Assessment Analysis Results of How Freshman Engineering Students Build an Entrepreneurial Mindset through Freshman Engineering Discovery Courses

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***Abstract* – The entrepreneurially minded learning (EML) pedagogical approach has been explicitly used and applied in the freshman engineering discovery courses developed at Marquette University's Opus College of Engineering. These two-semester long courses offer new engineering students the opportunity to discover and explore their potential through various course contents, topics, and activities integrated with the EML pedagogical approach. In order to indirectly assess and measure how freshman engineering students have built their engineering entrepreneurial mindset through these two semester courses, course surveys were given to students twice a year (one per semester) for the last three years – once at the beginning of the first (fall) semester and another at the end of the second (spring) semester. The new survey results obtained for the last three years were then compared and analyzed to previously collected results. This analysis has provided insight on how freshman engineering students learn to identify an engineer's societal roles and responsibilities while creating new innovative ideas and concepts with the potential to investigate existing markets and technologies; furthering the ultimate goal of the engineering discovery courses of providing new engineering students with a vision of how to become a future engineer with an entrepreneurial mindset. After introducing the overall course structure, contents, topics, and the corresponding activities, this paper presents the survey analysis results that show how the freshman engineering students build their engineering entrepreneurial mindset during their first year of college.**

Index Terms – engineering entrepreneurial mindset, entrepreneurially minded learning, freshman engineering discovery courses

INTRODUCTION

The two-semester long Freshman Engineering Discovery courses developed and currently running at Marquette University – Opus College of Engineering are primarily designed for new engineering students to learn and experience what engineering is and what engineers do through various course contents and activities. In order for the students to consistently exercise and develop their engineering skills and entrepreneurial mindset, they need to be exposed to a number of challenges and opportunities to practice their creativity and engineering problem-solving and design experiences.

The author's previous works [1-6] describe the details about the Freshman Engineering Discovery courses that have been running for more than ten years at Marquette University – Opus College of Engineering. The main objective of the two-semester course integrated with EML is to provide new engineering students with a vision as engineers with an engineering entrepreneurial mindset. As a result, they will be able to critically think as experienced and professional engineers.

During the first semester, in order to meet the course objectives, students are asked to find guided and creative appropriate solutions to a selection of various multi-disciplinary engineering problems. The students practice solving various pre-selected engineering problems within the *Engineering Problem-Solving* module session, through the use of proper problem solving steps and team discussions. The students also begin to recognize and eventually follow various engineering standards (e.g., engineering ethics, engineering graphics, computer-aided design, teamwork, etc.) through the course content. As the semester progresses, the students are asked to participate in a team project that includes both individual and team responsibilities.

During the second semester, the students study and experience the following three topics: *Engineering Computing*, *Introduction to Disruptive Technology with Products and/or Services*, and *Engineering Design Challenge* with an engineering entrepreneurial mindset. The students build and apply their knowledge, experience and skills which they learned before and during their first semester as engineering students. They also participate in various *Design Challenges*, which are group-based multi-disciplinary projects that address various current world issues. The students learn how to work together with other team members, share responsibility for their work, and develop a flexible foundation of engineering knowledge and skills.

After introducing the overall course structure, contents, topics, and the corresponding activities, this paper presents the survey analysis results to show how the freshman engineering students build and foster their entrepreneurial mindset during their first year of college. This paper also describes how the freshman engineering discovery courses have been integrated with EML, supported by survey analysis results.

ENTREPRENEURIALLY MINDED LEARNING (EML) WITH ENTREPRENEURIAL MINDSET

It is a commonly-known fact that most instructors who teach entry or introductory-level engineering courses prefer to use and adapt the subject-based learning (SBL) and/or the problem-based learning (PMBL) approaches to build a student's proper domain knowledge related to the course topics. Some instructors who teach upper-level core engineering courses prefer to use project-based learning (PTBL) and/or case-based learning (CBL) to allow students to practice applying the engineering fundamentals in order to solve real-world actual problems. Some instructors who teach senior-level engineering courses, such as senior capstone design and elective courses, may utilize PTBL for the students to apply their knowledge and experience that have been built throughout their engineering courses and related activities.

