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Free Your Mind: Unlock Your Inner Creativity

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Abstract - **Creativity is a major factor in many careers, subjects, and disciplines. Although many people first assume engineering to be a field of study that does not require any creativity, it is actually an essential tool for successful engineers. The mark of a truly accomplished engineer is the ability to problem-solve effectively; in other words, to generate creative solutions. Although the goal as engineers is to become more creative throughout one's career, is it even possible to gain creativity? Is creativity an innate quality, or a learned one? Since the engineering process demands creativity, we looked into how creativity can be improved, and how exactly it is used in the engineering design process. We surveyed engineering freshman students to determine how they view themselves and how important they think creativity is in relation to engineering. We then conducted research to see what creativity means to different people, how one can improve creativity according to various theories, and how creative processes have been used in past engineering projects. We presented this information to all sections of a second-semester engineering freshman course and surveyed the students at the beginning and end of the lecture to see how their views changed. We evaluated this data to discover if students perceive creativity as learned or innate and how it affects their ideas on engineering. The students showed an improvement in awareness of the importance of creativity in engineering and how often it is used. Many did not change their opinion of themselves with regard to creativity but some actually ranked themselves lower after the presentation, presumably because they realized the extent of how creative some people are, especially in regard to engineering. The other data we analyzed was student responses to short questions. We asked students what qualities they associate with creative people and the most commonly used words were "thinks outside of the box," "innovative," "confident," and "open minded." We also asked what the best techniques for improving creativity within a group are. The most common answers were "different backgrounds," "different ideas," "being comfortable," and "diversity." These answers mirrored the overall message we attempted to portray throughout our presentation to a fair degree.**

Keywords: Creativity, Engineering Design, Undergraduate Education, Assessment

I. INTRODUCTION

Creativity and its importance in the workplace are not often thought about in too much detail since people often believe they cannot change their creative abilities. Numerous professionals throughout the past few years have studied creative processes in different fields to better understand how it develops and how it can be applied. There has been research into how to best use creativity in engineering as well as research on the philosophy of group dynamics. There is work being done to see if the brain can help unlock some secrets of what makes a person creative. There are also several theories on whether creativity is learned or innate, and if it is learned, how it can be improved.

A. Creativity and Engineering

Even though engineering differs from many careers commonly related to creativity, such as arts and music, the importance of creative thinking is still vital in the field. One must approach a project with an open mind and be capable of generating new ideas in order to achieve success. When facing a problem in engineering, occasionally there is an obvious answer, but more often than not some level of creativity is required to obtain an elegant and efficient solution. Lumsdaine and Lumsdaine [1] argue that creativity is of utmost importance; however, in many cases the education systems tend to hinder the development of the skill. Schools tend to shape the minds of the students to more aptly retain large amounts of information, instead of to teach how to approach a variety of different, complex problems. With today's continuously changing culture, the ability to use resources in a creative and flexible manner is essential.

There is no set model for each new problem that arises during projects, no step-by-step process to obtain an answer; thus, a successful engineer must be able to use the surrounding resources to arrive at a unique solution. The techniques taught in many schools, to plug variables into given equations to obtain a solution, do not efficiently develop creative problem solving ability. Instead, they teach to tests such as the ACT and SAT. There is a demand for engineers, as well as other professionals, to have certain skill sets, to be able to generate solutions when they are not apparent. Yet, if it is not taught in school how to effectively be creative, how does one go about understanding the essentials of creative problem solving?

There are many theories detailing strategies and techniques to improve creativity. At the foundation of many of these is the idea that creativity is a developed skill. Often engineering firms require group effort. Although in groups it may seem easier to come up with more creative solutions, there are many ways that group work can hinder creative thinking. Fogler and LeBlanc [2] discuss several of the most common problems that groups may run into, such as not having a clear mission, overbearing "experts" who prohibit others from participating to their full extent, and unquestioned acceptance of opinions. One must be aware of these and other potential hindrances and consciously try to prevent them when working in a group setting.

