Re:IED

Rethinking Introduction to Engineering Design

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Introduction

Students in mechanical, civil, computer & systems, aeronautical, and other engineering disciplines are all required to take a course called "Introduction to Engineering Design (IED)" usually around their sophomore year at Rensselaer Polytechnic Institute. This course is four credits and its description is written as follows.

> "A first course in engineering design which emphasizes creativity, teamwork, communication, and work across engineering disciplines. Students are introduced to the design process through a semester-long project which provides a design-build-test experience. Oral and written communication are important elements of the course."

The problem is that most students do not obtain these learning objectives and end up having a poor experience in the course. For instance, the first emphasis of the course is supposedly "creativity", as stated above. However, the professors place such a high priority on functionality of the students' projects that any creative ideas or aesthetic concerns are immediately shunned and deemed a waste of time. Another example of the failure of IED is in its emphasis on "work across engineering disciplines". Due to the severe imbalance of students majoring in mechanical engineering, teams frequently consist of mostly mechanical engineers and a few aeronautical or civil engineers. The latter two majors share a very similar curriculum with mechanical engineers. This does not lead to diverse teams and students unfortunately miss out on a valuable experience.

We do not believe that the course objectives are misguided; they are important skills and experiences for engineering students. The problem is simply that IED fails to meet its own learning objectives effectively, and thus a need for a solution is justified. We chose to redesign IED and create our own course, Re:IED, which lists all of the same learning objectives as IED and yet is properly designed to satisfy all of them effectively.

We researched IED and engineering education in general to gain a deeper understanding of the problem. The traditional model of education has been in problem solving; learning about material properties, fluid dynamics, electrical circuits, etc. The engineers who are a product of this education can sit in front of a computer and solve problems all day. But when it comes to working on a team, interacting with other people in different disciplines, and communicating ideas, these engineers struggle. Unfortunately, in industry these are the most important parts. The ability to work on a team is significantly more valuable to a company than the ability to solve specific engineering problems. RPI recognized that these "soft" skills are a necessity after graduation, and therefore created a class to try to teach these skills.

Unfortunately, those people who created the class were the same engineers who went through a purely problem-solving curriculum and thus the class takes the wrong approach. The result of IED failing is that RPI engineering students still do not graduate with the soft skills necessary to succeed in industry or academia. If one considers that the entire purpose of college education is to prepare students for a successful career, this casts our problem as quite a serious one. If IED fails to provide students with soft skills, then by extension RPI is failing to adequately prepare students for a successful career. Students pay approximately $48,000 each year in tuition. This totals $192,000 for four years at RPI – an astronomical price for just about anybody. This price may get you a job just from simply graduating with a diploma from RPI. However, if you are not adequately prepared, it likely will not buy you a successful career. As you can see, a proper and functioning substitution for IED *must* be achieved to allow students to have a productive education that leads to an effective career.

We developed this class design (Re:IED) in place of a thesis that details the problem, research, and solution. Our design addresses the same facets of a traditional thesis paper in the following ways. First, we conducted initial bibliographic research, just as one might when beginning to write a thesis. Next, we started brainstorming possible topics around problems that we identified from our own experiences and from our bibliographic research. Someone who chooses to write a thesis might already have had a problem in mind, or they might also search through existing literature to narrow in on a more specific definition of their problem. At this point, they would begin to develop their stance on the problem and detail the specific issues they have with the problem from the perspective of the existing peer-reviewed literature. Our next step after brainstorming and choosing a problem to focus on was to pick our design project. By designing a “solution” to IED, we effectively have pinpointed our issues with the current IED class and have created a physically existing statement that demonstrates our points of view of those problems. So, while we *have* created a solution to IED, which contains the many problems that we are addressing, our solution is also a statement of the problems; just like a traditional thesis.

Literature Review

There is an apparent trend towards reform in engineering education in the United States (Frances Bronet, 2003). Many engineering departments are developing innovative classes to address the problems facing the United States engineering industry (Norman L. Fortenberry, 2007) (Rosu, 2014) (Frances Bronet, 2003). These problems and solutions are addressed at length in recent literature. Some of the research regarding engineering educational reform stems from an examination of the engineering education and industry of other countries that are more competitive than the US. In fact, this is one perceived problem – the United States’ lack of engineering talent compared to other nations (J. C. Croissette, 1963). This is an important ranking because of the enormous correlation between economic health and engineering industry strength (Sheila Slaughter, 2004) (Drucker, 1983). Engineering industry in the United States places the blame of its failures partly on engineering educational institutions and their inability to adequately prepare students for professional careers.

Let’s first take a look at the current state of engineering education in the United States. According to Drucker, there are many issues currently facing the engineering disciplines in the US:

> We call for unity of the engineering profession and educate our students so that they can barely communicate with each other on a professional level. Time indeed is running out for our system of engineering education and our country. (Drucker, 1983).

Grinter names a weakness of engineering education as the lack of integrative teaching:

> The weakness of engineering education has been neither the neglect of craftsmanship nor of specialized science, but insufficient attention to welding these together (Grinter, 1954).

Mills also supports this stance and shows that problems in engineering education are highly inertial and take large efforts and periods of time to resolve. In an article written 20 years after Drucker's, Mills still highlights some of the same issues:

> In recent years studies have been conducted in many countries to determine the technical and personal abilities required of engineers by today's industry. These studies have indicated some key concerns. Today's engineering graduates need to have strong communication and teamwork skills, but they don't. They need to have a broader perspective of the issues that concern their profession such as social, environmental and economic issues, but they haven't. Finally, they are graduating with good knowledge of fundamental engineering science and computer literacy, but they don't know how to apply that in practice. (J. E. Mills, 2003).

A succinct summary of the problems with engineering education can be found in an article written about the state of engineering design education:

> For nearly 40 years, it has been generally agreed that a proper goal of undergraduate engineering education is to provide students with an understanding of the fundamentals of engineering science. Mechanical engineering students learn the underlying principles of statics, dynamics, strength of materials, materials, thermodynamics, heat transfer, and fluid mechanics. In their courses, however, students learn very little about the current methods used in industry to apply the principles of these engineering sciences in real design or analysis situations. Though many problems are assigned for students to solve in engineering science courses, the purpose of these problems is not to teach current application methods but to elucidate the principles. (Dixon, 1991).

In our research, the most commonly occurring problems with the current state of engineering education that we observed were low retention rates (Drucker, 1983) (Norman L. Fortenberry, 2007), failure to incorporate creativity and design thinking (Grinter, 1954) (Frances Bronet, 2003), and an inability to teach the skills necessary to succeed in an engineering profession (Drucker, 1983) (Grinter, 1954) (Frances Bronet, 2003).

Now, since there are clearly problems with the existing state of engineering education, there are those that are looking for solutions. In fact, there is a surge of research and literature advocating for a reform of engineering education. Dym writes that design is a fundamental skill of being an engineer but that it is often not adequately addressed because design thinking is complex. Dym quotes Evans as follows:

> The subject [of design] seems to occupy the top drawer of a Pandora's Box of controversial curriculum matters, a box often opened only as accreditation time approaches. Even 'design' faculty—those often segregated from 'analysis' faculty by the courses they teach—have trouble articulating this elusive creature called design. (D. L. Evans, 1990).

Thus, many institutions don't give design a proper role in engineering education. And as Dym says, we must work to effectively integrate it into engineering curriculum. Additionally, this design thinking (Kolko, 2015) (C. L. Dym, 2005) needs to parallel the design practices maintained in industry since, as we have shown, engineering graduates are consistently unprepared for industry. The primary role of education is to prepare the graduate for a successful professional career:

> Engineering education should represent the highest type of professional preparation for engineering practice (Grinter, 1954).

It is impossible to learn all of the concepts that one needs to learn in their field before they graduate. Therefore, learning the skills of industry competence and learning how to learn is much more important.

> In engineering education, as in every other type of professional education, the key to professional success is to learn how to learn without a teacher. We can cover only a little of the art of engineering and a few basic principles before the graduate must leave the university. If this represents his entire education, the graduate will remain professionally illiterate for life. However, if he has learned how to study and to learn on his own, he has every opportunity to grow into professional stature. (Grinter, 1954).

It is important to understand that the economy of the United States is quite dependent on the engineering sector. To quote Drucker on the impact of engineering educational failure:

> That is the insidious nature of the crisis of engineering education, devastating to the economic welfare and defense capability of the country on a time scale of less than a decade ahead. … Should [the crisis of engineering education fail to be solved], our children's children may know enough arithmetic to balance a checkbook and be literate enough to read bank notices, but our economy will not be strong enough to permit them to have a checking account. (Drucker, 1983).

Many others have written on the negative impacts of a failing engineering education system (e.g. (Sheila Slaughter, 2004), (Norman L. Fortenberry, 2007), (Kolko, 2015), and (Drucker, 1983)).

We have thus far shown that engineering education is necessary for the success of students in their professional careers following graduation. The success of engineers in industry is critical because of the impacts it has on the United States' economic wealth. We have also shown that our current engineering education system is flawed. Combining these notions, one understands the need for reform in engineering education. Let's now examine some of the ways in which engineering education should be changed, and some examples of these strategies being applied.

In an article detailing one way in which engineering education research has benefitted teaching practices, Fortenberry suggests implementing a project-learning class that "connects the conceptual and educational side of engineering with professional practice". The article emphasizes previous research results that recommend experiential, interactive, and collaborative learning. The specific application in this article was a program developed at the University of Colorado at Boulder called the First-Year Engineering Projects (FYEP). Students that took the class, either voluntarily or by requirement, showed clear increases in retention rates at CU Boulder:

> Regardless of gender or ethnicity, retention in engineering is higher among students who take the FYEP course. These results add to the growing body of evidence demonstrating that first-year projects-based curricula promote retention of engineering students. (Norman L. Fortenberry, 2007).

