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The Role of Real-World Experience in a Web-Based Engineering Major Selection Model

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Abstract

Many students who enter a College of Engineering are uncertain of what their major should be or that the major they have selected is the right one for them. At Penn State, the College of Engineering has designed a web-based program to help students through the process of selecting an appropriate major from the ones offered by the College. The program is based on a decision-making model that requires students to identify their strengths and interests and match these with the interests and skills required of specific majors. Realistic and accurate information about the majors was therefore crucial to the construction of this model. Examples of job scenarios, typical days, required skills, and types of problems encountered were provided by practicing engineers and then used as building blocks in the development of the program. This paper will focus on the role that the information obtained from practicing engineers played in the development of the program.

I. Introduction

Instruments have been designed for students who are beginning the path of self-exploration and career choice to help them distinguish among broad categories of majors or careers. Instruments such as the Myers-Briggs Type Indicator, The Birkman Method**,** Campbell Interest and Skill Survey (CISS) ask students to answer questions about what they like to do, where they want to live, what is important to them, etc. These may be starting points, but the difficulty is that students that have selected to enroll in the College of Engineering have many similar skill sets and attributes. One of the most common reasons given by students for being in engineering is: "My high school guidance counselor said that I would be good in engineering because I was good in math and science". Such factors may separate the engineers from accountants, but they do not differentiate among the engineering majors.

Little information is available to help differentiate one type of engineer from another. Since different types of engineers share many of the same traits, it became necessary to create a discovery program that enabled students to explore different fields of engineering and find out more about themselves so that they could find a possible match. Since differentiating among the majors was a significant problem, many resources were used.

Prior to the development of the web-based model called *Engineering Destinations,* students followed a more traditional path in the selection of a major. This path began with students being directed to information and discussion meetings with faculty and current students in specific majors. Advisors made suggestions and expected students to act upon them. Other activities included encouragement to attend a career fair and an open house sponsored by the College of Engineering. This process of major selection depended on student initiative and ability to discuss personal issues with an advisor and/or with students in a major. One of the problems with this process was timing. Students were generally unable to schedule a meeting just when they wanted answers. Another problem was location. Faculty and students in a major are only available at one location, leaving about half the students without easy or direct access to traditional sources of information about majors.

The major decision-making process relies on the analysis of information about majors, knowledge of themselves, and the requirements of the majors. In the past, students needed to gather such information from several resources that may not have been located in the same building, or even on the same campus. This project brought together diverse and widespread resources required to make decisions into one interactive program that is available online, on demand.

II. Goals and Objectives

The goal of the project was to help students find an appropriate major in engineering. This was accomplished by helping them build individual mental models (internal mental picture) of what can be done in each of the different engineering fields and match the models to what they discover about themselves.

In developing the *Engineering Destinations* program as a decision support tool to assist students in the selection of one of twelve majors in the College of Engineering, input from practicing engineers and students in the major was used in the design. The objectives of the project were:

1. To create an interactive system to enhance the decision-making process of selecting a major in the College of Engineering. This system is to be used by students in the first and second years in conjunction with the services offered through the Engineering Advising Center (EAC).

2. To help develop life-long decision-making skills that will be applicable to making further career choices after graduation. This was accomplished by:
   - Creating a process of discovery for the students;
   - Showing a path of choices and results;
   - Generating a scenario simulation for students to follow and solve the problems of "what do I think I would like to do?" scenarios;
   - Developing a peer advisor section set as an “ask system” where students can ask students already in a major what they did when deciding on a major;
   - Allowing students to explore each major and what courses are required, what types of jobs are available, and how each major can lead to related jobs in other fields of engineering.

3. To create a method of communication for networking with alumni and other professionals in fields which interest the students, the following methods of communication were developed:

- A listserv to ask questions of faculty, alumni and career professionals about the choices they made;
- Discussion modules that will be part of an engineering course.

III. Program Development

a. Theoretical Foundations

Constructivist learning theory shaped the program's design. The program was conceptualized from the beginning as a learning environment in which students could build mental models of what the engineering majors were and how they differ from one another. The core content of that environment is the practical experience of engineers and engineering students. The manner in which that core was accessed and processed by the students was founded on the following principles of constructivist learning theory[1]:

1. The learning environment needs to provide a problem appropriate to the learner;
2. The learner needs to have ownership of the learning;
3. The environment should include a number of related cases to enable case-based reasoning and enhance cognitive flexibility;
4. The environment should provide learner-selectable information just-in-time;
5. Social/contextual support for the learning environment should be provided.