The entrepreneurially minded learning (EML) teaching method has been advocated by KEEN [7] in order to help engineering students foster and develop an entrepreneurial mindset (defined with the 3C's of *Curiosity*, *Connections* and *Creating Value* [7]). Importantly, EML builds upon other widely accepted pedagogical methods, which allows this approach to be complementarily stacked alongside other methods. Table I summarizes EML's emphasis. It also shows how the EML method is linked with others by adding the key element of entrepreneurial mindset.

TABLE I
EMPHASIS OF THE EML METHOD

Entrepreneurially Minded Learning (**EML**)	Students learn to create value by gathering and assimilating information to discover opportunities or insights for further action.

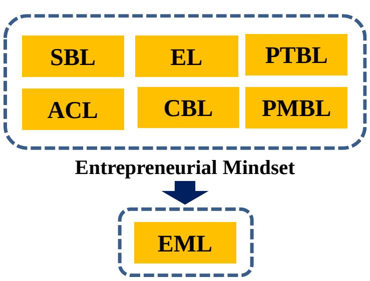


Table II shows the entrepreneurial mindset defined by KEEN in which three keywords, 3C's (*Curiosity*, *Connections* and *Creating Value*) were created for educators to follow as a guideline in order to provide students with an entrepreneurial mindset. Table II also shows the expected students' primary outcome and example behaviors in order for them to properly build and foster the entrepreneurial mindset [7]

TABLE II
STUDENT PRIMARY OUTCOME AND EXAMPLE BEHAVIORS WITH ENTREPRENEURIAL MINDSET [7]

STUDENT OUTCOME	EXAMPLE BEHAVIORS
ENTREPRENEURIAL MINDSET	**CURIOSITY** DEMONSTRATE constant curiosity about our changing world EXPLORE a contrarian view of accepted solutions **CONNECTIONS** INTEGRATE information from many sources to gain insight ASSESS and MANAGE risk **CREATING VALUE** IDENTIFY unexpected opportunities to create extraordinary value PERSIST through and learn from failure

FRESHMAN ENGINEERING DISCOVERY COURSES INTEGRATED WITH EML

I. Freshman Engineering Discovery 1

The course, *Freshman Engineering Discovery 1*, is offered every fall semester for freshman engineering students at Marquette University – Opus College of Engineering. It consists of one lecture for a one-hour period (on Monday) and two studio classes (on Tuesday and Thursday) for a four-hour period per week. Table III describes the overall structure and topics of the course.

TABLE III
FRESHMAN ENGINEERING DISCOVERY 1 – OVERALL COURSE STRUCTURE AND TOPICS

Engineering Graphics Fundamentals & Computer-Aided Design (CAD) Practice	Introduction to Engineering and Engineers & Department Module Engineering Problem Solving
Graphics & CAD Team Project – Poster Exhibition & Competition	

Introduction to engineering and engineers, department module and engineering problem solving sessions. New engineering students in this course are primarily introduced on how to use and follow a set of rules and guidelines to experience the field of engineering, and to understand the roles and responsibilities of an engineer. This is accomplished through various class and lab activities such as Fermi's problem solving exercises, scientific/engineering (US and SI) unit systems and their usage through various types of sample engineering problems.

For the department module sessions, each department (biomedical, civil and environmental, electrical and computer and mechanical engineering at Marquette University – Opus College of Engineering) provides the students with an overview of their departments and areas of practice, along with appropriate research works and activities. Through this type of department module session, the freshman engineering students are able to recognize the multidisciplinary perspectives of engineering fields.

During the engineering problem-solving module session in this course, the students are primarily introduced to simple engineering problem-solving steps or procedures (as shown in Figure 1) while they study the selected engineering topic – basic modes of heat/energy transfer (i.e., conduction, convection and radiation). In this course, the analogy between heat flow/transfer and electric current flow [8] has been introduced and used to practice engineering problem solving.

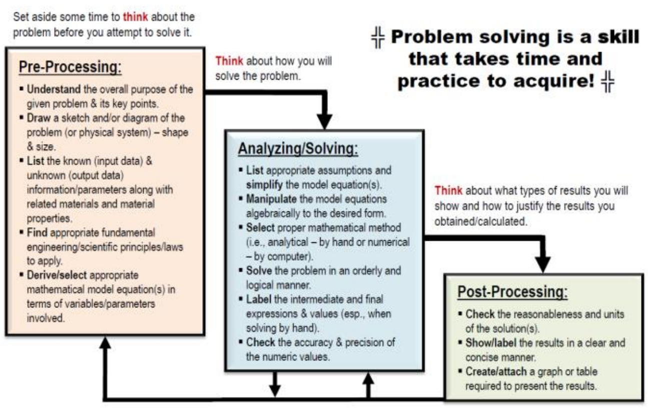


FIGURE 1
GENERAL ENGINEERING PROBLEM-SOLVING PROCEDURE USED IN THE COURSE

After studying basic fundamentals on heat transfer, such as heat conduction, convection and radiation with proper forms of thermal resistances, the students are able to consistently analyze and solve various types of energy/heat system example problems.