Another article that stems from Rensselaer Polytechnic Institute argues that the leveraging of multidisciplinary pedagogy in design prevents the failure of most engineering and design programs to integrate their various insights and expertise. Bronet elaborates:

> What is often taken for granted by architectural educators, the collision of the formal with the social and technical through design, is a radical shift for engineering pedagogy. … According to a survey that we conducted of industrial and product design programs around the country, these programs fall into two categories: one stresses technical or engineering expertise (housed in an engineering school), and the second stresses aesthetic or arts expertise (housed in an arts and/or architecture school). Since there is little, if any, overlap, they fail to integrate the insights and expertise of each other. (Frances Bronet, 2003).

In this case, the specific application is a program developed to integrate the multifaceted nature of engineering and design and bring together several schools and disciplines. The program, Product Design and Innovation (PDI), seeks to use the strategies listed above. The course accomplishes multi-disciplinary study through a series of design studios. Like the FYEP mentioned previously, the PDI program roughly follows a design-build-test cycle of product prototype development. Unlike the FYEP, PDI is a major offered at RPI and encourages creativity and aesthetic attention quite heavily.

Finally, a faculty group formed at the University of Illinois called iFoundry is redesigning the heavily engineering-focused curriculum. Bryan Wilcox is a professor in iFoundry who has spent many years in industry. This article, which he coauthors, therefore offers an insightful perspective into strategies to better prepare engineering students for industrial careers:

> Executing work in the framework of a project more accurately reflects the nature of work our students will face once they are practicing engineers. Learning the skills best gathered through experience is a key element of structuring work in this manner. I am very positive about using projects as a framework for learning and feel my experience has revealed some fundamental realities of human nature when attempting to learn abstract principles in the context of real problems. (Rosu, 2014).

What Wilcox and Rosu are suggesting is again a project-learning approach to engineering education, just as Fortenberry anecdotally recommends with the FYEP at CU Boulder. However, project-learning is not the only popular philosophy for reforming engineering education. In an article by Mills, she attempts to compare project-based learning with problem-based learning; a style that is closer to the problematic engineering education paradigm that we are trying to migrate from. Mills concludes:

> In the context of the requirements of revised accreditation criteria and the calls from industry on what they need from engineering graduates, it would appear that these demands are unlikely to be satisfied by a traditional engineering curriculum and "chalk and talk" pedagogy. A mixed-mode approach as successfully adopted at several of the institutions examined in this review, with some traditionally taught courses, particularly in the early years, mixed with some project-based components and with the project-based components increasing in extent, complexity and student autonomy in later years of the program, appears to be the best way to satisfy industry needs, without sacrificing knowledge of engineering fundamentals. It has also been demonstrated that the engineering profession and academics are more familiar with the concepts of projects in their professional practice, than with the concepts of problem-based learning. It therefore seems that project-based learning is likely to be more readily adopted and adapted by university engineering programs than problem-based learning. The use of project-based learning as a key component of engineering programs should be promulgated as widely as possible, because it is certainly clear that any improvement to the existing lecture-centric programs that dominate engineering would be welcomed by students, industry and accreditors alike. (J. E. Mills, 2003).

It should be abundantly clear now that the current state of engineering education in the United States requires change if we are to compete with other nations and survive economically. An engineering education reform incorporating project-based learning, innovative design, and multidisciplinary strategies is necessary. In fact, there have already been many programs created or redesigned that have approached the existing problems from the same perspective of the literature as us and have seen success.

Methods

While Rensselaer has made many strides in combatting these pitfalls of engineering education, the institution is not immune or clear of these challenges. Their rigorous curriculum leaves students exhausted and provides them with minimal room to innovate. The Introduction to Engineering Design (IED) course is RPI's way of tackling some of the current issues existing in engineering education mentioned in the Literature Review. IED aims to incorporate many of the suggested strategies from the literature, but is failing to affect positive change on the Institute. Some of the shortcomings arise from improper implementation of these strategies, while others are simply due to an absence of an attempted solution. We worked to define these shortcomings and create a design that is both a critique and a solution of IED's failures.

After our research in Organizational Design and Workspace Design, we spent quite a while framing and outlining our final project. While we all agreed we were interested in Organizational and Workspace Design, we were not completely sure what argument to make given our bounty of research. Our original intention for the project was to research questions of organizational culture via interviews, observation, and personal recollection; focusing on imposed outcomes and dissonant results. We began by discussing our own experiences in relation to organizational and workspace paradigms. These included different workplace examples from internships and discussing the organization of many shared classes here at RPI. It eventually became clear that we all had one converging "sore spot": Rensselaer's Introduction to Engineering Design Course. As all three of us are dual Mechanical Engineering/PDI majors, we all took this course around our sophomore year. Although we each had a unique experience in the class, we collectively agreed that it could be vastly improved.

The Introduction to Engineering Design (IED) Course is a course offered by Rensselaer in the Engineering Department with the core objective of teaching teamwork and communications in the context of an engineering design process (Steiner & Anderson, Sr., 2015). IED must be taken by all engineering students, except those in the Chemical Engineering department who take their own collaborative engineering course, and is one of the most griped about courses at Rensselaer. IED is in an attempt to create a multidisciplinary classroom consisting of students across all engineering disciplines. While the course is meant to teach students how to work creatively and constructively in an Engineering Design environment, after assessing our own personal experiences in the class, and interviewing several peers on theirs, it was determined that the actual outcomes were very different.

IED's organizational and educational model encourages students to avoid risk, essentially sabotage other students in their own groups, and to take a back seat in the engineering design world. These are all the opposite of their intended outcomes. IED does not reinforce group work despite its questionable attempts to do so. After identifying this, we decided to take a look at why we found IED failed during our and several other students' experiences.

We came to several conclusions of why IED fails. They are as follows:

1. IED grades students on their measure of mechanical success. IED is built so that all students must be responsible for only one integral piece, or subsystem, of their final group design. While this is a great idea in theory, it seems to fall apart when put in place side-by-side with a very specific grading matrix. This grading method essentially assumes that all features are equal, which in all honesty, they are not. Some students may spend an hour building a wooden box, meant to be just a box, and will therefore receive an A for their efforts; while other students may spend triple the amount of time doing motor and torque calculations, assembling gear systems, and conducting other necessary analysis, to recieve a C due to unintended errors. The grading is solely based on if the subsystem is functional, disregarding the project as a whole. This teaches engineers, way too early in the game, that risks are not only not worth it - but are detrimental and counterproductive. Students learn how to manipulate others to get easier subsystems to ensure they receive a better grade and sabotage their opportunity to learn by doing so. Essentially students learn that the easiest way out and the safest way out is the best one.

2. IED does not encourage innovative behavior for students. Just as with subsystem failure, overall project failure detrimentally affects students' grades as well. For this reason, students will choose to do an easier, "safer" project to ensure they do not receive a poor grade in the course. Innovation does not come from safety and no significant strides in technology come from 'playing it safe.'

3. IED does not equip students with the proper tools to be innovators and does not push students out of their comfort zone. IED is situated in the perfect position to push students out of their comfort zone. The class does not have any core curricula besides the engineering design process and professional development, yet it still fails to capitalize on that fact. It does not work to encourage students to test out new engineering methods outside of their discipline or ones inside of their discipline they already haven't utilized. It does not stress the importance of learning about on-campus opportunities, facilities, or manufacturing capabilities. It does nothing to challenge students' current way of thinking. In the end, IED stagnates students by not challenging them.

4. IED does not excite students about engineering. IED does a subpar job at getting students excited about engineering. It does not show students what is 'cutting edge' in the engineering world, it does not allow students to work hands-on during class periods, and it does not get students excited about being in an engineering work environment. Many students become engineers because they like to build, create, and innovate, and as IED stands, it does not allow room for any of those. However, it is one of the only courses offered in the engineering curriculums at RPI that offers this hands-on aspect.

There four core problems, as well as many other facets of IED including the class size, professors, and physical space, are not only negative parts of the engineering experience at Rensselaer, but also detrimental to engineering students' educations. From here, we decided to take a look at the current IED syllabus and begin exploring how to make an impactful stride in engineering education. We sought out to develop a new course with a new syllabus that meets all of the learning outcomes through more engaging and impactful activities and educational experiences.

Implementation

What we found most stunning when reviewing the syllabus was that all of the learning outcomes could be met and exceeded through a better class organization and a more hands-on approach. The class could be, and should be, taught in an engaging and exciting way. With that in mind, we decided to create a curriculum that exceeded all of the learning outcomes of IED with a more engaging and hands-on approach.

We decided to take a look at IED's structure overall. IED currently meets three times a week per section. The course splits these classes into two 2-hour class periods a week (MR or TF) and one 2-hour lecture per week (W). These classes seat approximately 30 students/section, with the overall Wednesday lecture consisting of all 200+ students in the course. This theoretically accumulates up to 6 hours of in-class time a week but realistically, not always. Many students skip this middle Wednesday period, as they can have other students check in for them because they fail to find any useful material in these large lectures. This excessive skipping can be interpreted as students not being excited to learn what the course is offering. IED is intended to be a collaborative class where students are encouraged to innovate and build. For that reason, we decided to first and foremost make sure our class was as hands-on and engaging as possible. We wanted to ensure students only talk positively about the course with other students instead of sleeping through it in their dorm rooms. This information helped us to make two of our largest decisions. We decided our course structure should be a weekly activity-centered approach and that our target users are first year, first semester engineering students at Rensselaer.

First, we decided to focus on first year, first semester engineering students. This choice was deeply rooted in our desire to push first year students out of their comfort zones and excite them about the all of the opportunities in engineering. While all students may not go into engineering design, many students have an expectation that they will be building things when they get to engineering school and we want to fulfill that expectation. This decision was also strongly supported in the existing literature of engineering education.

Secondly, we wanted students to be interested and engaged. Much of the time throughout engineering education, students lose interest in what they are doing when they don't think it's applicable. Students find that coursework can be tedious and become disgruntled with the amount of pen-on-paper work they must do. Students should be interested and engaged in their learning experience whenever possible, and a hands-on approach does just that.