Each principle, as it relates to this program, is elaborated below:

1. The learning environment needs to provide a problem appropriate to the learner: this means providing a problem appropriate to the students' needs, a problem relevant to the student. According to constructivists, such a problem is ill structured, i.e. it has no easily definable correct answer, or may have many correct answers. Furthermore, the problem itself is not always clearly defined, or may be somewhat different for each student. To deal with such a problem, the learner needs to work through it to gain knowledge about the problem and subsequently, the solution. Choosing a major in engineering is a prototypical constructivist problem. Each student makes a decision based on any set of factors. These factors vary from parental advice to watching a space shuttle launch and dreaming of designing space vehicles to being good at math and science. The experience of the engineers and engineering students from whom we obtained our information provided a set of unique solutions to the problems, thus providing an array of equally viable "solutions" to the problem of choosing a major.

2. The learner needs to have ownership of the learning: if higher education is to produce true independent learners, students need to feel that they can choose what they learn and that it is their motivation which yields the learning. Any student with web access has the means to go through the *Engineering Destinations* program when they choose. Furthermore, the program promotes student ownership over decision making because what information the student gathers and the order in which they gather it is within their control. Students also are not given one final major, but complete several modules of discovery that results in two or three possible solutions. The final decision thus remains for the students to make, but the program has already allowed the students to make many decisions, so the students' comfort level with making decisions should improve upon completion of the program. This process reflects the real world when life

decisions need to be made without a mandate from a parent or a teacher. Working through the process allows students to practice making decisions on their own and adapting to the consequences.

3. The environment should include a number of related cases to enable case-based reasoning and enhance cognitive flexibility: classroom learning is often assessed through tests which look at how well students can apply what they have learned to new situations. Similarly, when examining information on a major, students need to be able to look beyond the information given to what the major could be and to the opportunities to which it could lead. The *Engineering Destinations* program provides examples of real engineers with the same degree doing very different jobs. A pool of real-world job examples is presented to the students from which students choose those cases that interest them the most. A new array of cases, derived from their original choices, is then presented to them and they are asked to choose again. By seeing examples of job situations which are very different yet could stem from the same major, the students begin to develop the ability to see beyond a major description into the numerous possibilities offered by any one major.

4. The environment should provide learner-selectable information just-in-time: students can learn best when they are ready to learn. Advisors sometimes do not realize this when they tell students a myriad of facts in one session, i.e. information about prerequisites, entrance-to-major requirements, internships, and study abroad programs. The *Engineering Destinations* project puts diverse information at the students' fingertips in a just-in-time fashion. Since the students are not confined to a specific order of working through the components of the project, they can start with any section about which they are most curious or need the most information. If they are unsure about the course requirements for a particular major, they may explore a Majors Exploration section; if they want information to answer their most troubling questions, they can consult a Peer Advisor section. Should they want to know what types of jobs they could possibly get after graduation, they can consult the case-based stories of experts in the field.

5. Social/contextual support for the learning environment should be provided: if the learning environment exists in a vacuum, i.e. does not resonate with the rest of the students' environment, then the mental models forged in the constructivist way by the students' own making, will fade. Since the information contained within *Engineering Destinations* comes from practicing engineers and students in a major, it directly provides contextual support for the learning environment.

b. Information Gathering

To apply this theoretical context to the selection of a major, the input of practicing engineers, professionals and students already in a major was essential. These contributors had successfully chosen a major and/or have worked in a career after having made that choice, and were able to provide examples of how they chose their major, what they did after graduation, and how each of their jobs related to their major.

An on-line survey of students already in a major was conducted to discover what were the most difficult aspects of deciding on the major. Over 300 students responded to the survey.

Responses from students fell into 7 themes that were used to design a system based on instructional design theory to help students discover more about themselves and the College of Engineering. They were:

1. What would I like to do for the rest of my life?
2. I had no problem deciding, because I always knew what I wanted.
3. I was very worried about the workload; I wasn't sure I could do the work required.
4. I always knew I wanted to be an engineer but I did not know what the different kinds of engineers did.
5. I was worried about the job market after graduation and what would be the best major.
6. I did not have enough information about any major to help me decide.
7. I couldn't decide whether I wanted to give up all the free time and fun that my friends in other majors enjoyed, and I was unsure that I could really make the necessary commitment.

Practicing engineers were asked for the following information to discover how their choice of major impacted their careers after graduation:

- What are the primary entry-level positions after graduation which students in each major are most likely to get?
- How likely were you to change positions within the same field, or how likely were you to change into different fields of engineering?
- What types of problems did or do you solve in job(s)?