The author's previous work [4] describes in detail how the student teams work on the class energy term project for a two-week period with the theme of analyzing and estimating energy/heat usage, system efficiency and energy usage cost. Each project team was asked to find and identify the object or problem from the campus of Marquette University, such as the dormitories, cafeterias, classrooms, libraries, etc.

Engineering graphics fundamentals and computer-aided design (CAD) practice. The entrepreneurially minded learning (EML) approach described in Table I has been used in this course for the students to study and practice the topics of engineering graphics fundamentals and computer-aided design (CAD) through the use of the textbook developed by this author [9]. Through this activity, the students are able to create a series of 3D solid (component and assembly) models during lab classes every time they practice CAD modeling by using the routines and/or methods that they have used to create previous 3D solid models. Furthermore, the students are asked to create and summarize their own 3D solid modeling steps for all the 3D solid objects selected and assigned as homework.

The class project model, gear pump system with seven independent components, has been selected for the students to create all components every time they practice CAD modeling, and assemble them to create a complete assembly model and drawing as shown in Figure 2. Through this type of EML method, the students build confidence in applying the most commonly used methods and routines for creating a 3D solid model along with professional engineering drawing documents.

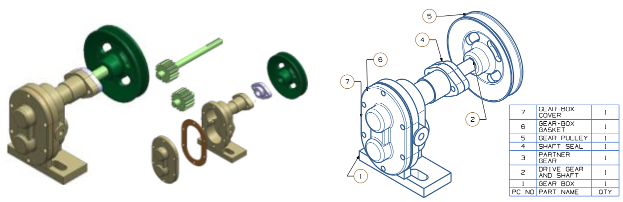


FIGURE 2
CLASS PROJECT MODEL – GEAR-PUMP SYSTEM; COMPONENT AND ASSEMBLY MODELING AND ASSEMBLY DRAWING

Graphics/CAD team project – poster exhibition and competition. After completing the object modeling practice mentioned above, the students are asked to form teams of about twenty students. Total of eight to ten design teams are established for the graphics/CAD team design project for modeling four or five different real objects. Each team member is assigned to create four to five components of a real object assigned to the team. All team members are expected to measure the geometric dimensions of the components of the object, create hand sketches of the components, and create 3D solid models and document drawings within a four week period.

Figure 3 shows the organizational diagram of the graphics/CAD team project where the roles of each team member and leader are indicated and show how they work together. Thus, throughout this team project, the students naturally learn how to work together and recognize the importance of each member.

In past years, various types of real objects, such as machines, devices, equipment and buildings located on the Marquette University campus, were selected for the graphics/CAD team project in order for the new engineering students to become familiar with their new environment and campus.

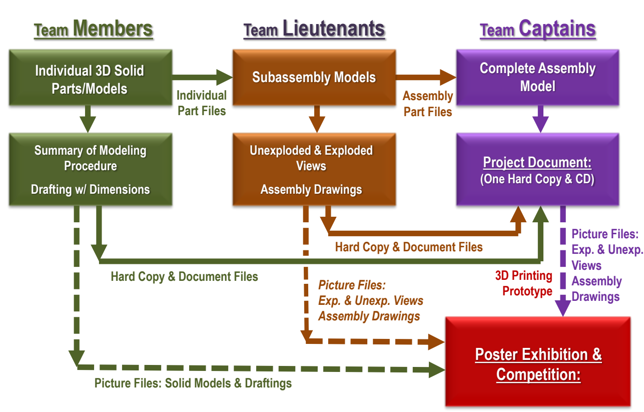


FIGURE 3
ORGANIZATION CHART FOR THE GRAPHICS/CAD TEAM PROJECT

Figure 3 shows some of the complete assembly models created by CAD teams within four weeks of work. Each team prepares two-page posters that include the summary of the overall CAD modeling procedure of the assigned models; the hand sketches of the individual parts with their measured dimensions and the corresponding 3D CAD models, the subassembly and complete assembly CAD models.