Once we had decided the core of our course, we decided to look into current design thinking and engineering activities. As our first step, we pulled from our own experiences as well as a breadth of resources to create a vast list of 'Design Thinking' activities that could be used to teach a breadth of skills and engineering principles.

Equipped with a list of Design Thinking and engineering activities, we narrowed down the most important skills and correlated weekly themes necessary for students to be equipped with. These skills and themes were then ordered and reordered until the fifteen most important and relevant were listed and defined. These fifteen important skills were then mapped to design activities. The activities and weekly themes were then iteratively edited and reviewed until a final class curricula was created into a detailed course syllabus and lesson plans.

During the theme and activity scoping, a number of issues were already addressed. First, the teamwork aspect of IED and Re:IED were discussed. While IED has a number of unintended outcomes, most of which tend to be detrimental to the learning experience - a number of these unintended outcomes have become positive class attributes in disguise. Difficulty when working in teams is most definitely one of these positive unintended outcomes and we wanted to ensure that Re:IED addressed this issue properly without creating an unbelievably difficult experience for first year students. To aid in creating a good balance of positive and negative teamwork experiences, the course follows a 2-4-8 team member progression. This progression breaks class into three distinct segments where students first begin in a pair of their choosing, then are matched up with another pair by the professor to create a four person team, and then once again four person teams are matched to create a final eight person team. Each of these teams takes up 5 weeks of course time, covering the entire 15 week semester. Professors will be instructed to pair up four person teams with differing skill sets, interests, or personalities in mind, to ensure that students work with other students who have differing views and interests. We find that this diversity aids in emulating real life work experiences and teaches students how to speak with those outside of their own discipline.

After designing the course the way we wanted it to be, we presented the idea to an Engineering Design professor, Dean Nieusma. Overall, his feedback was positive about the course we created and was able to further affirm some of the ideas we put into the project. After speaking with him we learned that one of the most important aspects of this new course was to incentivise risk taking and reward failure. Dean suggested that the grading be on the quality of the idea and the process of executing the idea. Another important take-away from this interview was to encourage the students in the course to be ‘plussers.’ In other words, students should be reinforcing and helping each other as opposed to shooting down ideas. This interview was very encouraging and helpful to us as a group. Not only did it reinforce the need for our project, it helped us to design an even better course.

Expected Results/Sample Use Cases: Implementing the Class at RPI and How it Will Function

Ideally, this class will be implemented as soon as possible to allow students coming into RPI in the next few years to have the opportunity to sign up for the course. The course would be written into all engineering programs as a first year fall semester course. The course will be required for all students who are any engineering major, including mechanical, electrical, civil, undecided engineering, etc. For all other majors, it would be an optional, but encouraged course. Most other majors, including Architecture, Communications, and Chemistry have required four credit electives that this course would fulfill. We want the class to be taken in a student's first semester at RPI in order to introduce him or her to engineering design right at the start of his or her academic career.

The course will attempt to create a single, common class amongst the vast majority of freshman students that will promote students to share ideas and thoughts about the class with each other and encourage technical and creative conversation within the freshman class. This would also mean that most upperclassmen have already taken the course and could share stories and encourage the freshman to embrace and enjoy this class as they did. Older students and mentors can share the projects they worked on and having a common class among so many students will foster more conversation between students.

The first step in implementing this course would be to ensure it fits into every engineering curriculum at RPI. It would require changing most of the freshman fall semester curriculums to allow for them to take this course. Advisors and incoming students would need to know the importance of taking this course in the first semester and students should make sure to not move the course to another semester if possible. Similarly, any transfer engineering student, international visiting student, or student that has not taken the course yet for any reason should be made aware of the course offering and encouraged to sign up and experience the class. The course will be a full four-credit class to encourage students' participation in the course. A full four credits demonstrates to students that this course is as important as the rest of their course load, including most other required freshman engineering courses. Making it a 4-credit class will allow students to spend the necessary time in and outside of class on the course material. According to the Learning Center at RPI, students are supposed to spend a total of at least twelve hours per week on the course material for a 4-credit course. This would be an ample amount of time for the students to actively work on the projects given and would allow for a low-stress experience because of the large amount of time allotted.

Currently, RPI admits about 1,300 undergraduate students each year. According to an administrator in the CORE Engineering Department at RPI, 804 of these students admitted were enrolled in the School of Engineering in 2015. These numbers for previous years are similar at values of 844 students for 2014, 817 students for 2013, 833 students for 2012, etc. In order to be able to ensure that every student is able to sign up for the course, there must be enough sections and physical space for each student. We would hope to make it possible for all freshman to sign up for the course, while not making the class size too big. It was determined that the ideal class size for this course would be no more than 40 students to allow for the best way to group students in pairs, teams of four, and teams of eight. To make this work, each class section will allow 80 students to register for the section of the course. The class is planned to meet two times a week, either a Monday and Thursday, or a Tuesday and Friday, for three-hour time blocks. Students will be required to come to class one of those days and then meet with their group outside of class the other day.

Therefore, the group of 80 students registered for that course section will be split into two groups of 40 students. Group A would come to class during the first meeting time and use the second meeting time for group work. Group B would do the opposite; doing group work during the first meeting time and coming to class during the second meeting time. In order to accommodate all freshman students, there would be a total of 12 different sections offered. This would mean that two different sections would meet at the same time. The space that this class is taught in would include two separate classrooms for each of these sections and would potentially share lab space or presentation space. Allowing 80 students per section for 12 different sections would leave a total of 960 seats available. This greatly exceeds the previous School of Engineering class size, ensuring that all engineering students can sign up, and leaving room for students from other majors.

Because two of the class sections would be meeting simultaneously, the space would need to accommodate this. The space we have imagined would include several presentation areas, conference rooms, work spaces, small kitchen, storage space, and room to comfortably sit the 40 student class with several professors or TA's. With two sections meeting at once, there would need to be two classroom parts of the space that can meet separately but share all of the other spaces. With work spaces separate from the classroom space, this will also allow students who do not have class that day to come work or get supplies from this room. All students enrolled in the course would have to be granted card access to the design space. Creating the new space would be the most time consuming part of implementing this project at RPI. If there were enough resources available, RPI could restructure a portion of the Jonsson Engineering Center to accommodate all of the goals listed above in this classroom.

In addition to restructuring a design room, RPI would have to provide an array of supplies, including tools, crafting materials, prototyping materials such as cardboard, construction paper, glue, etc., workspace surfaces like large tables and conference room furniture. The space would also require whiteboards for mind mapping, projectors and screens for presentations and enough room to accommodate all of the students enrolled. Ideally, this space would be inviting and a place that students like to be in to think creatively and work on projects from the course. This space could also be used to inspire students to pursue their own personal projects and get them interested in a design career because of the environment.

In addition to a space and a detailed syllabus, professors would need to be recruited to teach the course. Professors of the class would come from all disciplinary backgrounds including all engineering disciplines. They would be able to bring research and real-world working experience to help further teach students. Before the class begins, professors will be given all of the material necessary in order to teach the course as we intended it to be, including a detailed syllabus. This would help to ensure that all students are learning the same things across each section. All faculty for all sections must be committed to design, innovation, engineering, and creative teaching methods. Faculty must embrace, but not encourage failure and be committed to making engineering tangible and more enjoyable. He or she must be willing to keep the classroom a relaxed environment and encourage the students to have fun while learning about the engineering design process.

Faculty must be extremely open-minded to new ideas from students and willing to work with them with any and all problems encountered throughout the course. It is important for faculty to observe all students during the class time to ensure proper participation for correct grading. Students should never feel worried about their grade in the course as long as they are actively participating and completing all assignments. Professors and faculty of the class must be willing to help students during the class meeting time and provide assistance outside of class time. Students should feel comfortable talking and learning from all faculty members.

Conclusion

The focus of our project involved rethinking the Introduction to Engineering Design course currently taught at RPI. Throughout this semester, we criticized all facets of the course and drew from our own experiences in the class. After researching and analyzing the current course, we came to the the conclusion that the current classroom experience does not properly reflect real life engineering teams and is typically a negative experience for RPI students. The class becomes more about getting a good individual grade rather than working as a team and designing a product. The class does not allow for creative thinking and does not promote cohesive team work. The class we designed needed to be better organized to meet the needs and metrics desired from engineering education. It seeks to teach students the engineering design process in a relaxed, fun, and effective manner while working on multidisciplinary teams of their peers.

Before deciding on designing a new course for RPI, our group decided to focus on organizational design. The three of us decided to become a team, now known as "REnR," when on the first day of class we all expressed interest in organizational design problems. Each of us agrees that creating a system design is just as appealing, challenging, and rewarding as creating and developing a fully functional physical product. We discussed ideas and previous projects we had all worked on and then discussed our work experiences. We came to the conclusion that every company, including engineering companies, has a distinct corporate culture, whether intentional or not, and decided to focus on researching corporate culture. We all found the ideas and systems to be fascinating and thoroughly enjoyed discussing our findings from independent research on the topic. We then sat down to come up with a project proposal after being inspired by researching successful corporate cultures that included innovative thinking and creative spaces. This lead us to thinking of the RPI course, IED, and resulted in a semester-long project critically analyzing the course.

The literature review that we conducted in the beginning of this semester establishes a clear line of reasoning that justifies the magnitude of our problem. It was observed by many students at RPI that the class called "Introduction to Engineering Design (IED)" has many problems. In order to support the claims made by students of the failure of IED, we interviewed Dean Nieusma, a professor at RPI currently conducting research on the forefront of contemporary engineering education practices. He agreed with the perceived failures and helped us to refine our definitions of them. Proceeding with these affirmed failures, we found many engineering education articles stressing the need to have immersive interdisciplinary design work in an engineer's undergraduate education in order to succeed in the workplace. We also confirmed from literature of engineering industry that this type of preparation is so much more important than being able to solve specific types of problems. From these existing statements, we justify the connection between a failure of IED and a failure of RPI, thus further supporting our conclusion of the need to change IED. This therefore substantiates our research and our project, which make a statement of critique and provide a possible solution to the failures of IED.