Identifying the issue is the first of many areas in problem solving or engineering design where one could potentially fail to use creativity. In most cases, problems are multifaceted; there are several paths to start an analysis and they all would lead to different solutions to the original problem. Creative people are more likely to spend a longer amount of time assessing their different options before embarking on forming a solution [3]. This issue is important because it shows that even before the solutions are being formed, creativity is prevalent and important in the process. To be an engineer without creativity would result in being ill suited for all but the most remedial tasks. It is important to consider the benefits of learning about creativity and how to enhance one's personal creative techniques.

B. Neuroscience

Over the past sixty years, the interest in the neuroscience behind creative thought has surged. Countless experiments have been conducted, each attempting to pinpoint exactly what is occurring in the brain during the creative process. There are several aspects of creativity that have been tested in such experiments, each employing vastly different testing methods. The primary methodologies used by neuroscientists in these experiments are based on the results of electroencephalography (EEG), positron emission tomography (PET), or functional magnetic resonance imaging (fMRI) tests. An EEG detects electromagnetic fields generated by brain activity through sensors placed on the scalp. While it can detect changes in activity almost immediately, it can be difficult to determine the location of the activity. PET measures neural activity by monitoring changes in blood flow in certain regions of the brain. It takes longer than EEG (about forty seconds) but it can be more helpful in determining the specific brain regions in which activity occurs. fMRI is the most common of these techniques; it uses a magnetic field to detect the ratio of oxygenated to deoxygenated blood. When activity increases in a region, the blood flow increases faster than oxygen is used [4]. While all of these methods are helpful in the scientific study of the creative process, it can be difficult to rely on any one test or trial. Many trials must be conducted, often using a combination of methodologies, in an attempt to increase the accuracy of conclusions.

There are several problems that arise when reviewing experiments related to brain activity and creativity. The first of which is the question of how creativity can be measured. Many researchers rely on tests that incorporate divergent thinking, but this does not always guarantee creative thought. There is inconsistency in defining what exactly creativity means. Keeping these concerns in mind, most researchers have chosen to use either the Torrance test [5] or Williams' Creativity Assessment Pack (CAP) test [6], both of which are designed to measure test subjects' ability to use divergent thinking. In reviewing 72 published experiments, the most recent published in the spring of 2010, Dietrich and Kanso [7] show that many of the conclusions are contradictory. This leads to the even bigger problem of determining which data is more reliable. There is a wide variety in the data gathered, which makes it nearly impossible to draw conclusions on which specific part of the brain is responsible for creativity, or, more accurately, is responsible for divergent thinking. However, there was one conclusion that seemed fairly clear from the data: creative thinking is tied to the prefrontal cortices. The question of which cortices are more involved than others remains hard to determine. In relation to right-brain versus left-brain dominance, the results of different experiments do not support each other. For example: Goel and Vartanian [8] reported right-sided activation while Chavez-Eakle [9] reported left-sided activation.

On the topic of dominance, Herrmann developed a complete theory of brain dominance referred to as the Herrmann Brain Dominance Instrument. In the Herrmann model, the brain is divided into quadrants, each correlated with different characteristics and ways of thinking. Herrmann argues that Quadrant D, the upper right cerebral quadrant, is mainly responsible for creative thinking, which would seem to indicate that creativity is indeed right brain dominant (see discussion in [10]). However, data acquired from countless experiments fail to support any link between divergent thinking (creativity) and the right side of the brain. While the data does not disprove such dominance theories, it is also insufficient to fully support them.

C. Improving Creative Skills

Clearly there is much debate about the nature of the neurological processes of creative thinking. This ties into the bigger question of whether or not creativity can be learned or improved. As aspiring engineers, we decided to further analyze the idea of learning to be more creative. We began by taking a closer look at the history of creativity in general and the ways in which creativity has been used in engineering. This also required looking at different methods of developing creativity.

A major proponent of creativity as something that can be improved is Nordgren [11]. He believes that creativity can be found in everyone, but that each individual must consciously choose to take advantage of it. Nordgren also argues that channeling one's creativity is key to becoming successful in the business world. Due to efforts of other individuals who share Nordgren's beliefs, the concept of being able to improve someone's level of creative thinking is becoming more widely accepted.

