Work-in-Progress: An Evaluation of a First Year Chemical Engineering Module on Students' Curiosity & Connectivity

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Abstract

This project is a work in progress. This project will focus on a Chemical Engineering module of Introduction to Engineering. In the Chemical & Biomolecular Engineering Dept., two sections of the course have been offered previously. The style of the course has been predominately lecture-based. In this project, the intervention course was redesigned to include predominately hands-on activities that connect to chemical engineering concepts, i.e. conservation of mass and surface tension, and chemical engineering jobs. These activities were designed to engage students' curiosity and connection to what chemical engineers do in the real world.

In this study, approximately 70 students took the intervention section of this course, which predominately consisted of hands-on activities and connections to real-world chemical engineering careers. The control section, which was predominately lecture-based, had approximately 90 students. Students in both sections were asked to take pre- and post-surveys that measured their curiosity. In addition, students in the intervention course participated in homework assignments that asked them to connect chemical engineering to the real world. Analysis of the students' assignments will show to what level students were able to connect chemical engineering concepts to industry and job markets based on the new hands-on activity style of the course. We will also investigate if the different sections, gender, and established majors prior to the course influenced students' curiosity and connectivity.

Introduction

The introductory to chemical engineering module is a part of Vanderbilt's first year experience. Students in the school of engineering get the opportunity to explore three different majors through these introductory modules [1]. The modules are 4.5 weeks long. Modules meet three times a week for 50 minutes. Engineering departments usually offer 2 to 3 sections of this introductory module focusing on a specific interest for the major. There have been 13 introductory modules offered previously. The main goal of the modules is to showcase to students, what they will learn and give students enough information about the major so they can decide what major to study. At Vanderbilt undergraduate students are not required to take departmental courses until the start of the second year. Chemical engineering historically has offered only 2 sections of this introductory module. The chemical engineering sections have been predominately lecture only. Focus areas that have been taught are computational, materials, and biomaterials.

Vanderbilt University is a partner of KEEN, the Kern Entrepreneurial Engineering network. The focus of KEEN is to introduce undergraduate students to the "entrepreneurial mindset." This mindset can be summarized by three words curiosity, connections, and creating value – the three C's [2]. KEEN has an increasing collection of exemplar work that showcases the three C's

implementation in the undergraduate program [3]. In this work we will look at how to assess the three C's of students in this course redevelopment.

For this research project a new chemical engineering introductory module was created to give students experience in design and research thinking through hands-on activities linked to chemical engineering concepts. The course consisted of 5 hands-on activities related to a chemical engineering concept students will learn later on in their academic career. Students were asked to conduct the experiment in groups of about 4, collect the data, and make some observational conclusions. After each activity, a discussion session was held to uncover how the experiment was linked to the chemical engineering concept, industry, and job market. Through this model we hope to ignite students curiosity, ability to connect chemical engineering to the real world, and an example of how to create value. For more information and descriptions about the specific course activities see Vernon et al. [4].

Hypothesis - We hope that through the implementation of hands-on activities we will increase students mindset in the three C's as compared to a control group. The assessment includes curiosity scale pre & post survey and three reflection assignments.

Methods

Participants - This research project was approved by Vanderbilt's IRB # 191344. Participants in this research were broken into two major groups, intervention and control. The intervention group are students who enrolled in the new introductory chemical engineering module. The control group are students who enrolled in the historical model of the chemical engineering section. Table 1 below, summarizes the number of students in the control and intervention groups.

Table 1. Enrollment data for Control and Intervention Modules

	Control		Intervention	
	No. of Students Enrolled	No. of Students who Agreed to Participate in Pre & Post	No. of Students Enrolled	No. of Students who Agreed to Participate in Pre & Post
Module 1	29	26	22	17
Module 2	29	23	21	17
Module 3	33	13	34	23
Totals	**91**	**62 (68%)**	**77**	**57 (74%)**

We clustered participants who agreed to be a part of the research project by gender and students' intended major. Overall gender distribution was similar for the both the control and intervention groups, see table 2 below. Overall the students intending to major in chemical engineering for both the control and intervention were similar. The control had higher intended biomedical majors than intervention. Whereas the intervention had higher "other majors", defined here as not biomedical or chemical engineering. This was done due to the tendency of students switching from biomedical to chemical and vice versa.