Our project resulted in the creation of a course, titled "Re:IED", that will cause the current IED course professors and students to question the current paradigms of engineering education at RPI. The course intends to create a stronger alignment between intended course outcomes and actual course outcomes. In the beginning of creating our project idea, we researched corporate culture and organizational structures. Our class design draws from these themes and creates a better parallel to the engineering work reality. This new class satisfies all of the same learning outcomes and course objectives as IED, but using stronger methods as supported by engineering education research. Additionally, the IED course spaces were analyzed and a new concept idea was developed. Our final product is an introductory course to engineering design that is enjoyable and cohesive, so as not to turn new engineering students off to their field of study in their first year of college.

When we first imagined designing this course, we had several different things we wanted to incorporate. These included designing a better design space for the course, rethinking the way we can teach the design process, having relevant activities for the students to do each week, and creating themes for each week to focus on. When we sat down to start to make a syllabus we realized that 15 weeks is not very much time to do everything that we wanted. It was a difficult task to structure the course in a weekly manner that made sense and accomplished all of our goals. After focusing in on the main topics that we wanted to the students to learn, we organized them into a sequence that made sense and assigned themes to each week of a semester. After assigning themes we sought out to create and find activities that would tie into the theme and be engaging for the students. This was more difficult than we had anticipated as we wanted to ensure each week had a unique, creative, and challenging task. In the end, we were able to create a week-by-week detailed lesson plan book that includes all aspects of the weekly activities, themes, and discussion questions. In addition to designing this course, our project is also a statement of the problems and intends to be a statement to current IED professors, staff, and students.

The next steps of this project would be to present the course objectives and syllabus to obtain more feedback from various people. All of the weekly activities were thought of by the three of us and we ran through a “mock-trial” round for a few of them. We plan on having some of them available to try out during the presentation day on December 15th for our peers and anyone else who is in attendance. We can then observe how those people respond to the activity and ask them questions pertaining to the weekly theme it goes with. From this information, we can get an even better understanding of what each of the weekly activities are accomplishing and if it matches our intent. Then, the class would be all set to be incorporated in the curriculums here at RPI as outlined earlier in this paper. It would take a few semesters to really work out all of the unforeseen flaws, if any, with the course and eventually it would be fully incorporated into this school and other engineering programs at other colleges and universities.

Overall, the final project has made a bold statement regarding engineering education, engineering design, and IED at RPI. The new design for the course should shed light for professors, administrators, and students about the needs of current engineering education and how to create a course to fit these needs. REnR have worked together throughout this semester and were able to learn more about organizational design, corporate culture, how to properly research, and how to design a course to make a statement.

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Re:IED

Rethinking Introduction to Engineering Design

Course Coordinators: Ryan Jenkins, Emily Farella, & Rebecca Radparvar

Rethinking Introduction to Engineering Design

Fall 2015 Syllabus

Course Hours: 4

Course Description

Rethinking Introduction to Engineering Design (Re:IED) is a piece exemplifying what Introduction to Engineering Design (IED) at Rensselaer could be, and how all of the same educational benchmarks can not only be met, but exceeded, through more engaging and collaborative curricula that provides students with the proper environment to thrive as engineers. Where IED dissuades risk taking, punishes hard work when it fails, and leaves students with a disappointing view of what collaborative engineering work is, Re:IED does the opposite. Re:IED incentivises calculated risk taking, teaches students that failure is a step on the way to success, and that engineering can be engaging, collaborative, and exciting.

Course Objectives

This course will teach students about the importance of teamwork and communications in the context of the engineering design process. Interactive engineering design and professional development exercises will provide students with the knowledge and skills necessary to innovative effectively as a team. Coursework is designed to challenge students to improve and expand upon your oral, written and visual communication skills, as well as their creative, critical thinking, and engineering abilities.

Learning Outcomes

1 | Students will have the capacity to solve engineering design problems, while instilling the importance of creativity in developing innovative solutions.

2 | Students will know how to identify customer needs, establish design objectives, and translate these into engineering design specifications.

3 | Students will exercise and improve important design skills of visualization, calculation, experimentation, and modeling.

4 | Students will have skills in organizing people and ideas for successful design. Skills include teamwork, project management, verbal and written communication, and documentation.

5 | Students will be able to function on multi-disciplinary teams and communicate effectively.

6 | Students will understand professional and ethical responsibility.

Shop Access

Students will have supervised access to the shop at various hours. The shop schedule will be posted on the shop door and on LMS.

Course Conduct and Academic Integrity

Student-teacher relationships are built on trust. For example, students must trust that teachers have made appropriate decisions about the structure and content of the courses they teach, and teachers must trust that the assignments that students turn in are their own. Acts, which violate this trust, undermine the educational process. The Rensselaer Handbook of Student Rights and Responsibilities defines various forms of Academic Dishonesty and you should make yourself familiar with these. If you have any question concerning this policy before submitting an assignment, please ask for clarification.

1 Failing Fast

Ideate, Prototype, Test

Students will learn to become comfortable with failure as a learning tool via incentives and teamwork.

Learning Objectives

- Understand that the final goal is always to create a successful design
- Accept that failure is an essential step along the way and can aid in the successful design of a product or system

Materials Needed

- Toothpicks
- Erasers
- Tape
- Tables
- Whiffle Ball
- Measuring Tape

Pre-Class Prep

- Gather necessary materials
- Pre-plan teams of four students
- Request 3 other Instructors (Professors or TAs) to attend
- Mark 3' above each table on wall

How To

1 | Organize students into groups of four

2 | State the title of the activity (Failing Fast) and explain it in the following language
   a | Your team will race against the other teams to build a structure that is three feet tall and doesn't break when I throw this wiffle ball at it.
   b | First team to successfully complete gets (prize... maybe extra credit?)
   c | We encourage you to build and test often (hint-hint). Minimize planning.
   d | Once you believe you have succeeded, call one of us over.

3 | Pass out a box of toothpicks and a whiffle ball to each team and say "Begin!"

4 | Professors and helpers circulate around the room observing
   a | If you see a team fail (structure falls, breaks, collapses), bring over the box of other supplies and offer them one item and ask them to justify why they need the one that they chose.
   b | If teams ask why they don't get extra materials, dodge the question. If you want to give a hint, tell them to remember the title of the activity.

5 | If a team claims to have won, measure their structure and test it with the whiffle ball. If it doesn't work, give them a new material. If it does, the activity is over and everybody stops.

6 | Each team has an opportunity to look at other team's structure.

7 | Then, discuss lessons learned with the class.

Debrief Questions

- Can someone explain what caused a team to earn a new material? (Ideally, the team that fails the quickest will win)
- What things made your team successful? What things made your team unsuccessful?
- Discuss how failing isn't the goal, but that failure is a necessary step in the design process. Fail early, fail often, succeed.

2 Critical Thinking

Define, Ideate

Students will do critical thinking exercises to teach them that there are a number of ways a problem can be tackled and solved.

Learning Objectives

- Learn that a problem can be seen a multitude of angles
- Understand how to effectively communicate and problem solve with others

Materials Needed

- Pen
- Paper
- Copies of handouts with one question on each

How To

1 | Pass out the first question to all of the groups, allow them ten minutes to discuss and come to a final answer. Attempt to answer as little questions as possible to allow students to find their own methods and use their own though processes to answer each question.

2 | After the first question, have all students present their answer and their thought process to the class. Discuss the importance of open ended questions, such as these - and their application in the real world.

3 | After the first question, pass out each of the next questions one by one. Once all groups find an answer for the question they are working on, pass out the next question.

4 | After each group has attempted to answer each problem and the correct answer is announced, allow each group three minutes to discuss why that is the answer before moving on to the next problem.

Critical Thinking Problems

How Many Gas Stations are in America?
Answer: none

Five pirates have 100 gold coins. They have to divide up the loot. In order of seniority (suppose pirate 5 is most senior, pirate 1 is least senior), the most senior pirate proposes a distribution of the loot. They vote and if at least 50% accept the proposal, the loot is divided as proposed. Otherwise the most senior pirate is executed, and they start over again with the next senior pirate. What solution does the most senior pirate propose? Assume they are very intelligent and extremely greedy (and that they would prefer not to die).
Answer: http://www.techinterview.org/post/526325766/pirates/

In a country in which people only want boys every family continues to have children until they have a boy. If they have a girl, they have another child. If they have a boy, they stop. What is the proportion of boys to girls in the country?
Answer: 50%

You have eight balls all of the same size 7 of them weigh the same, and one of them weighs slightly more. How can you find the ball that is heavier by using a balance and only two weighings?
Answer: Weight 3 and 3, if equal, weight the other two. If not equal, weight two from the three heavier ones - if equal, if it's the odd one out, otherwise, it's the heavier one.

Debrief Questions

- How did working in a group change your critical thinking process?
- Which questions did you find the easier? The hardest? The most fun?

3 Design Process Overview

Define, Research, Ideate, Prototype, Test

Students will be given an overview of the design process and how everyone who's involved in the product creation process works, what they do, and the difference it makes.

Learning Objectives

- To understand how upcoming weekly activities map to certain parts of the design process
- Understanding the importance of interdisciplinary work, cross-functional groups, and understanding the value of other non-stem disciplines

Materials Needed

- Presentation and handouts on the Design Process

How To

Review the Design Process PPT with students and discuss the importance of following the Design Process as well as making the Design Process your own and augmenting it to fit your needs as a designer and engineer.

Define

↓

Research

↓

Ideate

↓

Prototype

↓

Test

Debrief Questions

- Why is interdisciplinary work important for the design process?
- What are the benefits to interdisciplinary work?