Current research regarding creativity, how it exists, and whether or not it can be improved is found in multiple areas of study. In nearly every branch of academia, there is a desire to understand creative processes and how they can be improved, since the majority of career fields can benefit from more creative personnel. An interesting distinction in personal creativity that is currently being explored is whether creativity is found in a person as a whole, or if it is only expressed in certain characteristics of a person. If the latter is true, it could stand that everyone is creative in certain areas, but not necessarily in others, and that some people may not perceive themselves as creative simply because they have not developed their specific creative characteristics. Research on the differences between domain specific theories and general creativity theories have been debated and explained by Baer [12]. His argument of domain specificity supports the argument that creativity lies in nearly everyone, and can be unlocked if only one knows where to look for it.

Research on personality traits is also being done to better understand the roots of creativity. It is often assumed that artists and musicians are more creative than mathematicians and scientists, but is there any proof to that assumption? Walonick [13] discusses what it means to “be creative”, and how there is more than one interpretation of the term. Using the work of Wycoff [14], a creativity consultant, Walonick details four common traits found in creative people: they are willing to take risks and have the courage to be wrong, they are willing to express their thoughts and feelings, they have a sense of humor, and they accept and trust their own intuition. These traits are interesting because some people could argue that these things can be taught, but others would say they are innate.

It is also important to note that these are not the only set of characteristics used to define or categorize a creative individual. Other theories discussing personality traits have arisen, such as the ideas from Ogot and Okudan [15]. They believe that creativity is based on four things also: desire and fulfillment, knowledge of objects and principles possessed, openness and willingness to accept criticism from others, and knowledge of processes, especially design and problem solving in regards to engineering. Their theory argues that creativity can be learned, since knowledge of processes and knowledge of objects and principles can be learned by anyone who has the drive. The other two traits are more difficult to teach. Being able to identify what helps people stimulate creative thinking is a step in the correct direction in terms of utilizing and enhancing creativity processes not only in engineering, but in nearly any career.

D. Goals

The primary objective of this study was to observe how freshmen engineering students perceive themselves and their creative abilities, both before and after they were given a brief presentation on creativity. The authors are a group of honors engineering freshman students, their faculty advisor and instructor, as well as two collaborating engineering faculty. We wanted to see if our presentation would have an impact on their outlook in regards to their career path and its creative elements. The hope was that the presentation would help the students realize their own creative potential, as well as to argue for the importance and necessity of creativity in the field of engineering. Due to the nature of the lecture, it would have been very difficult to cause a strong change in the students’ creative abilities; thus, we aimed instead to present a variety of proposed methods of improving creativity and to discuss how each method could be applied in an engineering setting.

II. PROCESS

The process that we went through for our research on how students view themselves with regard to creativity and the way that they view creativity in regards to engineering began in spring 2012. At the University of San Diego all first year engineering students are enrolled in ENGR 102: Introduction to Engineering Design. The honors section of this course took on the task of understanding and teaching the other ENGR 102 students the importance of creativity. After we conducted research on theories about creativity, we developed a lecture to teach the Engineering 102 student what we had learned. We then went through the IRB process to get the research approved. Before and after viewing the lecture the students all took a survey on how they felt about creative processes and if their views changed after hearing about current research.

A. Lecture Material

At the beginning of the 45-minute lecture, the students participated in a couple of brain teasers, to get them thinking about problem solving. We used an interactive activity where students had to rearrange a couple of cups of juice to get them in a certain order in the minimum number of moves. Not an obvious solution, it required the student to recognize the unwarranted assumption that cups can only be moved and not poured.

Once the opening activities were completed, we went over the physiological processes of creativity. The information on the differences between creative thinkers and the general population was easier to explain than the breakdown of what part of the brain does what job. The explanation was put into simple biological terms, but it was still hard to discuss neurological processes when, in general, the audience did not have a background in biology.