(a) Trak K3 Mill (b) Campus Gesu Church (c) Horizontal Band Saw

FIGURE 3
SAMPLE MODELS USED FOR THE CAD TEAM PROJECT

Table VI shows some of students' learning outcomes obtained from the graphics/CAD team project, in which the three keywords from the 3C's of the entrepreneurial mindset are connected to each item in order to assess how well the students experience the entrepreneurial mindset.

TABLE IV
SUMMARY OF LEARNING OUTCOMES OBTAINED FROM THE GRAPHICS/CAD TEAM PROJECT

- **Problems** encountered (such as matching part dimensions) overcome through teamwork (w/ ***Curiosity*** & ***Connections***)
- **Communication** through a hierarchy (team captains and lieutenants) (w/ ***Connections***)
- **Time management** to meet deadlines (w/ ***Connections***)
- **Delegation** of roles and responsibilities to contribute to the whole (w/ ***Connections***)
- **Collaboration** and sharing different techniques (w/ ***Connections***)
- **Application** of engineering graphics fundamentals & CAD modeling techniques (w/ ***Connections*** & ***Creating Value***)

During the graphics/CAD project poster exhibition and competition event, engineering faculty, staff members and upper-level engineering students are invited to judge the team project posters. The author's previous work [5] shows the simple rubric used by the judges to evaluate the project posters. It shows three simple evaluation items connected to the three keywords from the 3C's, along with the minimum and maximum evaluation points obtained from the poster judges. It can be seen that all design teams scored well above average on their team project work. Therefore, it is believed that this type of teamwork activity helps and motivates the students to foster and develop their engineering entrepreneurial mindset.

II. Freshman Engineering Discovery 2

This course is offered every spring (second) semester, consisting of a one-hour lecture on Monday, and two four-hour lab classes on Tuesday and Thursday of each week. Table V shows the overall structure and topics of the course in which various class activities are included.

Engineering computing with MATLAB® and its applications. In order for freshman engineering students and entry-level college students to efficiently practice MATLAB® during the lab class hours, the MATLAB® textbook has been developed by this author [10]. It includes self-study guides and sample example problems. The textbook guides the students on how to properly enter MATLAB® basic commands and codes in order to produce the numerical and graphical results required.

TABLE V
FRESHMAN ENGINEERING DISCOVERY 2 – OVERALL COURSE STRUCTURE AND TOPICS

Engineering Computing with MATLAB® & Its Applications	Introduction to Disruptive Technology – Products/Services
	Engineering Design Process with Design Challenge #1
	Engineering Design Process with Design Challenge #2
Design Challenge #2 – Poster Exhibition & Competition	

After practicing the MATLAB® basics and the corresponding programming algorithms, the students use and apply the MATLAB® basics to solve useful engineering and scientific problems by using proper numerical methods such as solving system linear equations, interpolation and curve fitting, nonlinear equations and numerical integration and differentiation. These numerical methods are very useful for the students in their engineering courses.

Introduction to disruptive technology – products/services. After introducing sample selected products and services related to disruptive technologies, along with the basic fundamentals of disruptive products and services, a team of students (three to four students per team) work to find and identify additional existing and available disruptive products and services in our society and marketplace. They are then able to consider and identify the elements of the entrepreneurial mindset included and involved in the identified products and services. The author's previous work [6] shows the samples of students' work and their corresponding measured outcomes.

Engineering design process with team design challenge #1. There are various resources and references related to the engineering design process [11-13]. In this course, a simple six-step engineering design process (i.e., problem identification, preliminary ideas/concepts, refinement, analysis, decision and implementation) has been used for the freshman engineering students to use and follow for the design challenge works.

The theme used for design challenge #1 relates to an issue about helping the underprivileged (i.e., underrepresented and underserved). Table VI shows the theme for disruptive engineering design challenge #1 work and the corresponding guideline for the students and their teams to follow and finish the project within a four-week period.

