DEVELOPMENT AND IMPLEMENTATION OF A CORNERSTONE COURSE: ENGINEERING OPPORTUNITES

Dr. Kyle G. Gipson, James Madison University

Dr. Kyle Gipson is an Assistant Professor at James Madison University (United States) in the Department of Engineering (Madison Engineering) and the Center for Materials Science. He has taught courses pertaining to topics for first-year engineering, materials science and engineering, engineering design, systems thinking and engineering leadership. He has a PhD in Polymer, Fiber Science from Clemson University. His research background is in the synthesis of polymer nanocomposites and engineering education. He was trained as a Manufacturing Process Specialist within the textile industry, which was part of an eleven-year career that spanned textile manufacturing to product development.

Dr. Justin J Henriques
Mr. Sancho Sequeira

Work in progress: Development and Implementation of a Cornerstone Course: Engineering Opportunities

Abstract

In response to the vision presented in the Engineer of 2020 Project, many engineering educators are redesigning courses and curriculum to provide students with opportunities to conceive, design, and implement engineering solutions to complex global issues.

This paper describes the development and assessment of a redesigned first year cornerstone course called Engineering Opportunities. The motivation for the course redesign was to both be a pathway into the engineering community and to equip students for success in both the classroom and the engineering profession. The course is built on a learner-centered platform that is intended to create an inclusive environment for first year students to successfully transition from high school to college. The course content covers human-centered design, systems thinking, professionalism and ethics. The intention of this approach is to provide a high-impact educational experience within the first year for engineering students so that they can engage in opportunities to become acclimated with the process of self-guided deep learning.

Background

The undergraduate, non-discipline specific ABET accredited engineering program is the sole engineering program at the James Madison University. The Department of Engineering (Madison Engineering - MadE) was designed to develop engineering versatilists in line with the description provided from the Engineer of 2020 by the National Academy of Engineering: one who possesses strong analytical skills, strong communication skills, a strong sense of professionalism, creativity, and versatility[1,2]. The curriculum combines a liberal arts general education core with courses in math, science, engineering design, engineering science, engineering management, systems analysis, and sustainability to instruct, train and guide the engineering versatilist.

ENGR 101: Engineering First Year Student Seminar was the entry point into the program and the curriculum. The course was a one credit hour survey course that was offered in the fall semester where the whole first year cohort met once a week for fifty minutes.

While there were multiple iterations of the course were offered between 2008 and 2011, the general intent of the course was to give an overview of the engineering curriculum and to contextualize the engineering profession. The course was last offered in the fall of the academic year of 2011-2012. Without the ENGR 101 course, students only have one engineering course in their first-year.

Engineering Opportunities Course Overview

This paper represents the redesign and relaunch of ENGR 101 as the Engineering Opportunities course with a focus on the structure and assessment of the course.

Learning Materials

The course content focuses on:

1) *Human Centered Design & Design Thinking* - a problem solving approach that enables students to tackle design challenges in teams.
2) *Systems Thinking* - Helping students understand the world as interconnected systems.
3) *Professionalism and Ethics* - Helping students understand the role of the engineer in our department and our profession.

Learning Communities

To facilitate the creation community, the class is divided into “families” of approximately ten to thirteen first year students per family. Each of these teams is led by a pair of peer-mentors (students in the Madison Engineering Leadership Program).

Learning Activities

Students are instructed to share and document their process, sources of inspiration, and prototypes through sending tweets to the class Twitter account. The use of Twitter helps us:

1) Create community within and across the department
2) Encourage students to think about their professional online persona
3) Monitor the activity of the class in real time when teams are working in different locations

The following are a few of the learning project based activities and methods for assessing learning: group design challenges, presentations, reading quizzes, canvas discussion, and small group discussions. Teams complete place-based design challenges throughout the course. These include a:

1) 1st day design challenge of everyday objects
2) Local design challenge
3) International design competition using the online platform

Assessments

Below are the guiding statements that were utilized to establish the assessment approach:

a) Understanding the first year student’s attitudes and perceptions in transitioning from high school to college and into the engineering community.
b) Understanding the efficacy of a high impact intervention within the redesign of this cornerstone course for the purpose of aiding students in their academic careers and enhancing student learning.

Engineering Opportunities Course Structure

The structure of the Engineering Opportunities course draws inspiration from the model of seminars, colloquium, and tutorials. Like a seminar, during class students often prepare and present their original work for discussion and critique. In the style of a colloquium, the instructors often assign readings for each session that students discuss in small groups led by peer-mentors. Finally, student teams work on a topic and meet with peer-mentors weekly for discussion and guidance as they would in a tutorial oriented class.