The next subject covered was personality traits and how they relate to creativity. Some of the key characteristics include a desire to test unknowns, an ability to visualize, and possess a multitude of opposing traits. These characteristics sound similar to what one thinks of when thinking about characteristics of engineers in general;

usually engineers are curious, want to test unknown possibilities, and have the ability to visualize changes.

Before deciding on how to teach creativity, one has to consider whether creativity can even be taught. The lecture also went over the two sides of the nature versus nurture argument: whether we are who we are because we were born this way or because we were raised this way. This part of the lecture was one of the most influential topics, as teaching creativity does not seem to be a widely accepted notion. After discussing right-brain dominance versus left-brain dominance, we closed the topic with another activity. We drew a nine dot problem up on the board, where students had to connect all the dots without lifting their pencils. We had students try to solve it on the board. Interspersing several tests that involved divergent thinking was a way to keep the students interested, and also showed how creativity is helpful in a multitude of situations.

We then talked about the difference between general intelligence and creativity. People often confuse the two as being synonymous, but tests that measure general intelligence tend to miss creativity. We went over Sternberg's [16] writing on what intelligence is and the three types of intelligence. We went over the meaning of knowledge and how it is being able to recognize information that is genuinely new. Sternberg's theory also covers the thinking style, personality style, and motivation of creative people. It is about questioning the known information, taking risks, and being able to stay motivated. To conclude the portion about intelligence and creativity, we restated the idea that tests miss creativity. One test in particular that every audience member is familiar with is the SAT. We talked about studies that show that high SAT scores do not automatically guarantee success later on [17]. We tried to emphasize that intelligence and creativity combined is what brings a new perspective to problem-solving, as well as providing the best odds for success.

The next lecture topic was on professional creativity. We talked about Sweden's soccer players and how professional athletes demonstrated above average creativity arguably linked to improvisation in competition [18], briefly summarized Nordgren's [11] ideas on creativity, and then transitioned into creativity within engineering. We began with engineering design theories of creativity. We tried to explain each one in a way that everyone could understand, but it was a lot of information to cover. The two that seemed easiest to explain were overcoming contradictions (solving a problem without compromise) and function sharing (simplifying a design whenever possible). The creative industry slide probably interested the audience more than the theories, as it talked about how jobs that incorporate creativity are likely to not only command a higher salary, but also be more enjoyable for employees. Everyone in the room would love to be a Disney "imaginer" [19], for example. From there, we discussed the common barriers to innovation. The first of these roadblocks was small group dynamics. Everyone in the room can understand how working in a small group tends to stifle creative thinking and going outside the box, especially after all the group work in engineering freshman labs. When in a group, it is not as simple as trying out ten different ideas; everyone has to agree on which idea to try and which to dismiss. This also ties into the problems with departments and poor leadership.

The main goal of the lecture was to show that creativity is important, necessary, and accessible in nearly every situation and every person. It is beneficial to think of oneself as creative and try to enhance it to improve countless situations.

B. Assessment

Before and after the lecture, students filled out a survey which had questions ranking how creative each student believed they were and how important creativity is for engineering. They ranked their answers on a scale from 1 to 10. This scale was later found to be too large, but we were able to use the results regardless. We created the survey using a before and after method. The students filled one out before viewing our material, then filled out the same questions along with a few extra short answer questions after the presentation so a comparison could be made on how their opinions changed and what they learned. The questions asked the students to think about how creativity is applicable to the field of engineering as well as their own everyday lives. These questions allowed us to evaluate what students knew about creativity as well as to see the effectiveness of the lecture material.

C. IRB Process

To get the research involving human subjects approved we became familiar with the Institutional Review Board (IRB) process and obtained IRB certification. We then created the presentation and the survey to give to the ENGR 102 students. These students were our pool to gauge what engineering students already know about creativity and how they regard themselves in respect to creativity. We then completed and submitted an IRB application. It required a statement of purpose and that all materials that would be used during the study are attached. We also had to justify any risk that the study put the participants in and write a form to get signed informed consent. The form was mostly a technicality because the creativity research did not involve any risk beyond that encountered in daily life to the subjects and the study was completely optional. After addressing a couple of suggestions, the proposal was approved.

