finances and family. For this group, the research experience lead to enlightenment.

Illustration #4.



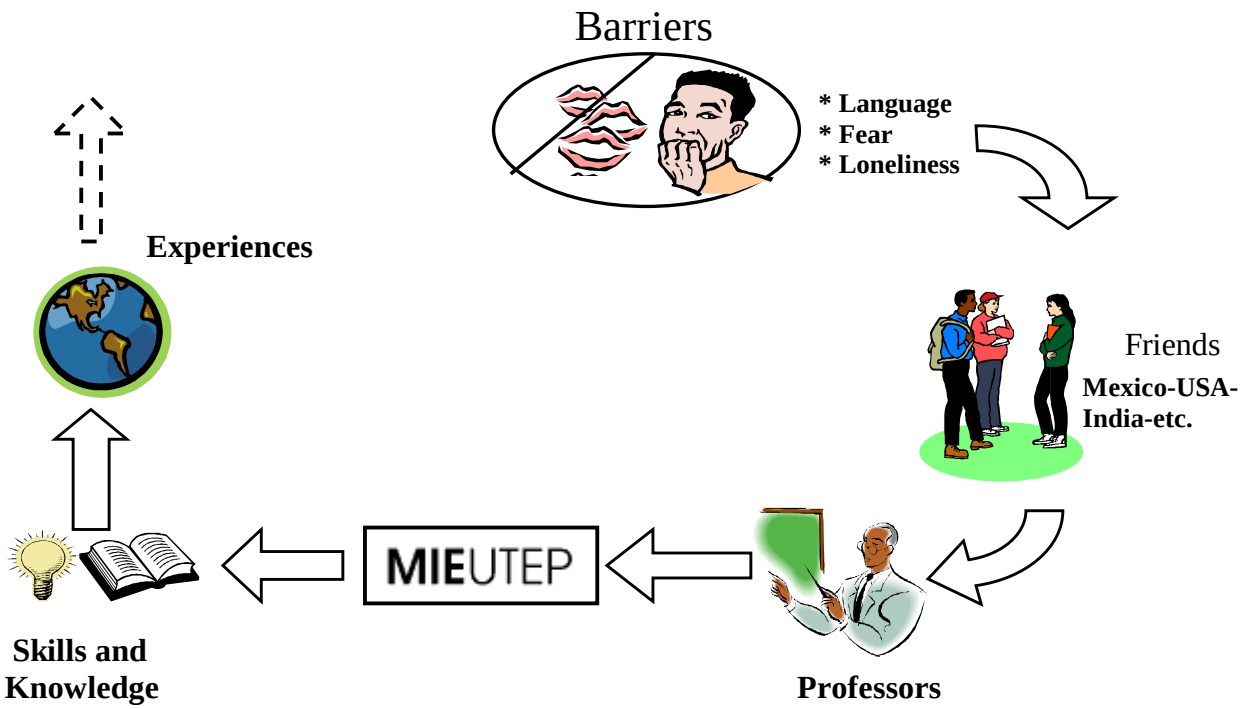
The fifth group described the research experience as a "gateway" to opportunities, experience and money. For these students the process leading up to the research experience was anchored by career goals but interrupted by serious doubts, such as incompetence, boredom, work overload, slow progress, and no free time. These students specifically mentioned their mentors who provided them with encouragement, opportunity, guidance, friendship and travel.

Illustration #5



For the students in the sixth group, the time before the research experience was a time of language barriers, fear and loneliness. Eventually they made friends and met professors who encouraged them to participate in an undergraduate research experience. The experience provided them with opportunities to gain knowledge and skills that will lead to more experiences and opportunities.

Illustration #6



In summary, what we find is that the research experience for students is seen as positive when represented in graphic form. When asked about their representations or in other interviews, students mention the frustrations and obstacles they face during a research experience. This suggests that the graphic representation of the research experience should be accompanied by interviews that probe students into explaining the intricacies of the research experience and its impact. The strength of the graphic representations is that it revealed that students did perceive, after the fact, that the time before the research experience was "tough" and that participation in an REU assisted in students attaining higher levels of competence and confidence in their knowledge and abilities.

The graphic representations of the research experience did not map well with BEST PRACTICE in ways that would illuminate essential characteristics of a research experience. What was clear from these representations is that for most of these students the undergraduate research experience was a positive experience. Only one group "hinted" at the struggles of balancing work (the research experience) with school. This disconnection points to an area of future study. In addition, the lack of fit with BEST PRACTICE leads us to explore better ways of framing the task and combining in-depth interviews with students so they can explain their group representations as well as their individual representation. Graphic representations provide an opportunity for developing culturally-sensitive evaluation of the undergraduate research experience. Students who reported language barriers were able to express the issue without "fear." It is the judgment of the authors that this method when linked to other methods can

provide insights into the place of the undergraduate research experience in students' journey to received their undergraduate degrees in science, engineering and mathematics.

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[1] Advisory Committee to the National Science Foundation, Directorate for Education and Human Resources, Melvin D. George (Chairman), *Shaping the Future: New Expectations for Undergraduate Education in Science, Mathematics, Engineering, and Technology,* May 1996.
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[3] Kubo Della-Piana, C. & Bernat, A., *Evaluating the Undergraduate Research Experience in Computer Science: Developing a Framework for Gathering Information about Effectiveness and Impact*¸ Frontiers in Education, Puerto Rico.
[4] Westat, Inc., (1996). *Profiling the Science and Engineering Research Semester: An Pproach to Fromative Evaluation,* Rockville, MD: Westat, Inc.

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