Approximately 120 first year engineering students were enrolled in ENGR 101. The class met two times every week. The first meeting is a ninety-minute instructional session held where all of the first year students, two instructors and twenty-one peer-mentors meet. The second meeting for the first-year families is a ninety-minute application session that is led by peer-mentors from the Madison Engineering Leadership Program (MadE Leaders). Activities in the application sessions compliment the projects that progressively moved the first year students to think locally and to act globally.

ENGR 101 introduces students to the values and mission of the Madison Engineering Program:

- *Values*: Respect, Collaboration, Generosity, Learning, & Excellence
- *Mission*: Through an engineering curriculum grounded in novel instructional practices, we foster an engaged educational community of conscientious and adaptable learners who develop solutions for the betterment of society.

Three elements of the mission are used to be the connective links of the course to the mission:

1. *Conscientious and adaptable learners (L)* – Developing one's self
2. *Engaged educational community (C)* – Becoming a contributing member of the Madison Engineering Community
3. *Develop solutions for the betterment of society (P)* – Aiding in providing solutions for the complex challenges facing society as a practitioner.

The Goals of ENGR 101 are as follows:

1. Gain access and connection to the Madison Engineering Community by understanding attitudes and expectations of being a Madison Engineer
2. Cultivate the abilities to frame problems and create solutions ideas within a set of defined constraints related to time, material, personnel, and problem parameters
3. Develop an understanding of the profession and the ethical responsibilities of engineers

ABET, the external accrediting body for applied science, computing, engineering, and engineering technology education, have established eight general criteria for baccalaureate level programs. Student outcomes are one of the eight general criteria. Specific course outcomes and the relation to the Madison Engineering Department Mission, Course Goals and ABET criteria are displayed Table 1.

Table 1. ENGR 101 course outcomes

Course Outcomes Upon successful completion of this course, first year student will be able to:	**ENGR Mission**	**Course Goals**	**ABET Outcomes**
Identify the 5 core values and discuss the mission of the Engineering Department based on how it relates to their life	L, C, & P	1	f
Research, define, frame and develop a persuasive argument about a problem given a contemporary issue	L, C, & P	2	e, g, & j
Exercise the process of avoiding harm & seeking to do good by evaluating the ethical dimensions of an issue by addressing the 8 key ethical questions given a contemporary issue	L, C, & P	3	f, g, h & j
Discuss attitudes and positions objectively within written and focus group forums among peers, peer mentors, faculty & staff given time to reflect on recent events	L, C, & P	1	g
Demonstrate a positive association with the Engineering program given opportunities to meet faculty & staff as well was working with peers and peer mentors	L & C	1	

Project-based Learning

The majority of the course is built with project-based learning strategies. These strategies are designed to incorporate real-world problems, issues, and scenarios into mini or major projects that are devised to prompt students to investigate, gather, and apply knowledge. Project-based learning aims to engage students in realistic, thought-provoking problems; typical projects present a problem to solve, a phenomenon to investigate, a model to design, or a decision to make[3].

At the core of project-base learning are the following[4]:

- Students learning knowledge, processes, and methods in order to wrestle with realistic problems they would encounter in the "real-world"
- Increased student control over their personal learning
- Teachers serving as coaches of inquiry and reflection
- Students working in groups

The following sections contain the core projects that are a part of the Engineering Opportunity course.

First Day Design Challenge

The first day of class the first year students are randomly placed in first year families with peer-mentors (MadE Leaders). After "ice breaker" activities within the first year families (1st Families), the families are assigned their first project as team. The thirty-minute in-class design challenge focuses on improving the user *interaction* or *experience* from one of the items in the list below after evaluating all the items:

- Vending machine (e.g. snack, cold beverage, hot beverage, etc.)
- Water fountain
- The food court queuing system (i.e. lining up to select, order, and pay for food)
- The food court waste receptacles

The items in the list are to serve as the benchmarks for the improvements. The families are prompted to focus on redesigning the *service* that the item provides or on the *object* itself. The families had come to an agreement on what the focus should be. The homework portion of the challenge is to compare and contrast benchmarks and their improvements with other similar items located in different parts of campus. The deliverable for the challenge is creating a presentation utilizing seven slides that express the task, document the process, show results, and summarize the project. Physical, analytical, or visual prototypes are highly encouraged.