TABLE VI
OVERALL THEME AND GUIDELINE USED FOR DESIGN CHALLENGE #1

OVERALL THEME: "Designing Innovative (or Useful/Valuable) Products (Devices or System) or Processes for the Underprivileged" **DESIGN GUIDELINE:** • Identifying & selecting the problems/issues • Generating/creating new concepts/ideas to solve the issues/problems with proper hand sketches • Selecting/refining and finalizing idea/concept • Developing system working principles & creating physical system (3D solid) virtual models • Performing a basic/proper engineering and cost analysis/calculations of the selected objects with some degree of entrepreneurial aspect to the products/system

The author's previous work [5] describes the details of students' sample works and the overall performance of the design teams' work with properly developed evaluation items. It was found that the overall performance and the evaluation scores are very high.

Engineering design process with team design challenge #2. After finishing design challenge #1, the students are asked to regroup their design teams for engineering design challenge #2, to be performed for a period of six weeks. Table VII shows the overall theme, potential project areas/topics and design guidelines used for design challenge #2 of this course. Since design challenge #2 work requires each design team to build and test product prototypes and mock-ups, additional periods of time were given to the students

TABLE VII
OVERALL THEME AND GUIDELINE FOR DESIGN CHALLENGE #2

OVERALL THEME: "Developing/Designing the System/Device Related to Energy & Water Sustainability" **POTENTIAL PROJECT AREAS/TOPICS:** • (General) energy and/or water savings, renewable energy, fuel resources and supply, etc. • Water production, maintenance, purification, etc. • Water and thermoelectric power interdependency **DESIGN GUIDELINE:** • Identifying the global water & energy related issues • Generating concepts (or ideas) - potential solutions • Developing an innovative solution & considering its impact on the energy/water issues • Designing/developing system/device & its working principle(s) with some degree of entrepreneurial aspect to the products/system • Developing virtual (UGS NX) models and building & testing (small-scale) prototype (mock-up) system/device • Finalizing the design project – report, presentation & poster

The author's previous work [5] describe the details of some of students' work for design challenge #2 and the corresponding measured outcomes with the appropriate rubric which is related to the 3C's of entrepreneurial mindset. It was apparent that the students and their design teams used their imagination and creativity to create a product (system and/or device) related to the project theme, "*Energy and Water Sustainability*." It also shows that various types of multidisciplinary topics have been selected by the design teams. Since the students practiced and experienced the engineering design process with an entrepreneurial mindset through design challenge #1 work, it was found that the students' motivation and performance on design challenge #2 works consistently improved.

ASSESSMENT ANALYSIS RESULTS OF HOW FRESHMAN ENGINEERING STUDENTS BUILD AN ENTREPRENEURIAL MINDSET

In order to indirectly assess or measure how the freshman engineering students built their engineering mindset through the two semesters of the engineering discovery courses, a course survey with a number of questions were given to the students twice – once at the beginning of the first (fall) semester and another at the end of the second (spring) semester. Table VIII shows three questions/cases among others. More than six hundred students participated in the survey for the past three academic years.

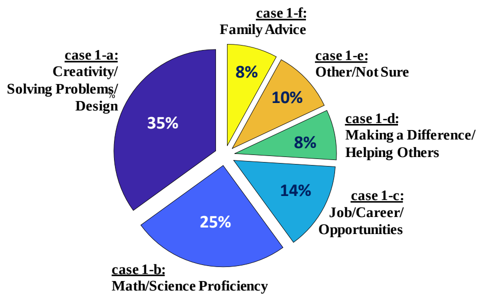
As shown in Table VIII, similar types of questions were used in the survey to compare and investigate how much the freshman engineering students' mindsets have been changed and built since they came to Marquette University – Opus College of Engineering. In this paper, proper keywords were selected and created to sort and categorize the survey results. For each case, lower-case letters were used to show different keywords for the survey results obtained at the beginning of the first (fall) semester while the upper-case letters correspond to those obtained at the end of the second (spring) semester.