Table 2. Student's Gender and Intended Major

	Control % (No.)				Intervention % (No.)			
Module	**1**	**2**	**3**	**Subtotal**	**1**	**2**	**3**	**Subtotal**
Male	65% (17)	39% (9)	31% (4)	48% (30)	47% (8)	53% (9)	70% (16)	58% (33)
Female	35% (9)	61% (14)	69% (9)	52% (32)	53% (9)	47% (8)	30% (7)	42% (24)
Major								
Chemical Engineering (CHE)	48% (12)	0% (0)	46% (6)	29% (18)	41% (7)	12% (2)	30% (7)	28% (16)
Biomedical Engineering (BME)	28% (7)	78% (18)	39% (5)	48% (30)	24% (4)	41% (7)	13% (3)	25% (14)
Other (Computer Science, Computer Engineering, Mechanical Engineering, Civil Engineering)	24% (6)	22% (5)	15% (2)	21% (13)	35% (6)	47% (8)	56% (13)	47% (27)

Survey – The same survey questions (see Appendix 1 for actual survey questions) were administered to both intervention and control groups electronically through the SurveyMonkey platform. The survey contained Kashdan et al validated five dimensional curiosity scale [5]. The five dimensional scale with names and descriptions can be found in table 3 below.

Table 3. Description Five Dimensional Curiosity Scale

Factor Name	Factor Description	No. of Questions
Joyous Exploration	Openness to new experiences; level of tendency to learn; ability to gain positive emotions when learning new things	5
Deprivation Sensitivity	The level of persistence to learn to close one's information gaps through problem solving, knowledge acquisition and analytical thinking.	5
Stressed Tolerance	The ability to resist stress from being exposed to new information, knowledge and environment.	5

Social Curiosity	Level of tendency to learn about what other people's thinking and doing.	5
Thrill Seeking	Level of willingness to take risks to learn, explore or experience.	5

Students were asked to choose the most suitable answers from "Does not describes me at all", "Barely describes me", "Somewhat describes me", "Neutral", "Generally describes me", "Mostly describes me" and "Completely describes me" (Scale of 1 to 7).

Pre and post surveys were administered at the beginning and the end of the modules, respectively. Only students who gave consents in the survey and completed both the pre- and post-survey were included in the data analysis. The overall compliance percent were 75% and 68% for the intervention and control groups respectively. Factors like failure to complete post-survey and unwillingness to give consents contributed to low compliance rate.

Data Analysis - After collecting all the survey responses from both intervention and control groups, several steps were followed:

1 - Data cleaning and matching. Only those students that took both the pre and post surveys were included.

2 – Responses coding. Answers to curiosity questions were coded into numeric responses. Reverse coding was conducted separated.

3 - Excel and STATA were used to analyze data. Averages of each factor were calculated. Excel data was imported to STATA. A reliability test was conducted using command "alpha vars1 vars3 vars3" on all 25 questions. Reliability coefficient surpassed 0.7 in all modules. Summary statistics were tabulated, including mean, standard deviation, standard error, maximum value, minimum value and number of values on the scores of the five dimensions.

Independent group t tests assuming unequal variances were conducted on the five dimensions by both intervention and gender. One-way ANOVA tests were conducted to test significance levels within and between three major groups, "Chemical", "Biomedical" and "Others". Tables of statistic output were transported from STATA to excel.

Preliminary Results

The data show from the first iteration of the course the data shows that there was no statistical difference between the control and intervention groups for four out of the five curiosity scale factors, see figure 1. Figure 1 below, shows pre and post average scores for the five curiosity dimensional factors. The control and intervention groups all started at similar levels for all of the five curiosity factors. The only significance differences that were observed were for the intervention group for the stress tolerance and social security factor.