Food Court Study – System Thinking Case Study[5]

Students conduct a study of population, consumption and technology within an on-campus food court. Before starting of the study, students in their 1st Families have to create a hypothesis around the following variables within the categories of people, consumption and technology: people – rate, quantity, gender, ethnicity, age; consumption of food, packaging and utensils – input and output; technology – phones, computers, the family of "i" (pods, pads, etc.), writing, communications, cooking implements, and cash register. During the study, a boundary area approximately ten cubic meters where people are eating is established for observation. Data was gathered for a minimum of sixty minutes without interaction with or impacting the data of other teams. Teams could not be closer than three meters to the focal point of another team. Deliverables for the group project was a presentation with a time limit of seven minutes. Students were tasked with defining their system, summarizing their study (hypothesis, procedures, and results), explaining problems observed in terms of sustainability, providing potential engineering solutions for described problems with reflections on what could be done differently.

Human-Centered Design

Human Centered Design and Design Thinking is a basic problem solving approach that enables students to tackle design challenges in teams. Human-centered design is a user centered design process that focuses on the end user during all stages: discover, ideate, prototype, and implement. The introduction of packets allowed students within the families to move through each stage during the instruction and application sessions.

Families spent time outside of class to work on the projects tied to the packets. Projects ranged from engineering solutions to encourage low-income families to save money, to enabling access to affordable healthier food choices.

GM Ignition Switch – Ethics Case Study

Students are instructed to read articles pertaining to General Motors Ignition Switch situation. After reading the articles, each student has to write a one minute impromptu argument on the most important ethical issue as it related to Code of Ethics of the National Society of Professional Engineers.

To further explore the ethical content in the issue, the James Madison University 8 Key Questions (8KQs - an ethical reasoning approach) are used to aid in the determining key questions that could be used to evaluate the ethical dimensions of a problem. The additive properties of using eight lens helps to understand other peoples decisions and helps to decide the most appropriate course of action that avoids harm and seeks to do good. After answering the 8KQs, students read the Kneupper article on structuring an argument based on the Toulmin Model to produce another one argument[6]. Each argument was posted public on the course management system as well as discussed publicly in the application sessions with peer-mentors. A wrap-up of the case study was concluded during an instructional session.

Individual Pecha Kucha Video Presentation

Reflection is a key tool in introducing the students to the community. The midterm project for the first-year students is to create an individual Pecha Kucha style presentation (twenty slides, each for twenty seconds advancing automatically as someone speaks) based on their own individual understanding of the values and mission of the Madison Engineering Department as it related to their personal values and ethics. The students are asked to take in consideration their 1st Families, the department, the college, the university and the discipline of engineering. Each student had to create slides, provide a narrative (transcript) and give the presentation to be recorded at the Student Success Center. Each 1st Family selected one presentation that best fit the collective vision, ethics, and mission of the 1st Family, department, the college, the university and the discipline of engineering to be viewed by the entire class.

IDEO – Ebola Challenge

The Ebola design challenge is the culminating class project connected to the Open IDEO platform as part of the USAID Grand Challenge. Students uploaded their individual ideas and prototypes devised by the families in accordance to the timeline set by IDEO. The Ebola challenge provided a means for the first-year students to participate in a project that could result in a better quality of life for others. By uploading ideas, students are afforded opportunities to interact with the experts linked to the project. The interaction with experts is highly encouraged so that the students could use the feedback to iterate and improve on their design. Students would receive emails from Open IDEO that strength the content shared in class and aiding in the pacing of the self-guided/group-guided project. Below is an example of an email from Open IDEO:

"Testing assumptions with prototypes is an essential step in moving ideas forward. Prototyping allows us to assess the viability of our ideas, adjust and refine in an agile way, gather user and stakeholder feedback and discover new insights that add fresh, human-centered perspectives to our thinking.

This week let's build out our ideas and load prototypes to the platform. Whether it's a PPE suit made of trash bags and oven mitts or a user experience map for your community outreach program, making our ideas tangible is a great way to get targeted feedback from the community."

Assessment Methods

The current study sets out to utilize qualitative and quantitative methodologies to more fully understand the impact of the current educational intervention with first year engineering students. Elements of qualitative and quantitative research approaches (e.g., use of qualitative and quantitative viewpoints, data collection, analysis, inference techniques) were utilized for the broad purposes of breadth and depth of understanding and corroboration[7]. In this study, the experience of first year engineering students is evaluated for the purpose of better understanding.

Procedure

This study seeks to gain an understanding of (a) student attitudes and perceptions about college and engineering as well as (b) the efficacy of the first year interventions. The assessment instrument focuses on:

1. Understanding the first year student's attitudes and perceptions in transitioning from high school to college and into the engineering community.
2. Understanding the efficacy of interventions within the redesign cornerstone course for the purpose of aiding students in their academic careers and enhancing student learning.