4 Brainstorming | Mind Mapping

Research, Ideate

Students will be given two activities in order to teach the importance of Mind Mapping as a tool and to challenge their current views of what something is or can be.

Learning Objectives

- Understanding how to Mind Map and it's value to the Design Thinking Process

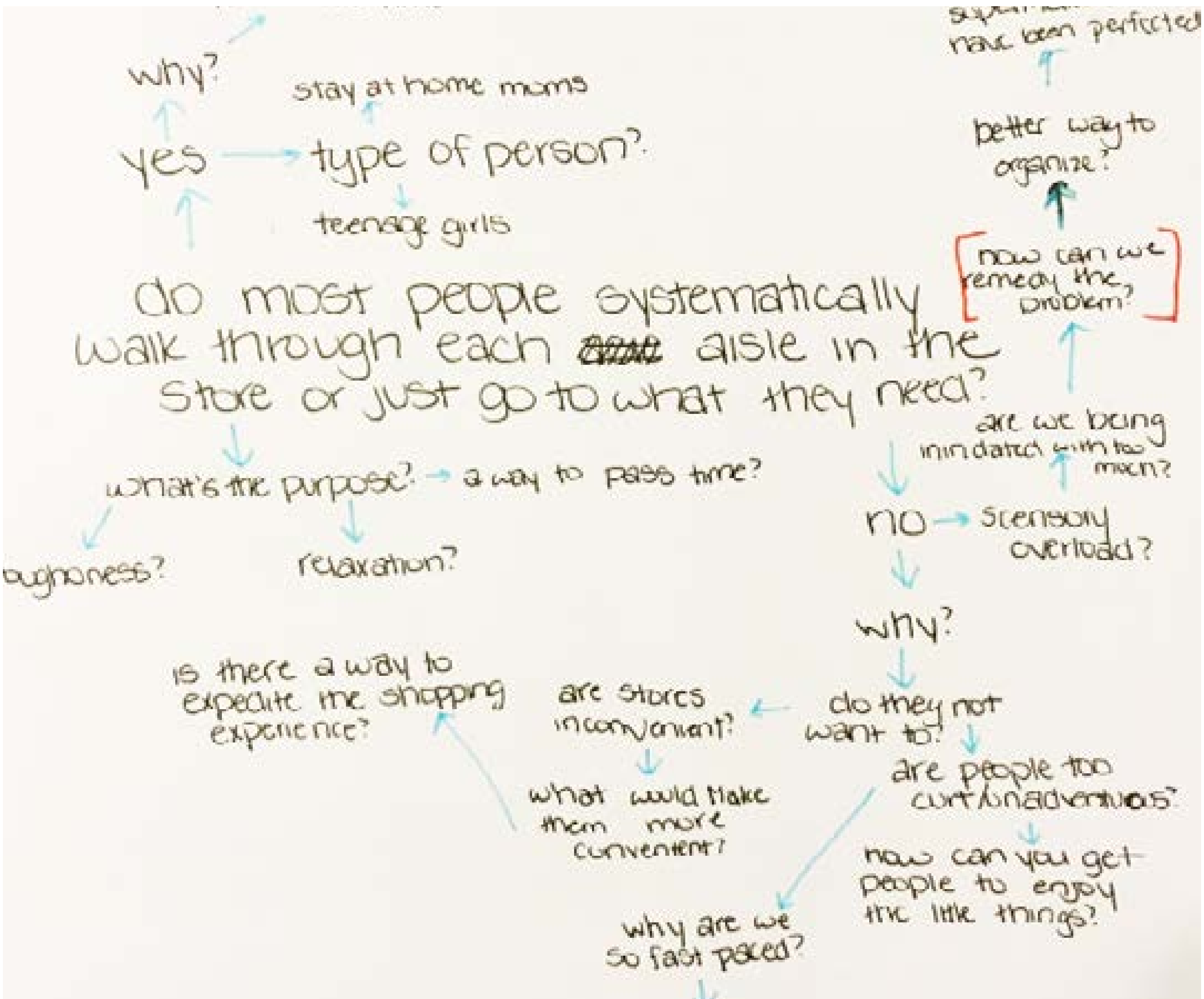
Materials Needed

- Large Paper Pads
- Markers (Various Colors)
- Handout with Blade of Grass Mind Map

Pre-Class Prep

Create four person groups by combining pairs. These groups of four will work together for the next five weeks of the semester, and join another group of four to create eight person groups for the final stretch of the semester.

Ensure that four person groups encompass a variety of majors and personality types, where possible.



How To

Part One

1 | Present students with some topic examples to mind map such as:

> How your room currently functions.
>
> What you could need to do to make your room more functional.
>
> The best route to class based on different circumstances.

2 | Have students in pairs decide on a topic to mind map. Once students have decided as a pair what topic they would like to explore, have them individually map out the product or experience.

3 | After 10 to 15 minutes, have students combine mind maps into a larger mind map.

4 | Once students have assessed core problem statements, have students brainstorm on how to improve one branch of their combined mind map.

Part Two

1 | Announced assigned pairings for partners in order to create the four person groups.

2 | Present a handout with an example of mind maps for a blade of grass.

3 | Instruct each student to pick one of the four remaining topics out of a hat (Keys, Elephant, Computer, Shirley Ann Jackson) and mind map that topic.

4 | After ten minutes, have students pair with their respective partner (Keys & Elephant, Computer & Shirley Ann Jackson) and identify the connections between their maps on a new piece of paper.

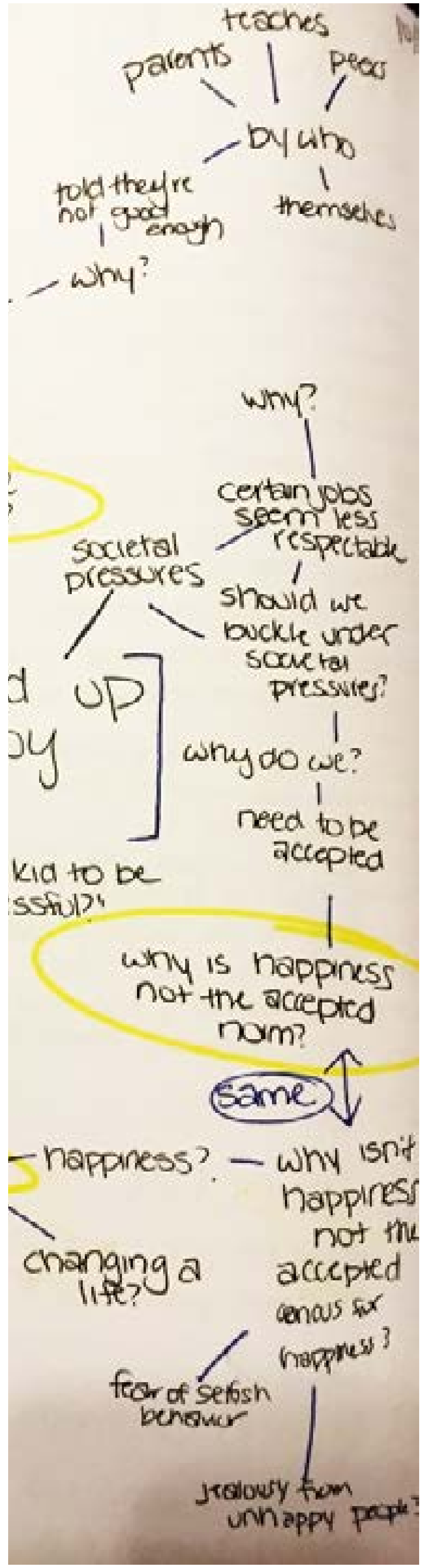
5 | Then, have the group of four join together and create a final mind map connecting the Elephant to the Computer.

6 | Finally, the groups should be able to form connections between a blade of grass and Shirley Ann Jackson.

7 | Have students create a final representation of how they got from a blade of grass to Shirley Ann Jackson.

Debrief Questions

- What are some other ways in which you can reinforce the connection between a blade of grass and Shirley Ann Jackson
- In what ways are the connections you made weak?
- For what stages of the Design Thinking Process do you think this is an important tool?



5 Research Methods

Research

Students will be taught a number of design thinking research methods and will be enabled to use two or three in a class setting to better understand a user's need based on a prompt.

Learning Objectives

- How and when to utilize different Research Methods

Materials Needed

- PPT on Research Methods
- Handout copies on Research Methods
- Obscure objects
  (at least 20 so class to class what people have is changed and people have a harder time figuring out/letting other people know what they'll have before the class starts)

How To

Part One

1 | Present the class with a group of obscure products and have student pairs each pick one product. Give students 15 minutes to explore and answer the three following questions:

> What is your product? What does it do?
> How does the product work?
> How could the product be used?

2 | Once students have discussed in pairs for 15 minutes, have students present their findings to the class and tell students the application of the tool.

3 | Once all students have presented, give students another 15 minutes to design a better product and once again present to the class.

After the first class activity, present the Research Methods PPT & hand out Research Methods definition sheet (content below).

Part Two

Have pairs of two team up with other pairs. Send students around campus to research and map out how the desks in different halls at Rensselaer work/don't work. Students must utilize at least three different research methods. Tell them to return with 45 minutes of the class left to present their findings.

Research Methods

Affinity Diagramming	Affinity diagramming is a process used to externalize and meaningfully cluster observations and insights from research, keeping design teams grounded in data as they design.
AEIOU	AEIOU is an organizational framework reminding the researcher to attend to, document, and coder information under a guiding taxonomy of Activities, Environments, Interactions, Objects, and Users.
Behavioral Mapping	Behavioral mapping is used to systematically document location-based observations of human activity, using annotated maps, plans, video or time-lapse photography.
Scenarios	A scenario is a narrative that explores the future use of a product from a user's point of view, helping design teams reason about its place in a person's day-to-day life.
Role-Playing	Acting the role of the user in realistic scenarios can forge a deep sense of empathy and highlight challenges, presenting opportunities that can be met by design.
Participant Observation	Participant observation is an immersive, ethnographic method for understanding situations and behaviors through the experience of membership and participation in an activity, context, culture, or subculture.
Observation	A fundamental research skill, observation requires attentive looking and systematic recording of phenomena - including people, artifacts, environments, events, behaviors, and interactions.
Mind Mapping	When a topic or a problem has many moving parts, mind mapping provides a method of visually organizing a problem space in order to better understand it.