III DATA ANALYSIS

The survey for the creativity presentations included two parts: a pre-lecture survey and a post-lecture survey. The pre-lecture survey was designed to test preconceived notions about the subject of creativity as it relates to successful engineering practices, the subject's own self-awareness about his or her own creativity, and whether or not creative approaches have worked in the past. These first three questions were administered before the lecture and were all quantitative. Subjects were asked to grade these questions on a scale of one to ten with one being the lowest in necessity, creativity, or effectiveness respectively. The post-lecture survey was administered after the lecture and included the same three original questions along with four questions that required qualitative answers. These four questions asked: what the subject felt were traits and characteristics of a creative person; the best ways to enhance creativity in small group settings; scientific and technological innovations that were made possible with creativity; and challenges overcome with the robots used during the first semester.

These final four questions were asked after the conclusion of the lecture to encourage reflection on the lecture topics and personal revelations about the subject's own self-awareness of their creativity. The qualitative questions that preceded them served a similar function. They were the exact same questions asked in the pre-lecture survey, however they were asked at the conclusion of the lecture. These questions were used to record the trend of improvement of how the subject viewed himself or herself creatively after seeing the lecture material on creativity with the pre-lecture questions serving as a calibration tool.

A numerical difference, if positive, would denote an improvement on an individual level in the understanding of creativity and a heighted self-awareness. A negative difference denotes a stark realization on the individual level gained through the presentation that the subject was not as creative as they had thought or that creative practices were not as important or necessary. A null difference would denote no change for an individual.

A. Initial Analysis of the Common Three Questions

In our survey, 67 sets of results were included. As previously stated, the first three questions were common to both surveys. As such, it was possible to directly compare individual as well as group responses pre- and post-lecture. A qualitative analysis of these three common questions follows: detailed statistical analysis on them follows in section IIIB.

1. *Do you consider yourself a creative person? Rate yourself on a scale of 1 to 10 with 1 being not creative and 10 being highly creative.*

The distribution of pre- and post-lecture responses to this question is shown in Fig. 1.

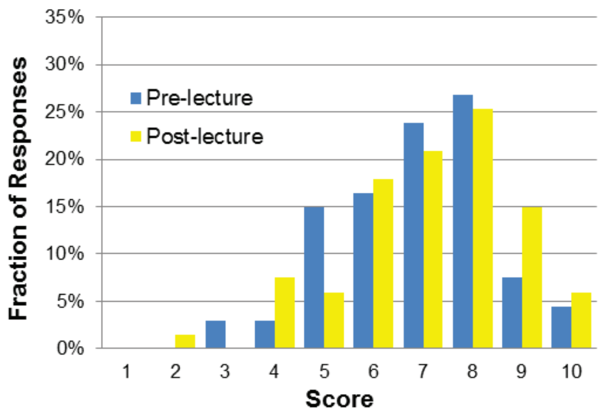

Fig. 1. Pre- and post-lecture results for question 1

The distribution shows some positive shift in responses due to the lecture: the mean score increased from 6.88 to 7.13 with 34% of the individuals reporting an increase and 18% reporting a decrease in their perception of self-creativity.

2. *Do you consider creativity necessary for solving engineering problems? Rate your decision on a scale from 1 to 10 with 1 being not necessary and 10 being absolutely necessary.*

The distribution of pre- and post-lecture responses to this question is shown in Fig. 2.