Selecting/Designing Instruments

As mentioned above, quantitative and qualitative measures are used to collect data and to understand the impacts of the reimaged ENGR 101. Below contains a description of the tools.

Quantitative Data Collection Instruments

The transition from high school to college for most individuals marks a very transformative time in their lives. Via observation and the work of Anderson-Rowland, freshman engineering students that have performed well in high school tend to believe that the strategies and habits that aided them will bear similar outcomes in college[8].

These students will therefore, believe they require little or no help in being successful in college as an engineering major[8].

Considering that research evidence has indicated that academic achievement of students is affected by cognitive abilities, motivation, interest and learning strategies[9, 10, 11, 12, 13, 14, 15, 16], the authors have selected instruments or have modified instruments to gain better understanding of motivated strategies of students for learning, special treatment that students may believe that they are entitled to have, the mindset of students in regards to intelligence, relationship building within the Madison Engineering Department and to undercover attitudes of first year students towards the redesigned first year course.

The Motivated Strategies for Learning Questionnaire (MSLQ) is incorporated into the assessment tool. The MSLQ has been used for more than 20 years and is specifically designed to measure college students. Specifically, it addresses the assessment of college students' motivational orientations and their use of different learning strategies for a college courses. Motivational orientation and learning strategies are important because different approached to learning by students can result in drastically different learning outcomes. Additionally, these approaches to learning can change over time within people, so changes over the course of the semester would not be surprising. There are a total of 15 subscales in the MSLQ, but each subscale can be used alone or in conjunction with any other scale depending on need. The subscales of interest in the present study are as follows:

- Intrinsic goal orientation (a measure that focuses on learning and mastery)
- Control of learning beliefs (beliefs that outcomes are the result of effort rather than luck)
- Self-efficacy (beliefs about competence and ability)

Ideally, as the semester progress students will increase intrinsic goal orientation – the belief that outcomes are the result of effort rather than luck, and increase self-efficacy.

The Academic Entitlement Scale[17] is also used as an assessment tool. Even with the recent development of the academic entitlement scale, it has been found to be reliable and has been well validated. Academic entitlement is the belief that one should receive a certain grade in a course regardless of actual performance. Students with high academic entitlement take less responsibility for their work and blame external factors (teacher, institution, content) for poor grades. These students are less likely to do well and expect to receive certain grades in class based on effort and not on the quality of work. Ideally, as the semester progresses students' scores on academic entitlement will decrease.

A scale measuring implicit theories of intelligence[18], as defined by Dweck, is also utilized. Dweck is one of the leading researchers in intelligence research, and her ideas have been mostly supported for more than 20 years. The theory behind this scale is that there are two mindsets that students can have about intelligence: a fixed mindset or a growth mindset. Learners with a fixed mindset view intelligence as set, therefore when they encounter problems they are more likely to give up. Learners with a growth mindset view intelligence as something you can increase so they are more likely to persist when they encounter a problem. Fixed and growth mindsets are not mutually exclusive, but instead student fall on a continuum between the two.

Modification of Existing Instruments

The University Mattering instrument was revised to become the Madison Engineering Mattering Instrument that was incorporated into the instrument. The revision will be used to assess the attitudes of the first year students towards the MadE Department in general as an entity or whole community. The aspect of interest is the relationships with the people in the Madison Engineering community.

The other revised instrument was the General Attitudes Toward Your College Classes. This instrument is based on the expectancy-value-cost framework. The revised instrument was utilized to increase information on the general attitudes of first year students toward ENGR 101 relative to other college courses. The subscales of interest are as follows:

- Expectancy (an individual's anticipated ability to successfully accomplish the task)
- Value (an individual's perceived importance for the task)
- Cost (how much an individual perceives that he or she has to sacrifice or give up to accomplish the task)

Quantitative Data Analysis

The data analysis for the quantitative portion of this project includes primarily descriptive statistics using the statistical tool SPSS. The attrition of students completing the assessment surveys as the semester progressed was high, with an initial sample size of 123 to a final of 28. The large difference in sample size across samples means that inferential statistics are unstable and statistical assumptions would not be met. Additionally, there could be a selection bias, with certain types of students being more likely to fill out the survey than other types. Due to these factors, only descriptive statistics will be reported about the assessment results.