Debrief Questions

- What research methods worked best? What research methods worked worst?
- Where would you use these methods outside of this class?
- What was the benefit of using different methods? Where some better for certain applications?

6 User Needs & Journey Mapping

Research, Test

Students will interview classmates with fake personas to create a product to properly meet their needs.

Learning Objectives

- Understanding the Users, User Needs, and Empathy
- Learning the journey mapping experience
- Understanding that products and experiences are highly integrated

Materials Needed

- Pen
- Paper
- Basic building materials such as toothpicks, cardboard, etc for prototyping

How To

After being instructed in the Journey Mapping process, students will participate in a Customer Needs activity and Journey Mapping activity.

Customer Needs

1 | Students will be given a few moments to think of a user persona vastly different than themselves with a respective problem. Students will then be interviewed by their partner.

2 | Once both students have interviewed each other with their false persona and needs, they will map out the user's three core needs and rate them in terms of importance.

3 | Then they will create or modify a product or experience to solve all of their needs.

4 | Students will then present their product to the class.

Journey Mapping

1 | In pairs, students will be asked to think of a frustrating experience and Journey Map the entire process to understand the frustrations with the current experience.

2 | After assessing the pain points of this experience, students will work together to design a more enjoyable experience that achieves the same purpose.

Journey Mapping Definition

A customer journey map tells the story of the customer's experience: from initial contact, through the process of engagement and into a long-term relationship.

It may focus on a particular part of the story or give an overview of the entire experience. What it always does is identify key interactions that the customer has with the organization. It talks about the user's feelings, motivations and questions for each of these touch points.

Debrief Questions

- How did assuming a persona differ from being yourself as a user?
- How did designing for a user with vastly different needs than your own change your design process?
- How did mapping out step-by-step interactions aid you in understanding user needs?

7 Working with Constraints/Design Reqs.

Ideate

Students will learn how to pivot and adjust when impressed with a number of constraints.

Learning Objectives

- How to properly assess constraints
- Understanding how to quickly adapt and be creative in the wake of constraints

Pre-Class Prep

Lay out all supplies in a way that students can properly understand constraints.

Materials Needed

- Rubber bands
- Toothpicks
- Marshmallows
- Paper
- Pencils
- Pipe Cleaners
- Staples
- Glue
- Slinkies

... & Additional Prototyping Materials

How To

1 | Students teams will be given the task of creating a mock up or minimal prototype of a toy (i.e. model car) with one given constraint, similar to the constraints seen below:
  - Only use one color of supplies
  - Cannot use a binding agent (glue, tape, staples), only rubber bands
  - All material names must start with the letter 's'
  - Can only use three different types of supplies

2 | Students will then be given only 10 minutes to create the first iteration of their prototype.

3 | After the first 10 minutes, students will be asked to document their first iteration with photos, and rotate their constraints.

4 | Students will then have 5 minutes to add to their prototype with the new constraints. Students will then be asked to document their second iteration, and repeat the constraint rotation two more times.

5 | After the initial iteration and three constraint rotations, student groups will present their final prototype and discuss their iterative process?

Debrief Questions

- What was your favorite set of constraints to work with?
- What was your least favorite?
- Did your initial prototype turn out how you envisioned? If not, how was it different?

8 Plussing

Ideate

Students will take part in two class activities to learn the importance of “plussing” and the advantages of multiple opinions and viewpoints when designing.

Learning Objectives

- Learning how to constructively aid people in their design process
- Understanding the importance of working with other people and having multiple viewpoints

Materials Needed

- Large Paper Pads
- Markers
- Different color pens

How To

Activity One

Give directions on how to do something (i.e.: how to go on a first date how to get Walmart) only using a finite number of images/slides and no words (as if you're speaking to someone who doesn't speak the same language as you)

Activity Two

For each team of four, give each student a different colored pen.

Part One

1 | Give students a prompt .

2 | Have students write out an idea - no drawing allowed.

3 | Have people add onto the idea, no talking at all.

4 | Have the first person talk about what their perception of the final design of theirs was - have everyone else comment on the first persons design and how the perceived it. Go around the circle for discussion about everyone's pieces.

Part Two

1 | Give students a different prompt.

2 | Have each student begin drawing their idea - one minute, cannot use words, have then pass around the group.

3 | Give each person a minute to add onto everyone else's ideas (or their perception of the idea).

4 | At the end have students go through and say what it started out as and the other members comment on what they thought it was, what they added, etc and talk about how it evolved.

Part Three

1 | Give students a third prompt.

2 | Have students conduct the same activity as above with words and pictures.

Debrief Questions

- What was the best method of communication for this activity?
- Why is their strength in using multiple mediums to display your ideas?
- Why is properly displaying ideas important?

9 Prototype like a Pro

Prototype

Students will take partake in the 5 Chairs prototyping exercise to learn the importance of prototyping and material selection through the creation of chair design based on a user's needs.

Learning Objectives

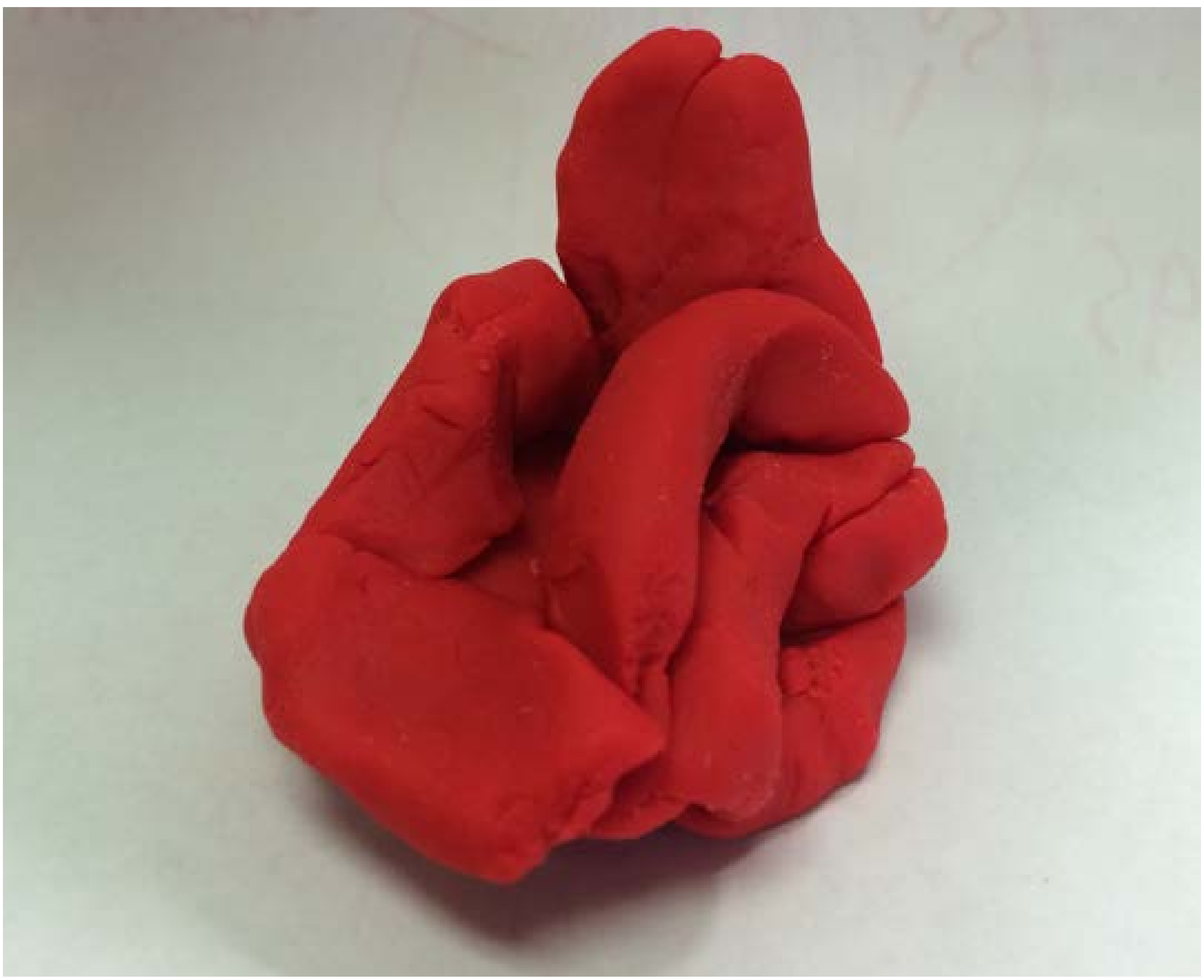
- Practicing how to assess and meet user needs
- Understanding different prototyping methods and their importance
- Learning the importance of iteration and it's benefits in the design process

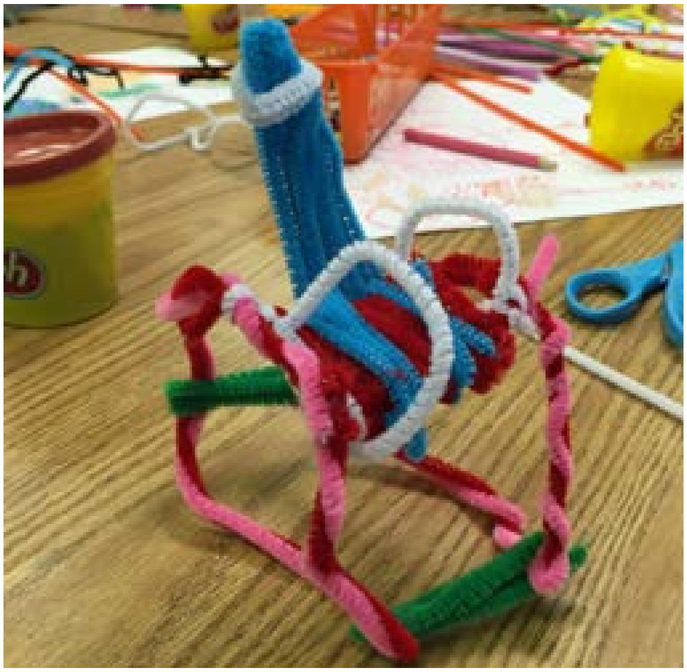
Materials Needed

- Newspaper
- Pipe Cleaners
- Legos/K'Nex
- Play-Doh
- Cardboard
- Glue
- Tape
- Paper

Pre-Class Prep

Plan to invite eight professors to class to embody a persona for the five chairs activity.