The responses from the practicing engineers to these questions were used to develop realistic job scenarios for the program. The responses from the students in a major were used to provide examples of actual decision making strategies related to majors. Both sets of experts provided examples of decision-making processes that could be used before and after graduation.

IV. Program

The *Engineering Destinations* program thus resulted from the use of information obtained from practitioners in support of constructivist learning theory. Based on the nature of the information obtained, the actual web-based program was organized into four areas.

One area is a problem solving component where the student selects the types of problems or environment in which they think they would be interested. This section provides a visual resource where students can click on the section of interest. Based on that choice, another group of visuals is presented and the student is asked to select again. The outcome of this second selection is the suggestion of two or three possible majors. The student is then advised to obtain more information about these majors by participating in the major discovery portion of the program. The major discovery section is the second area and is linked to the college's web site, in which all majors and their requirements are described. The third area is a quasi case-based method of exploring what it is that engineers do. This includes stories in the words of experts detailing what a usual day may be or a story about a unique problem that they solved. The fourth area is a system based on the input from current students. Students select questions that are relevant to them and then read the answers from students who have successfully selected a major.

V. Examples

The following scenarios were used in the section describing what it is that engineers do. Examples of the same engineering majors performing very different jobs are given to show how the program demonstrated to the students the many possibilities afforded by any one major.

Mechanical Engineer I:

> Engines in helicopters, boats, airplanes, and cars all make a LOT of noise. In fact, if these engines were left alone, the noise would overwhelm the people inside and the vibrations in some cases would shake the vehicle apart! I work in a research lab, one of the main goals of which is to come up with ways of reducing noise and vibration in mechanical devices. To do this, we set up computer simulations of noise and vibration and ways to control them, and then compare these simulations to experiments where we actually shake things up and make lots of noise! All of this involves a lot of mathematical and theoretical analysis, working with computers, principles of physics, brainstorming, and problem solving.

Mechanical Engineer II:

> Where I work, we take ideas for a new product presented to us by a client, make a prototype of the product, test it for problems, and work out the problems so that the product is ready to be made and used. The product, for example, could be a new type of torpedo, a new type of remote control underwater surveillance device, or a durable recording instrument able to withstand great depths and still take reading of temperature, pressure, and water composition. Much of this work involves running tests in a water tunnel - a huge mechanical device that forces a lot of water through a closed pipe system at VERY high speeds. My job can be as fast-paced as the water in the tunnel, because our clients tend to have short deadlines, and we often encounter all sorts of unexpected surprises during our tests of the idea. I am responsible for setting up a working plan for getting the idea up and running, and I must estimate how much this will cost. I also help to conduct the tests, analyze data from the tests, and watch for problems that occur along the way.

Civil Engineer I:

> Planes, trains, automobiles, and boats. These are all means of transportation. They all create traffic. They all can involve large amounts of people and potentially deadly situations. As a civil engineer I take transportation systems very seriously. I am especially interested in safety and capacity (i.e. how many people a mass transportation system can safely handle). I work mainly on commercial design projects involving the construction of transportation systems. In this position I get to travel to the transportation site and test the new system. I work with mechanical and electrical engineers and also with structural engineers. My most fun project was working on a minirail transportation system at a world fair.

Civil Engineer II:

> I work in the Dam and Flood Control Section as an engineer. My duties include hydrologic and hydraulic (H&H) analysis for various projects. As part of the H&H analysis, field investigations, meetings with clients and development of reports are required. I primarily work in our headquarters office on H&H assignments from analysis of bridge scour, bridge hydraulics, spillway analysis, dam failure and flooding evaluation, intake and outlet works for dams. In addition to the analysis, I also do several dam inspections every year. I have done some travel to our other offices and to site locations but in general the travel is very limited. I interact with other civil engineers including geotechnical engineers and structural engineers and occasionally mechanical and electrical engineers.

VI. Conclusion

Working with experts provided many advantages to our project and set it apart from other advising systems. Credibility was a main feature of the project since each of the stories used came directly from real-life situations, as told by the people who lived them. This partnership with practicing engineers provided the program with a "real world" context. Experts provide a connection between course-work and applications. The stories provided by the experts and the link to the majors that they had selected as undergraduates helped to validate student choices in engineering. By carefully integrating the various sources of information in one program, one resource became available to students to answer questions about major selection. In addition, working with information provided by practitioners provided realistic structure for the application of learning theory.

Bibliography

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