Qualitative Data Collection Instruments

Reflection questions that were part of the end of the semester course evaluation were developed to gather information to assess changes in attitude towards engineering. For the purposes of this paper the information pertaining to the first question will be presented. The three questions are as follows:

1. As a result of you taking this course, how would you describe your individual feelings about the MadE Community? (Look at what has happened and describe your individual feelings.)
2. As a result of you taking this course, discuss and share an important part of learning, growth and/or development that has occurred as a result of the ENGR 101 experience. (Look at making meaning of the ENGR 101 experience through describing how you have changed because of the experience.)
3. As a result of you taking this course, how do you hope to use the knowledge gained by the ENGR 101 experience to be a better you. (Will you take any actions or make any changes because of the experience?)

Qualitative Data Analysis

The qualitative results below represent responses of the students to the reflective question that was part of the end of the semester course evaluation. The question was developed to gather information to assess changes in attitude about engineering and new student understanding. The reflections were coded and analyzed for themes using thematic analysis and emergent grounded theory methods[19,20]. Thematic analysis helps draw out the strands that tie student's experiences together[21]. The use of emergent grounded theory aids in focusing on the participants words and experience to provide valuable insight into the ways participants construct their worlds and in this case, course experiences in Engineering Opportunities. The most common themes are illustrated in table form with the frequency and a student quote that elucidates the theme.

Assessment Results

Qualitative and quantitative methodologies were utilize to gain a better understanding if the activities associated with Engineering Opportunities had an influence on first year engineering students. As a result of the high attrition rate of students completing the assessment surveys as the semester progressed and the possibility of selection bias, only descriptive statistics will be reported about the assessment results within the quantitative results. Therefore, the qualitative results that will be discussed are based on questions developed to gather information to assess changes in attitude by the first year students towards engineering and new student understanding.

Engineering Matters Results

The Engineering matters survey allowed us to start understanding the motives and views of people who are entering the program as first year students. A majority of people entering the program did so because they plan on working as an engineer or attending graduate school for engineering. Most people had heard about the program from institutional information outlets. Interestingly, just as many people cited "a friend or relative" for how they heard about the program, which is surprising given newness of the program. When selecting the institution specifically, the engineering program was the 3rd most picked option after the campus and community. It was also found that the most common majors other than engineering considered are Math or Science Majors and Business majors. Finally, a majority of engineering majors decided to pursue engineering while in high school. The reasons that engineering was picked follows in order: career opportunities, personal interest, and financial incentives.

The Engineering matters survey also had questions specifically dealing with Engineering. Initially, most students said they chose the program because of newness of the program, hands on nature, and career opportunities. However, by the middle and end of the semester a design focus was picked more often than career opportunities. The decision to come to the university was both for the university itself and specifically for the program. When asked what engineering is most said problem solving, designing, and applying math/science/physics knowledge. Students said that they most felt like engineers when they were solving problems, building or constructing things, and thinking creatively.

A few other findings from the Engineering Matters survey are worth mentioning. The first is that students picked parents as the second most influential decision for perusing engineering after themselves. Another notable finding is that as the semester progressed "hanging out with engineering friends" become a higher answer to "I feel like an engineer when I am". Across multiple questions, students increased in picking "design" as an answer choice as the semester progressed. This shows that students increased the importance they placed on design as the class progressed.

Quantitative Results

The Dweck theories of intelligence scale, academic entitlement scale, MSLQ Self Efficacy Subscale, MSLQ Intrinsic Motivation Subscale, and the Expectancy-Value-Cost were administered at three different time points during the semester (August - Table 2, October - Table 3, and December - Table 4). The tables are provided for reference, but a summary of the notable results, broken down by measure, is provided below the tables in Figure 1.

Table 2. Descriptive Statistics for August Assessment

Scale (Subscale)	*M*	*SD*	*Min*	*Max*	*Skew*	*Kurt*
Dweck Intelligence	9.81	4.04	4.00	24.00	0.61	0.52
Academic Entitlement	21.29	6.93	8.00	47.00	0.82	1.40
MSLQ Self-Efficacy Subscale	45.53	9.72	8.00	63.00	-0.62	1.48
MSLQ Intrinsic Value Subscale	52.58	6.98	30.00	63.00	-0.66	0.42
EVC- Expectancy Subscale	5.86	0.74	4.60	8.00	0.79	0.34
EVC- Value Subsalce	5.61	0.68	4.20	7.53	0.75	0.45
EVC- Cost Subscale	5.33	0.67	4.00	7.46	1.01	1.12