How To

1 | Professors will pair student groups with facilitators who will embody a predetermined persona.

2 | Groups will then interview their personas using the research methods they have used in previous weeks to assess their needs.

3 | Once students have assessed their user's needs, each group member with individually brainstorm and sketch 3-5 designs.

4 | Students will then present within their groups and discuss the positives and negatives of each design. Once the students have properly assessed each design, students will create an iterative chair design as a group.

5 | Students will then present to their user and create another iteration of their chair.

6 | Then, students will present to the class to receive feedback and the opportunity to critique other groups in the class.

7 | Once all groups have received feedback, students will begin rapid prototyping their design. Students will prototype their design with five different materials in the order as listed below:

- Build with newspaper
- Build with pipe cleaners
- Build with Legos/K'Nex
- Mold from Play-Doh
- Build from cardboard

8 | Students will then discuss their iterative design process with the class and discuss the benefits and shortcomings of each method.

9 | Ultimately, students will assemble their own final model with any/multiple materials of their choice.

Debrief Questions

- Discuss the reason why students used different materials
- Review user prompt for 5 chairs exercise
- Have students explain why they designed the chair the way they did to develop empathy

10 User Testing & Prototyping

Prototype, Test

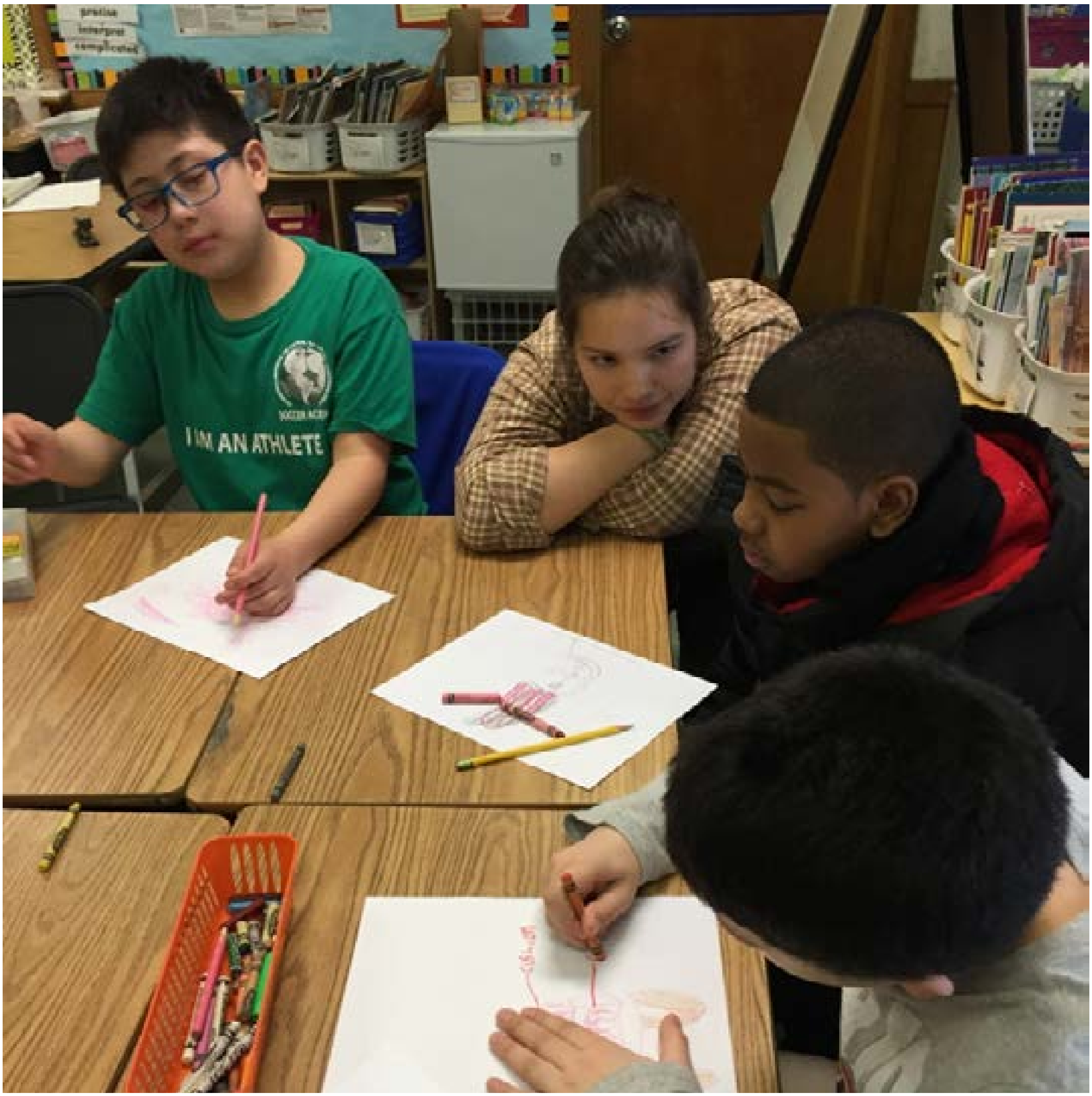
Students will participate in a user testing and prototyping activity to learn how to properly utilize user feedback and the importance of intuitive design.

Learning Objectives

- Understanding the importance of an intuitive design as well as instruction in certain circumstances
- Learning how to take proper user feedback
- Being able to utilize user feedback to constructively improve a product

Materials Needed

All prototyping materials that have been utilized through the semester





Pre-Class Prep

Readings in design intent, testing, and product agency.

How To

1 | Students will be given the opportunity to design a prototype to achieve any task they desire.

2 | After being given 45 minutes to create their prototype, student groups will trade one another and take turns testing each other's products. Students are not allowed to verbally or physically intervene to aid their users in utilizing their products.

3 | After each group tests the other's product for ten minutes, the teams are given 30 minutes to take their prototypes back to their work stations and use their user feedback to improve their product.

4 | Once the 30 minutes are over, students will once again trade their products with the same group and allow them to use it once again. After watching the group attempt to use their product for ten minutes, they will instruct the group on to use their product, and give them another five minutes to utilize the product.

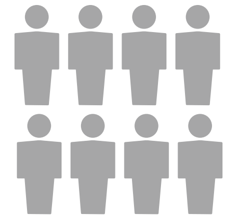
5 | Once both teams have utilized each other's products, they will sit down and discuss ways to improve one another's products and the experiences they had utilizing each.

Debrief Questions

- What features clued you into the product's intent?
- What made you mis-interpret (if applicable) the product's intent?
- What would you do differently?
- How did you notice the other group interacting with your product?

11 Get to Know Everyone!

Define, Research



Materials Needed:

- Lunch Catered by Institution

How To

Students will have a Breakfast/Lunch Meeting to get to know each other. After students have eaten, they will participate in a speed dating activity to get to know each other. Students will also be given their problem statement for the rest of the semester to begin work on.

Speed Dating

1 | Each original team will sit on side of a table. Paper bags with suggested questions will be placed inside paper bags.

2 | Students will pull a question from the paper bag and discuss.

3 | They will continue this for five minutes and then change partners

Team Project: Week One

Students will be given their problem statement for the five week long project, with the final goal of creating a non-finalized prototype deliverable. They are able to start researching, mind mapping, assessing users, etc. (Note: the problem statement will change semester by semester to keep the course new and innovative.)

12 Research & Ideation

Research, Ideate

How To

Students will continue their Team Project and work predominately on research and ideation. Students will be encouraged to rapidly prototype ideas to properly discuss and develop. They will utilize tools they have learned throughout the semester and be given the opportunity to be taught new tools by Professors and Teaching Assistants.

13 Ideation & Prototyping

Ideate, Prototype

How To

Students will be encouraged to begin honing in on a final or a final few designs. They should being creating their final prototyping and discussing testing methods.

14 Final Model Creation: Prototype & Testing

Ideate, Prototype, Test

How To

Students will finish creating their final prototype and conduct testing on their product. All students must present testing results in their final presentation, but can choose which type of testing they would like to conduct (user testing, system testing, mechanical testing, etc.)

15 Final Presentations

Pre-Class Prep

Invite Faculty and Staff Members from all Schools at Rensselaer to attend Presentation to aid in providing feedback.

How To

1 | Students will present a PPT presentation of their problem, process, and solution, as well as final prototype. All presentations could include:

- Problem Statement
- Scoping
- Research
- Ideation Process
- Solution (& Prototype)
- Testing Methods

2 | What They Would Do Next (Possible Re-scoping, Necessary Research, Further Testing, etc.)

3 | After each group presents, all students and professors will be incentivised to critique and other feedback.

4 | After all student presentations, there will be a class discussion about the course content, what students learned, what could be improved, etc.

5 | Then, the students will fill out personal reflection and group dynamic worksheets, as well as a formal course evaluation.