TABLE VIII
LIST OF SAMPLE/SELECTED QUESTIONS GIVEN TO STUDENTS REGISTERED IN ENGINEERING DISCOVERY COURSES

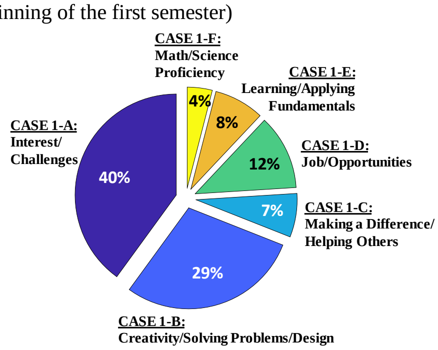
Questions given at the **beginning** of the **first** semester	Questions given at the **end** of the **second** semester
case 1: Why do you want to be an engineer and/or study engineering?	CASE 1: Why do you *still* want to be an engineer and/or study engineering?
case 2: What motivated you to come to Marquette University – Opus College of Engineering?	CASE 2: What (*and how much*) motivated you to *continuously study* at Marquette University – Opus College of Engineering?
case 3: What is your goal as an (future) engineer?	CASE 3: What is your *eventual* goal as an (future) engineer?

Category case/CASE 1 – survey analysis results: Figures 4 and 5 show the distributions of different keywords obtained from the survey category ***case/CASE 1*** shown in Table VIII. The statistical data displays information about some of the main reasons why the freshman engineering students want to be an engineer and/or study engineering. Survey results show that there are some changes for the major items - ***case 1-a*** with 35% into ***CASE 1-B*** with 29% and ***case 1-b*** with 25% into ***CASE 1-F*** with 4% (significant change).

A new item, ***CASE 1-A*** with 40%, is generated after the students take the engineering discovery courses integrated with EML, through which they have experienced and participated in various multidisciplinary class activities, including those with engineering analysis and design work since they entered engineering school. Figures 4 and 5 also show that other items are not significantly changed, such as ***cases 1-c*** with 14% into ***CASE 1-D*** with 12% and ***case 1-d*** with 8% into ***CASE 1-C*** with 7%.



(Obtained at the beginning of the first semester)



(Obtained at the end of the second semester)

FIGURE 4

CATEGORY case/CASE 1 – SURVEY ANALYSIS RESULTS

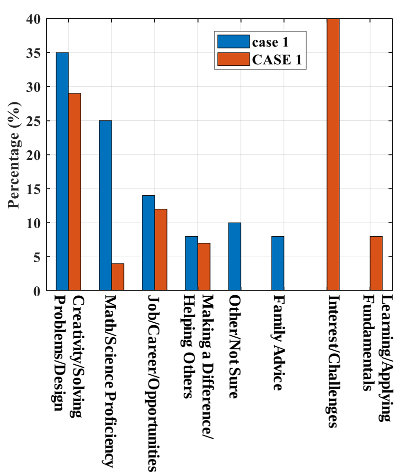


FIGURE 5

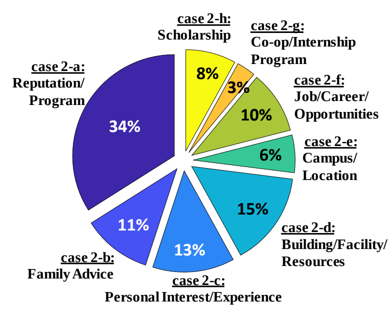
CATEGORY case/CASE 1 – OVERALL SURVEY ANALYSIS RESULTS

In order to investigate the variations and status of developing freshman students' engineering mindset during their first year of college, the survey analysis results obtained during the period of fall of 2010 though spring of 2015 [3] have been explicitly compared to the current survey analysis results obtained for the past three years. Table IX shows that ***case 1-b*** has been decreased from 29% to 25% while ***case 1-f*** increased from 4% to 8%. Analysis of the survey shows that ***CASE 1-B*** and ***CASE 1-D*** have increased from 21% to 29% and from 9% to 12%, respectively, while ***CASE 1-A*** and ***CASE 1-C*** decreased from 42% to 40% and 13% to 7%, respectively.

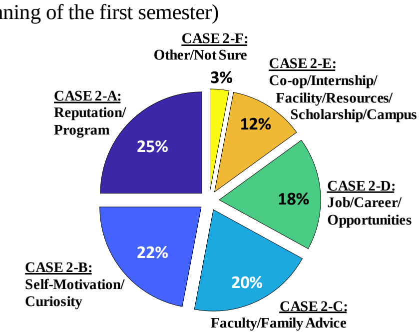
TABLE IX
COMPARISONS OF SURVEY ANALYSIS RESULTS FOR CATEGORY case 1 & CASE 1