N=123

Table 3. Descriptive Statistics for October Assessment

Scale (Subscale)	*M*	*SD*	*Min*	*Max*	*Skew*	*Kurt*
Dweck Intelligence	10.48	3.91	4.00	19.00	0.10	-0.64
Academic Entitlement	23.90	9.03	8.00	56.00	1.09	2.42
MSLQ Self-Efficacy Subscale	44.50	11.03	9.00	63.00	-1.37	2.95
MSLQ Intrinsic Value Subscale	47.22	10.41	9.00	63.00	-1.33	2.66
EVC- Expectancy Subscale	5.49	1.19	1.00	8.00	-1.67	6.72
EVC- Value Subsalce	5.28	1.09	1.00	7.53	-2.05	7.78
EVC- Cost Subscale	5.16	1.05	1.00	7.46	-2.07	8.55

N=53

Table 4. Descriptive Statistics for December Assessment

Scale (Subscale)	*M*	*SD*	*Min*	*Max*	*Skew*	*Kurt*
Dweck Intelligence	8.47	3.01	4.00	17.00	0.64	1.06
Academic Entitlement	22.72	8.22	8.00	43.00	0.88	0.61
MSLQ Self-Efficacy Subscale	50.48	6.78	38.00	63.00	-0.13	-0.55
MSLQ Intrinsic Value Subscale	51.07	8.25	30.00	63.00	-1.07	1.25
EVC- Expectancy Subscale	5.70	0.82	4.20	7.10	0.21	-0.66
EVC- Value Subsalce	5.54	0.79	4.20	7.00	0.41	-0.62
EVC- Cost Subscale	5.37	0.82	3.92	6.92	0.59	-0.54

N=28

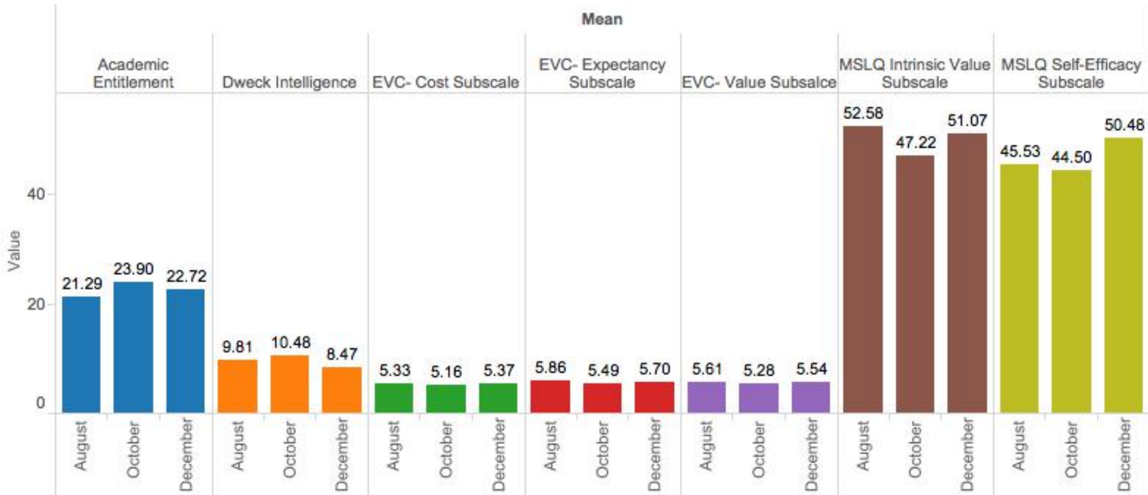

Figure 1. Mean values for scales for August (N = 123), October (N = 53), and December (N = 28)

Quantitative Results Summary

The attrition of students completing the assessment surveys as the semester progressed was high, with an initial sample size of 123 to a final of 28. The large difference in sample size across samples means that inferential statistics are unstable and statistical assumptions would not be met. Additionally, there could be a selection bias, with certain types of students being more likely to fill out the survey than other types. Due to these factors, only descriptive statistics will be reported about the assessment results.

The Dweck Theories of Intelligence Survey showed an increase from August (M = 9.81, SD = 4.04) to October (M = 10.48, SD = 3.91), but an overall decrease for December (M = 8.47, SD = 3.01). Lower scores represent a growth mindset, which means that students were more likely to persist when faced with academic challenges. Students with a growth mindset view intelligence as fluid and feel that hard work will result in increased intelligence. This makes students with growth mindsets more likely to succeed.

The Academic Entitlement Survey showed increases in Academic Entitlement from the beginning (M = 21.29, SD = 6.93) to the end of the semester (M = 22.72, SD = 8.22), with a peak during the October assessment (M = 23.9, SD = 9.03). Increased academic entitlement means that students felt that external factors such as the instructor or university are responsible for their grade, and that they deserve a certain grade for the work they have accomplished. Students with higher academic entitlement are less likely to succeed because they do not take personal responsibility for their learning.