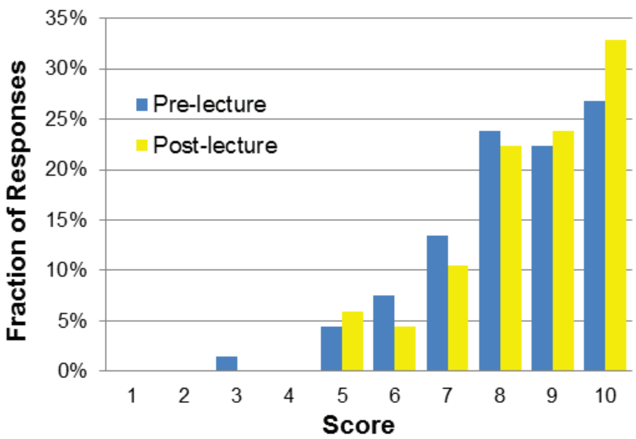

Fig. 2. Pre- and post-lecture results for question 2

Again there is some positive shift in responses due to the lecture: the mean score increased from 8.27 to 8.52 with 31% of the individuals reporting an increase while 12% reporting a decrease in their perception of the need for creativity in engineering problem solving.

3. *Have creative approaches been successful for you in any problems that you have been presented with? Rate yourself on a scale of 1 to 10 with 1 being not successful and 10 being highly successful.*

The distribution of pre- and post-lecture responses to this question is shown in Fig. 3.

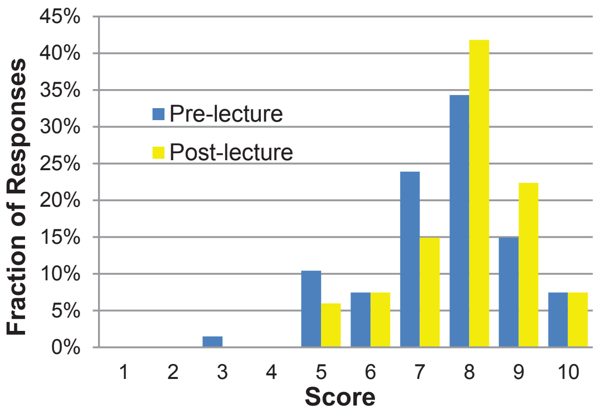

Fig. 3. Pre- and post-lecture results for question 3

There is positive shift in responses due to the lecture: the mean score increased from 7.52 to 7.90 with 28% of the individuals reporting an increase and 10% reporting a decrease in their perception of the need for creativity in engineering problem solving.

Overall in these three questions, there was a positive increase in higher numerical values of 8, 9, and 10, with a simultaneous drop in the lower numerical values of 5, 6, and 7. This indicated that numbers in the 5, 6, and 7 range could have moved to the higher 8, 9, and 10 range in the post-lecture survey. The final case for improvement rested with the frequency of the integers in the differences of the data sets. Here, the frequency of zeros, positives, and negatives was observed. Zeros occurred with 55% of the population, positives with 31% of the population, and negatives with 13% of the population. From this perspective, a negative shift only occurred with about one fifth of the group. One third remained stagnant and almost half saw a positive shift.

Overall, based on qualitative analysis of the numerical data, there seems to be a general positive shift in the population in the understanding of creativity.

B. Statistical Analysis of the Common Three Questions

Until this point, the analysis has been purely practical and intuitive with assumptions on the data being made with basic mathematical analysis of means and frequencies. To analyze this data, a Wilcoxon signed rank

[20] test is appropriate. For this test, two populations of nonparametric data were required. The Wilcoxon test compared the two sets of data and tested to see if there was a statistically significant change in distribution between the two.

The results represented two populations of nonparametric data required for the Wilcoxon test. This test determined if the null hypothesis could be rejected. The null hypothesis means that there is no change in the distribution for the data for a $p < 0.05$.

The test indicated that the overall grouping of scores (totals) was significantly different from pre to post-test ($W = 217$, $z = -3.3919$, $p < .05$, two-tailed test). Therefore, there exists a statistically significant result that there was a change in the distribution of the pre and post-test results for the totals that represents a positive increase. For Question 1 ($W = 201$, $z = -1.8672$, $p < .05$, two-tailed test) and Question 2 ($W = 130$, $z = -1.89203$, $p < .05$, two-tailed test), the z-stat reflected that there was no statistical significance in the distribution of the data with respect to pre and post-lecture surveys. However, the table for W values of the Wilcoxon Test for a two-tailed test with $p < 0.05$ put both of these W values for Question 1 ($W = 201$, $n = 35$) and Question 2 ($W = 130$, $n = 29$) just over the critical W value. It was a requirement that the W values be less than the critical values. For Question 1, the critical value was 195 at $n = 35$ and $p < 0.05$, a difference of 6 points. For Question 2, the critical value was 126 at $n = 29$ and $p < 0.05$, a difference of 4 points. Furthermore, if a z-stat (tie adjusted) score was used for both Question 1 (z-tie adjusted = -1.9670, z-critical = 1.95996) and Question 2 (z-tie adjusted = -1.9870, z-critical = 1.95996), the z-stat score was above the critical value, while only slightly. However, the original z-score indicates that there was no statistical significance.