Survey Period	Survey Data Analysis Results (%)	
	Fall 2010 ~ Spring 2015	Fall 2016 ~ Spring 2018
case 1-a	*34*	*35*
CASE 1-A	42	40
case 1-b	*29*	*25*
CASE 1-B	21	29
case 1-c	*13*	*14*
CASE 1-C	13	7
case 1-d	*11*	*8*
CASE 1-D	9	12
case 1-e	*9*	*10*
CASE 1-E	8	8
case 1-f	*4*	*8*
CASE 1-F	8	4

Category case/CASE 2 – survey analysis results: Figures 6 and 7 show the distributions of different keywords obtained and selected from the survey category case/CASE 2 shown in Table VIII. The statistical data displays information about what, and how much, the freshman engineering students were motivated to study engineering before and after taking the engineering discovery courses integrated with EML.



(Obtained at the beginning of the first semester)



(Obtained at the end of the second semester)

FIGURE 6

CATEGORY case/CASE 2 – SURVEY ANALYSIS RESULTS

It can be seen that there are some changes for the major items – ***case 2-a*** with 34% into ***CASE 2-A*** with 25%, ***case 2-b*** with 11% into ***CASE 2-C*** with 20%, and ***case 2-f*** with 10% into ***CASE 2-D*** with 18%. It was found that item ***case 2-c*** with 13%, is transformed into the new item, ***CASE 2-B*** with 22%, after the students go through the engineering discovery courses integrated with EML. Figures 6 and 7 also show that the items ***case 2-d***, ***2-e***, ***2-g*** and ***2-h*** with 32% are changed into the item ***CASE 2-E*** with 12%.

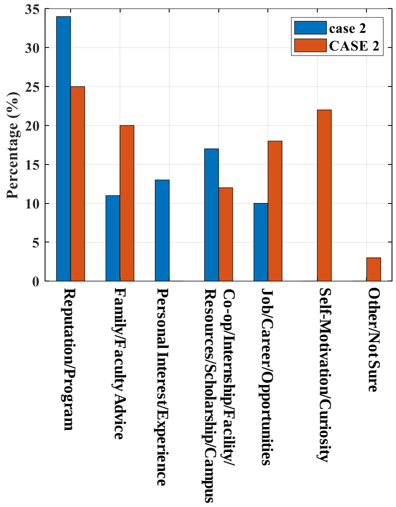


FIGURE 7

CATEGORY case/CASE 2 – OVERALL SURVEY ANALYSIS RESULTS

TABLE X

COMPARISONS OF SURVEY ANALYSIS RESULTS FOR CATEGORY case 2 & CASE 2

Survey Period	Survey Data Analysis Results (%)	
	Fall 2010 ~ Spring 2015	Fall 2016 ~ Spring 2018
case 2-a	33	34
CASE 2-A	23	25
case 2-b	16	11
CASE 2-B	21	22
case 2-c	16	13
CASE 2-C	20	20
case 2-d	11	15
CASE 2-D	18	18
case 2-e	8	6
CASE 2-E	11	12
case 2-f	7	10
CASE 2-F	7	3
case 2-g	5	3
case 2-h	3	8

In order to investigate the variations or status of developing freshman students' engineering mindset during their first year at college, the survey analysis results obtained during the period of fall of 2010 though spring of 2015 [3] have been explicitly compared to the current survey analysis results obtained for the past three years. Table X shows that ***case 2-b*** and ***case 2-c*** have decreased from 16% to 11% and from 16% to 13% respectively, while ***case 2-f*** and ***case 2-h*** increased from 7% to 10% and from 3% to 8%, respectively. It can be seen that ***CASE 2-A*** and ***CASE 2-B*** have increased slightly while ***CASE 2-F*** decreased from 7% to 3%.

Category case/CASE 3 – survey analysis results: Figures 8 and 9 show the distributions of different keywords obtained/selected from the survey category *case/CASE 3* shown in Table VIII. The statistical data displays the information about the goal that the freshman engineering students may have as a future engineer.

It can be seen that there are some changes for the major items – ***case 3-a*** with 25% into ***CASE 3-B*** with 18%, ***case 3-b*** with 29% into ***CASE 3-D*** with 19%, ***case 3-c*** with 20% into ***CASE 3-C*** with 19%, and ***case 3-d*** with 19% into ***CASE 3-A*** with 40%. From the significant percentage change of the item, ***case 3-d*** into ***CASE 3-A***, it is clear that the freshman engineering students have experienced and built a engineering entrepreneurial mindset through the freshman engineering discovery course integrated with EML.