The MSLQ scores showed a decrease during the October assessment for both the Self-efficacy subscale (M = 44.5, SD = 11.03) and Intrinsic value subscale (M = 47.22, SD = 10.41). Lower scores reflect less self-efficacy and less intrinsic, or internal, value which are both detrimental to academic performance. However, both the self-efficacy subscale (M = 50.48, SD = 6.78) and Intrinsic value subscale (M = 51.07, SD = 8.25) had an increase in December. When comparing the August assessment to December, self-efficacy had a net gain while intrinsic value slightly decreased. The self-efficacy increase is favorable because it shows that students were more efficacious about the class and their knowledge of engineering.

The EVC scores showed a similar pattern of change as the MSLQ scores, with lower scores during the October Assessment and comparable scores during the August and December Assessment. It is also worth noting that the scores for the October Assessment were leptokurtic for all three subscales, meaning that the distribution of scores were clustered close to the mean resulting in a distribution that is more peaked than normal. High scores are favorable for the expectancy and value subscale, but lower scores are favorable for the cost subscale. The decrease across all three subscales at the midpoint is interesting because theoretically the cost subscale should have a different pattern than the other two subscales.

Qualitative Results

The qualitative results to follow represent students' responses to one of three reflective questions that were part of the end of the semester course evaluation. The questions were developed to gather information to assess changes in attitude towards engineering and new student understanding. For the purpose of this paper the responses to the first question, "As a result of you taking this course, how would you describe your individual feelings about the MadE Community? (Look at what has happened and describe your individual feelings.)" will be explored. The qualitative themes were constructed using an emergent coding strategy as mentioned above. The student quotes below are in the student's words and the researchers did not make additions or modify their written statements. Illustrated in Table 5 are the most common themes and the frequency that they appear in the reflective statements.

Table 5. Emergent themes and student quotes regarding Q1

Q1. As a result of you taking this course, how would you describe your individual feelings about the MadE Community? (Look at what has happened and describe your individual feelings.)		
Theme	**Summary Response**	**Frequency**
Personal accountability	By taking this course I feel better at my decision about coming to JMU to be an engineer. I have learned the key objectives in what a Madison Engineer should be and how they should act in and out of the classroom. I have come to realize that the people that we have me through this year will be in our classes and around us throughout our next four years and it was good to get close with them. To see what our teacher advisors and	8

	professors were working on was very cool and inspiring to work hard.	
Sense of belonging	I feel like I matter. The professors were very personal and actually know who each of us are. I have made so many friends and feel comfortable around the majority of the Madison Engineering faculty. I know that I am in the right place.	13
Community and collaboration	I personally believe that the MadE Community is an entirely different Engineering "family" than I have ever seen before, especially at other colleges. The way we work with each other and the projects we undertake are far more empathetic than other Engineering communities.	11
Community and competition	The MadE Community is a competitive but friendly learning environment conducive to innovative ideas and designs.	7
Caring faculty and peers	Great community of individuals that are striving to better the community and solve real world problems I think its great because everyones very accessible and helpful.	10
Positive future outlook	I am excited and more astonished at the program. After taking this course along with the RLC [Engineering Residential Learning Community] , I now know what an engineer truly does and why the program does what it does. I think this is going to be awesome!	7
Increased understanding of engineering as a career	It has bettered my understanding of the program and how to go about solving problems. It provided me with insight on how to keep the user at the center of the design.	6

The common themes from this question center on student's feeling as represented by their statements, that by participating in the Madison Engineering program they have an increased sense of personal accountability, community, sense of belonging, positive outlook for the future, and a better understanding of engineering as a field. In regard to personal accountability students mention, "being inspired to achieve", "having a growing sense of confidence", and needing to "work harder" to be successful. One of the most common themes that has been broken down by sub-category, is a sense of community being most important. The community as represented by student responses is one that is simultaneously caring, compassionate, and creates a sense of belonging, while at the same time acknowledges competition in a positive sense. Students mentioned things like "feeling close to peers", feeling like "I matter", that the individuals in the department "care" and are "ready to help".

Conclusion

This paper describes the structure and assessment of the Engineering Opportunities course. The course used project-based learning strategies within a course structure that was a hybrid between seminars, colloquium, and tutorials class models.
The assessment of the course is limited by its sample size due to attrition. The inclusion of multiple data collection methods serves to mitigate the weakness of the smaller quantitative sample size and supplement with qualitative data. Engineering Opportunities provided first year students in engineering a space to transition into the MadE community through design challenges, working with peers, peer-mentors, faculty, staff and individuals in a broader community. Students stated that they most felt like engineers when they were solving problems, building or constructing things, and thinking creatively. Students also indicted that as the course progressed they felt that they were a part of the Madison Engineering Community and placed importance on design.