The fact that the data was close to both the W critical value and the z-stat (tie adjusted) critical values for both Question 1 and Question 2 argued for a practical significance in the data. While not statistically significant, the data still increased in distribution despite failing the necessary results to reject the null hypothesis and a practical argument can be made with the results for a change in distribution. The third question, Question 3 ($W = 65$, $p < .05$, two-tailed test) had a statistically significant change in distribution.

The results for the Wilcoxon test are displayed in Table 1 along with the Wilcoxon critical values.

TABLE I Wilcoxon results for questions 1-3

	Wilcoxon Result	n	Critical Values
Totals	217	45	343
Question 1	201	35	195
Question 2	130	29	126
Question 3	64.5	26	98

C. Observations on the Four Questions Unique to the Post-Lecture Survey.

The final four questions of the post-lecture survey related to material presented in the lecture and personal experiences.

4. What *are various characteristics that you would use to describe a creative person?*

Question 4 asked the survey takers to list the attributes of a creative person. There was a wide range of answers, but the most common by far was someone who can "think outside the box". The responses to this question are described by a Wordle Diagram [21] shown in Figure 4.

Seventeen people answered the question as such. No other attributes come close to being chosen as frequently. There were four adjectives written by at least six people: innovative, intellectual, open-minded, and problem solver. This was less than half the amount of people who chose the first answer. Occasionally there were longer explanations of the words, but for the majority there were only adjectives listed. Two people said that there were various personalities for creative people, and that there was no way to pinpoint one certain creative trait.

Fig. 4. A Wordle Diagram representation showing the frequency of responses to question 4. Larger words correspond to a higher frequency.

Fig 5. A Wordle Diagram representation showing the frequency of responses to question 5. Larger words correspond to a higher frequency

5. What do you think is the best way to enhance creativity in group settings? Why?

The fifth question asked how to improve creativity within a group. The key word in the responses for this question was "different". All of the most popular responses contained this word: different backgrounds, different ideas, and different people. The main point that most of the responses hit on was the need for diversity. Another important idea in the responses to this question was the need to share and combine ideas. Many survey takers said that it was important to share their own ideas and keep an open mind to other peoples' ideas. The responses to this question are described by a Wordle Diagram shown in Figure 5.

6. Name a technological or scientific innovation that required creativity. Do you think that this innovation would have been possible without the creative breakthroughs behind it?

One of the qualitative questions we asked the students was to list a creative invention. There was a wide range of answers, but there were a few that came up more often than others. The most popular creative invention that was listed was the cell phone. It is interesting to note that while seven students listed "cell phone" as their answer; five other students wrote "iPhone" as theirs. There is some ambiguity in analyzing these two answers. On one hand, they can be seen as virtually the same answer, because the iPhone is a type of cell phone. However on the other hand, some students could have chosen the iPhone because of its innovation in the cell phone industry, which would then separate the iPhone from the cell phone in the analysis. These two answers are significant because the amount of students who listed either of these is double that of the next highest answer, the car, listed by six students. An iPad, computer, and light bulb were chosen four times each. The light bulb represents the only item in the most popular inventions that is not technology that has been recently developed. There were many students who chose inventions that no other students chose; some of these are the wheel, the Tesla generator, and the sewing machine.

7. How would you describe the creativity that you employ when solving problems related to engineering, such as problems last semester with the robots? Did you use any creative approaches to solve these problems? Did you think that these approaches worked well?