In order to investigate the variations or status of developing freshman students' engineering mindset during their first year of college, the survey analysis results obtained during the periods of fall of 2010 though spring of 2015 [3] have been explicitly compared to the current survey analysis results obtained for the past three years. Table XI shows that ***case 3-a*** has decreased from 29% to 25%, while ***case 3-b*** increased from 27% to 29%. It can be seen that ***CASE 3-A*** and ***CASE 3-B*** have slightly increased, while ***CASE 3-F*** decreased from 4% to 1%.

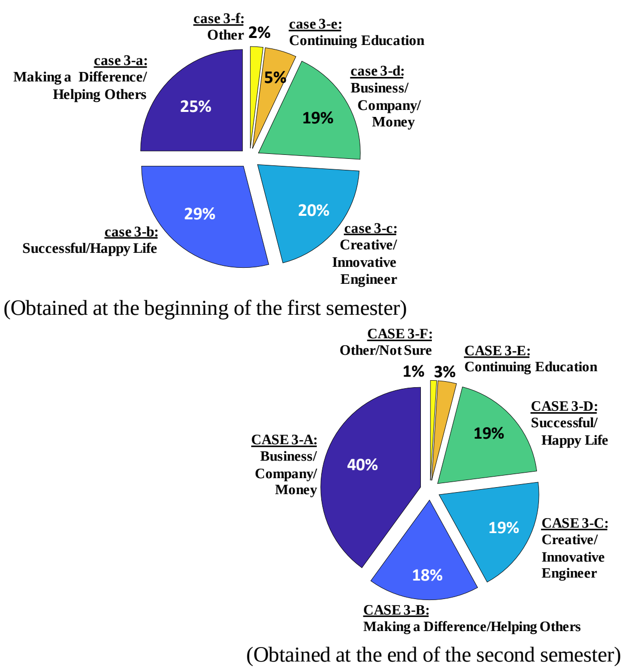


FIGURE 8

CATEGORY case/CASE 3 – SURVEY ANALYSIS RESULTS

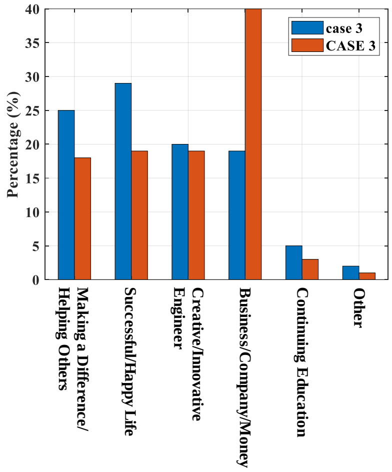


FIGURE 9

CATEGORY case/CASE 3 – OVERALL SURVEY ANALYSIS RESULTS

TABLE XI
COMPARISONS OF SURVEY ANALYSIS RESULTS FOR CATEGORY case 3 & CASE 3

Survey Period	Survey Data Analysis Results (%)	
	Fall 2010 ~ Spring 2015	Fall 2016 ~ Spring 2018
case 3-a	***29***	***25***
CASE 3-A	**38**	**40**
case 3-b	***27***	***29***
CASE 3-B	**19**	**18**
case 3-c	***19***	***20***
CASE 3-C	**18**	**19**
case 3-d	***18***	***19***
CASE 3-D	**17**	**19**
case 3-e	***5***	***5***
CASE 3-E	**4**	**3**
case 3-f	***3***	***2***
CASE 3-F	**4**	**1**

SUMMARY AND CONCLUSIONS

The *Freshman Engineering Discovery* courses integrated with entrepreneurially minded learning (EML) developed and currently running at Marquette University – Opus College of Engineering provide an opportunity for freshman engineering students to be able to see and lay out their vision as an engineering student and future engineer. They also realize the types of knowledge and skills necessary to succeed as an engineer, and discover their way towards the engineering disciplinary area of their interest.

Through various course contents and activities, new engineering students learn to create new innovative ideas and concepts with the potential to invigorate existing markets and technologies. This course is also designed to create students that are curious about the world around them, unafraid to challenge existing methods, able to identify unexpected opportunities for growth and eager to seek out innovative solutions to challenging problems. As a result, this course provides new engineering students with a vision to become a future engineer with an engineering entrepreneurial mindset.

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