Acknowledgements

The creation and development of the Madison Engineering program has been a collective and collaborative effort and the authors would like to acknowledge the faculty, staff, and administration of the Madison Engineering Department and James Madison University. The dedication of these individuals has facilitated a culture and environment that has allowed the faculty to design courses such as Engineering Opportunities.

References

1. National Academy of Engineering. (2004). *The Engineer of 2020: Visions of Engineering in the New Century*. Washington DC: The National Academies Press;

2. National Academy of Engineering. (2005). *Educating the Engineer of 2020: Adapting Engineering Education to the New Century*. Washington D.C.: The National Academies Press; 2005.

3. David, J. (2008). What Research Says About . . ./ Project-Based Learning. *Teaching Students to Think*, *65*(5), 80-82.

4. Barron, B., & Darling-Hammond, L. (2008). Teaching for meaningful learning: A review of research on inquiry-based and cooperative learning. Retrieved September 10, 2014 from http://www.edutopia.org/pdfs/edutopia-teaching-for-meaningful-learning.pdf

5. Nagel, R., Gipson, K., Spindel, J., & Barrella, E., (2013) Blending Sustainable Design, Systems Thinking, and Engineering Science Concepts in an Introductory Engineering Course, *120th American Society of Engineering Education Annual Conference & Exposition*, Atlanta, Georgia, June 23-26, 2013.

6. Kneupper, C. W. (1978) Teaching Argument: An Introduction to the Toulmin Model, *College Composition and Communication,* National Council of Teachers of English, 29(3), 237-241.

7. Plano Clark, V. L. & Creswell, J. W. (2010) Designing and Conducting Mixed Methods Research, 2Ed

8. Anderson-Rowland, M. R., "Understanding Engineering Freshman Study Habits: the Transition from High School to College," Proceedings of the 2009 American Society of Engineering Education Annual Conference Exposition, Austin, Texas, June, 2009.

9. Mayer, R.E., Thinking, Problem Solving, Cognition. New York, NY: W. H. Freeman and Company (1992).

10. Bloom, B.S., Engelhart, M.D., Furst, E.J., Hill, W.H. and Krathwohl, D.R., Taxonomy of Educational Objectives: The Classification of Educational Goals; Handbook I: Cognitive Domain. New York, NY: Longmans, Green (1956).

11. Mayer, R.E., Cognitive, metacognitive, and motivational aspects of problem solving. Instructional Science 26, 1-2, 49-63 (1998).

12. Marra, R.M., Rodgers, K.A., Shen, D. and Bogue, B., Leaving engineering: a multi-year single institution study. J. of Engng Educ., 101, 1, 6-27 (2012).

13. Schunk, D.H. and Zimmerman, B.J., Motivation and Self-Regulated Learning: Theory, Research and Applications. New York, NY: Routledge (2009).

14. Besterfield-Sacre, M., Atman, C.J. and Shuman, L.J., Characteristics of freshman engineering students: models for determining student attrition in engineering. J. of Engng. Educ., 86, 2, 139-149 (1997).

15. Pintrich, P.R. and De Groot, E.V., Motivational and self-regulated learning components of classroom academic performance. J. of Educational Psychology, 82, 1, 33-40 (1990).

16. Fang, N., Correlation between students' motivated strategies for learning and academic achievement in an engineering dynamics course. Global Journal of Engineering Education, 16, 1, 6-12 (2014).

17. Kopp, J. P., Zinn, T. E., Finney, S. J., & Jurich, D. P. (2011). The development and evaluation of the Academic Entitlement Questionnaire. *Measurement and Evaluation in Counseling and Development*, *44*(2), 105-129.

18. Dweck, C. S. (2006). Mindset: The new psychology of success. New York: Random House LLC.

19. Glaser, B., & Strauss, A. (1967). *The Discovery of Grounded Theory*. Aldine Publishing Company, Hawthorne, NY.

20. Charmaz, Kathy (2000). Grounded Theory: Objectivist & Constructivist Methods. In Norman Denzin & Yvonna S. Lincoln (Eds.), *Handbook of Qualitative Research,* 2nd edition (pp.509-535). Thousand Oaks: Sage.

21. Spradley, J.P., (1980). *Participant Observation*. New York: Holt. Rinehart and Winston.