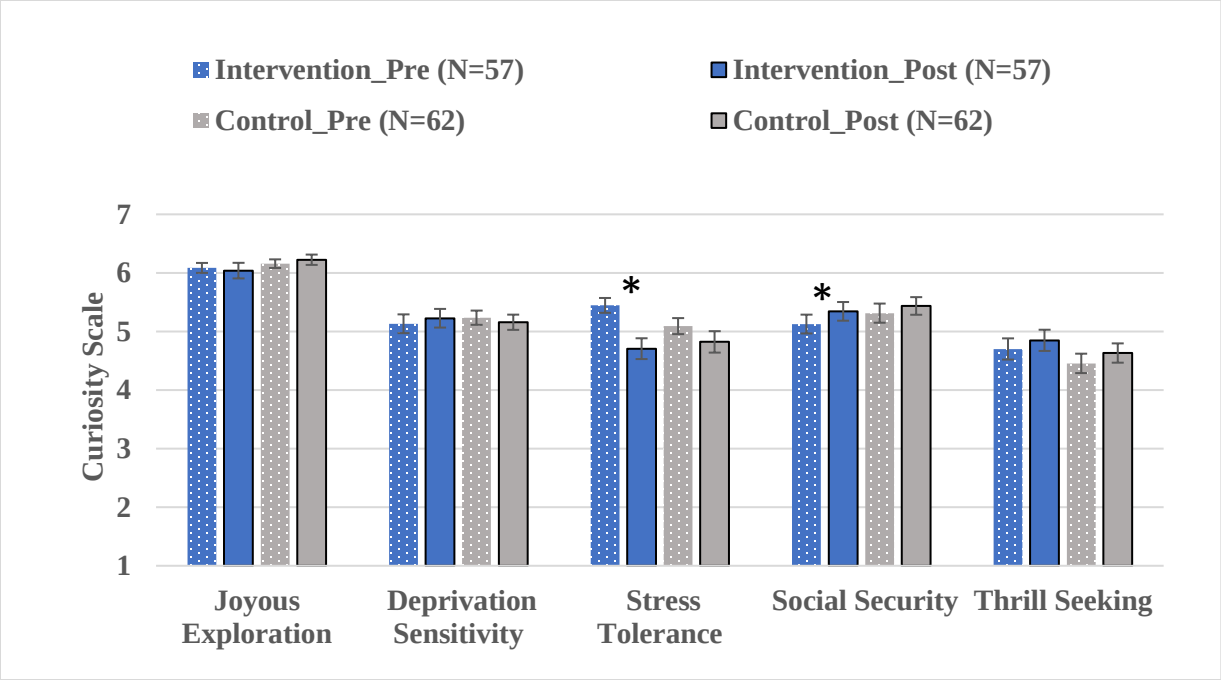

Figure 1. Average student's score with standard error bars, for the five dimensional curiosity scale for intervention and curiosity groups. *Stress tolerance and social security factors for intervention were significantly different between pre to post, p-value <0.01 and <0.09, respectively.

Figure 2 shows the breakdown of the groups by gender. Males in the intervention group had a significant increase from pre to post in three out of the five factors, joyous exploration (p-value = 0.06), social security (p-value = 0.03), and thrill seeking (p-value = 0.02). In addition the male intervention group had a significant decrease in the stress tolerance factor (p-value < 0.001). Males in the control group only had a significant increase in one of the five factors, thrill seeking (p-value = 0.04). The female intervention had a significant decrease in one out of the five factors, stress tolerance (p-value = 0.007).