Not all participants answered each of the three parts of question 7; about half of the participants left at least one of the three parts blank.

Some answers were too ambiguous to interpret with confidence. Other people were unable to answer the last two parts of the question because they were not at USD for their first semester. Few people actually wrote their answers in complete sentences; most used roughly five words on each part of the question that they were answering.

Many people did not "describe the creativity" that they used to solve problems, but instead stated a problem that they overcame, such as "how to improve going around obstacles." The question was not answered as intended making results difficult to analyze.

D. Error Analysis

Sources of error in gathering the data include the self-rating scale and differences in presentation. The self-rating scale asked participants to rate themselves on a scale from 1 to 10 where each question defined the relative strength of the values. The issue with this scale was that it offered too broad a spectrum of numbers; few participants felt inclined to dip below 5 unless the matter was extreme and for moderate to the opposite extreme others stuck to the 8, 9, and 10. Furthermore, the broad spectrum could have been confusing. On a scale of 1 to 10, the qualitative difference for a particular individual between 7 and 8 may have been minimal and the actual assessment of that individual's choice may have been misrepresented. For these reasons, a scale ranging from 1 to about 5 may have been more reasonable. Attaching a definition to a number such as "strongly agree" for a value of 5 could have also made the scale more comprehensive and more easily understood.

The difference in how the presentations were conducted could have affected the data. A different two-person group gave each presentation; therefore, no presentation was exactly the same. Particular groups could have been more motivating and thus received more positive results. On the other hand, a more dull presentation could have caused participants to lose interest and not take the test as seriously. A goal of the class was for the members of the honors section to gain the experience of preparing, presenting, and assessing a lecture on creativity. Since the lecture was given by different pairs of students, an intrinsic variability due to presentation styles was unavoidable and contributed to a possible unseen effect on the collected data.

IV CONCLUSION

We originally set out to gain a better idea of how our fellow freshman engineering students viewed the relationship between creativity and engineering. In order to pursue such an objective we first had to gain a broader perspective on the state of creativity research in general. While there remain many unresolved questions about the neurological processes behind creative thought and whether creativity is innate or learned, we presented a lecture to our peers on a basis that creativity is something we should all strive to incorporate into our engineering careers. We looked into research on neurological studies that try to figure out what in the brain relates to creativity. There is a lot of research being conducted about how to improve creativity. One of the theories is that creativity is domain specific, so it is necessary to focus on creativity in certain traits. There is also a lot of work on personality traits relating to creativity. Overall, the research we looked into taught us about the various methods for improving creativity in minor ways, and applying those improvements to engineering.

After collecting theories on how best to improve creativity, we presented to the ENGR 102 classes. They filled out a pre survey, watched and participated in the presentation, then filled out a post survey with the same questions as the pre with a few qualitative questions added. During the presentation the students participated in some creativity tests to give them an idea of how creative they can be when they try. We then gave them information on research being done on creativity, how it is believed to be improved, and what they can do to apply creativity to engineering. The questions in the survey included questions asking them to rank themselves on how creative they are, and asked them which characteristics apply to creative people. The most common answer was “thinks outside the box” which was an expected answer.

After analyzing the results from the surveys, several conclusions can be made. The first is that the presentation definitively altered the students’ perspective on the importance of creativity in the field of engineering. One of the focuses of the lecture was to illustrate how often creativity is necessary in the many types of problem solving that engineers, and many other professionals, face. The presentation showed that creativity can be useful in nearly every aspect of careers and lives. One of the results we found most surprising was that some students saw themselves as less creative after the lecture; we can only assume this is because they realized how great the potential is for incorporating creativity into even the simplest problem solving tasks which they had not done yet. The rest of the results were mainly as expected, but we were glad to see that some of the answers did improve after the presentation.

We set out to find out if creativity is necessary and if it can be improved. We found that the answer to both of those questions is yes and that we just need to figure out how. Presenting this information to the engineering students gave them some insight into how they can help improve their own creativity and utilize it in the future. As more research is done, we hope that more improvements can be made and engineering and all other career fields will benefit.

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