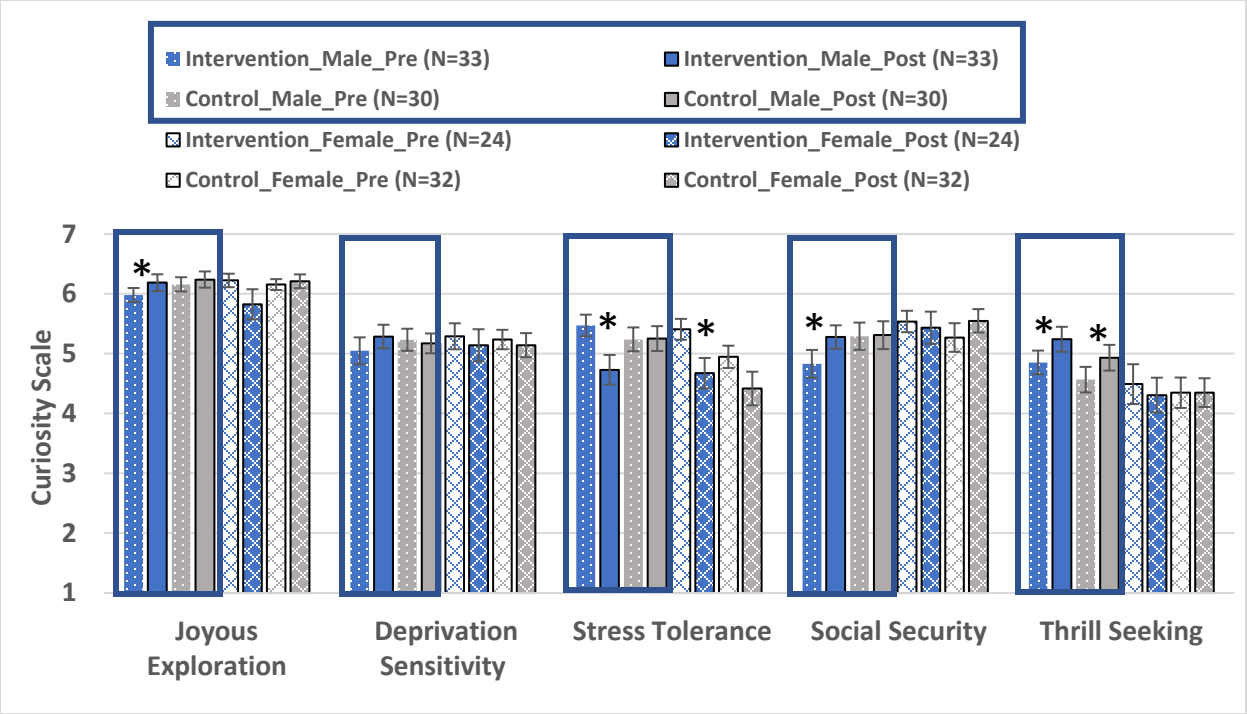

Figure 2. Average student's score with standard error bars for the five dimensional curiosity scale by gender for the intervention and control groups. * Denotes significant difference.

From the preliminary results seen in figures 1 and 2, we are predict that further analysis of the data will show interesting data trends to help others trying to do similar work in the first year programs.

Future work

The next steps for this project are to dig deeper into the data and correlate with similar studies found in the literature. Some questions we will investigate:

- Do the factors differ based on the module? Is average factor dependent on when the module is taught?
- Grouping participants based on intended majors to see if there are any differences in responses?
- Analyze and code homework assignments for connection and curiosity.
- Correlate participants' homework with the five curiosity factors.

We also hope in the second iteration of the course to increase the sample size of the data set.

References

1. Mahadevan-Jansen, A., & Rowe, C. (2004, June), *Module Based Freshman Engineering Course Development* Paper presented at 2004 Annual Conference, Salt Lake City, Utah. https://peer.asee.org/13180
2. KEEN, https://engineeringunleashed.com/mindset-matters.aspx [accessed 1/20/2020]

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4. Vernon, J., Rogers, M., Saba, B., Huang, Y. (2020, June), *Work-in-Progress: Fostering a Chemical Engineering Mindset through Hands-On Activities*, submitted 2020 Annual Conference, Montreal, Canada.
5. Kashdan, T.B., Stiksma, M.C., Disabato, D., McKnight, P.E., Bekier, J., Kaji, J., & Lazarus, R. (2018). The five-dimensional curiosity scale: Capturing the bandwidth of curiosity and identifying four unique subgroups of curious people. Journal of Research in Personality

Appendix 1 – Survey Questions [5]

I will view challenging situations as an opportunity to grow and learn.
I am always looking for experiences that challenge how I think about myself and the world.
I seek out situations where it is likely that I will have to think in depth about something.
I enjoy learning about subjects that are unfamiliar to me.
I find it fascinating to learn new information.
Thinking about solutions to difficult conceptual problems can keep me awake at night.
I can spend hours on a single problem because I just can't rest without knowing the answer.
I feel frustrated if I can't figure out the solution to a problem, so I work even harder to solve it.
I work relentlessly at problems that I feel must be solved.
It frustrates me not having all the information I need.
The smallest doubt can stop me from seeking out new experiences.
I cannot handle the stress that comes from entering uncertain situations.
I find it hard to explore new places when I lack confidence in my abilities.
I cannot function well if I am unsure whether a new experience is safe.
It is difficult to concentrate when there is a possibility that I will be taken by surprise.
I like to learn about the habits of others.
I like finding out why people behave the way they do.
When other people are having a conversation, I like to find out what it's about.
When around other people, I like listening to their conversation.
When people quarrel, I like to know what's going on.
The anxiety of doing something new makes me feel excited and alive.
Risk-taking is exciting to me.
When I have free time, I want to do things that are a little scary.
Creating an adventure as I go is much more appealing than a planned adventure.
I prefer friends who are excitingly unpredictable.