Re:IED

Rethinking Introduction to Engineering Design

Defining the Problem

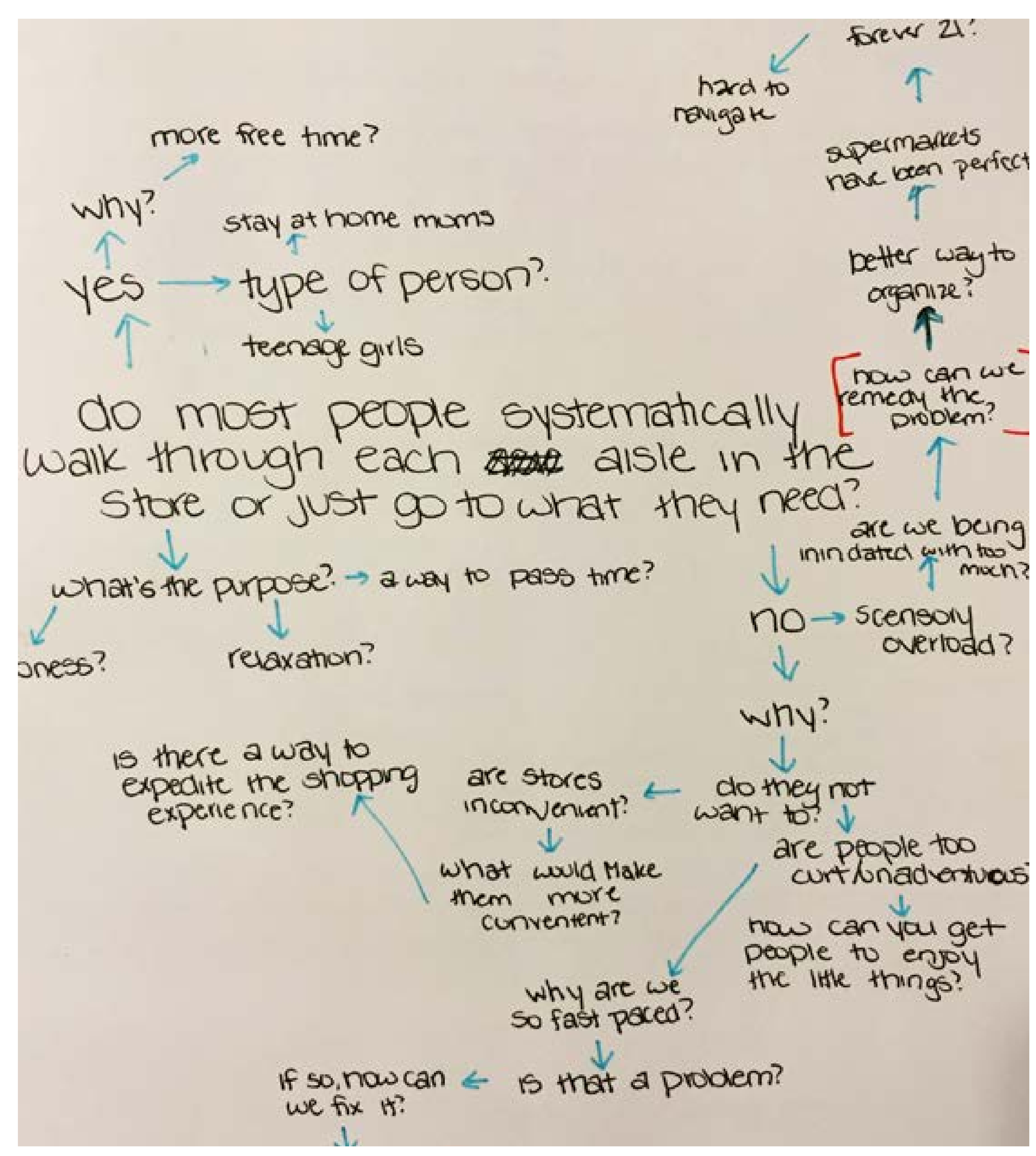
There is an apparent trend towards reform in engineering education in the United States. Many engineering departments are developing innovative classes to address the problems facing the United States engineering industry. These problems and solutions are addressed at length in recent literature. Some of the research regarding engineering educational reform stems from an examination of the engineering education and industry of other countries that are more competitive than the US. In fact, this is one perceived problem – the United States' lack of engineering talent compared to other nations. This is an important ranking because of the enormous correlation between economic health and engineering industry strength. Engineering industry in the United States places the blame of its failures partly on engineering educational institutions and their inability to adequately prepare students for professional careers. While many institutions aim to mitigate these problems with teamwork based engineering courses, much of the time their efforts fail. At Rensselaer, Introduction to Engineering Design falls into this category.

Course Description

Rethinking Introduction to Engineering Design (Re:IED) is a piece exemplifying what the Introduction to Engineering Design (IED) course at Rensselaer could be, and how all of the same educational benchmarks can not only be met – but exceeded – through more engaging and collaborative curricula that provides students with the proper environment to thrive as engineers. Where IED dissuades risk taking, punishes hard work when it fails, and leaves students with a disappointing view of what collaborative engineering work is, Re:IED does the opposite. Re:IED incentivizes calculated risk taking, teaches students that failure is a step on the way to success, and that engineering can be engaging, collaborative, and exciting.

Course Objectives

This course will teach students about the importance of teamwork and communications in the context of the engineering design process. Interactive engineering design and professional development exercises will provide students with the knowledge and skills necessary to innovative effectively as a team. Coursework is designed to challenge students to improve and expand upon your oral, written and visual communication skills, as well as their creative, critical thinking, and engineering abilities.



Learning Outcomes

1 | Students will have the capacity to solve engineering design problems, while instilling the importance of creativity in developing innovative solutions.

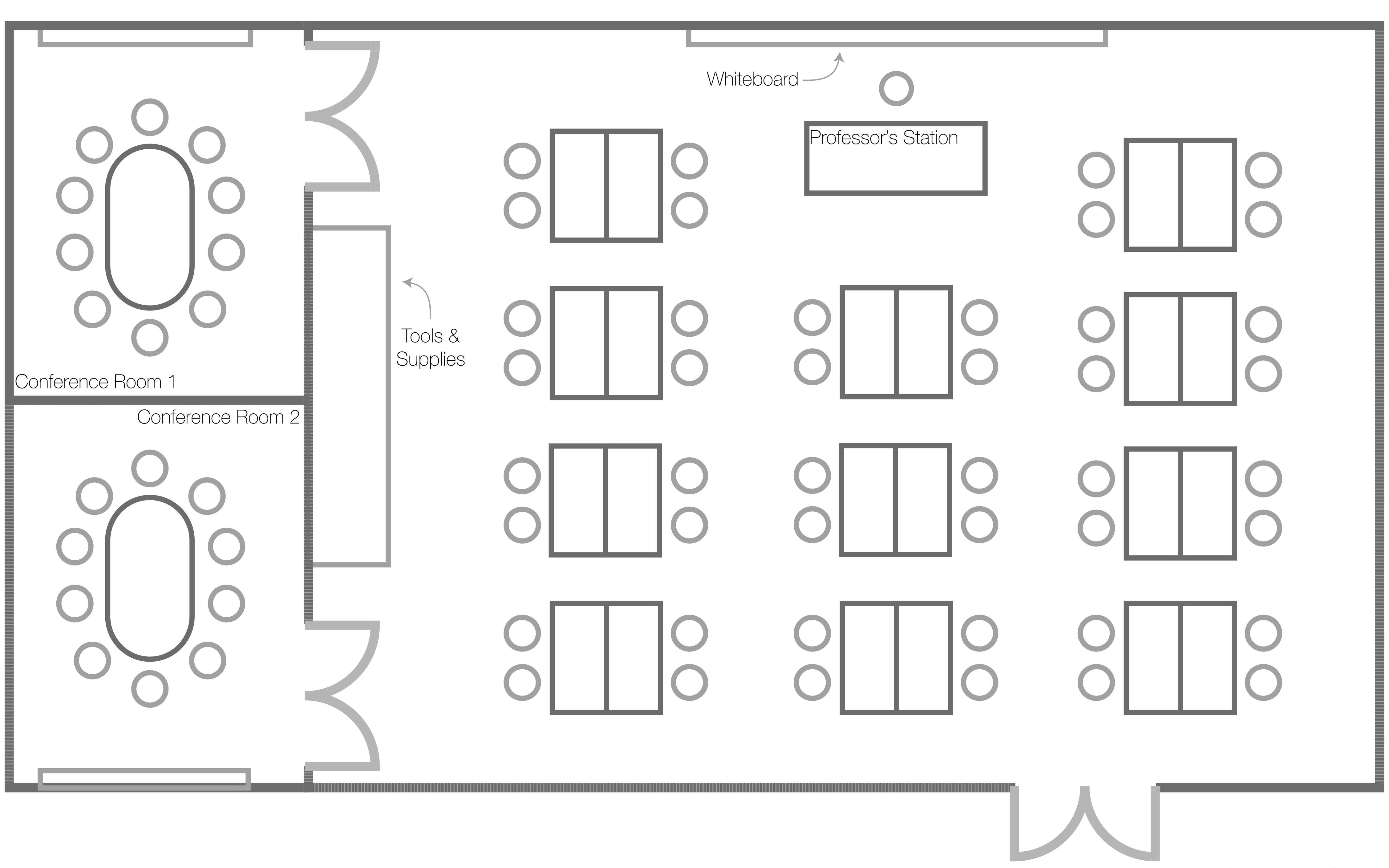
2 | Students will know how to identify customer needs, establish design objectives, and translate these into engineering design specifications.

3 | Students will exercise and improve important design skills of visualization, calculation, experimentation, and modeling.

4 | Students will have skills in organizing people and ideas for successful design. Skills include teamwork, project management, verbal and written communication, and documentation.

5 | Students will be able to function on multi-disciplinary teams and communicate effectively.

6 | Students will understand professional and ethical responsibility.



Course Coordinators: Ryan Jenkins, Emily Farella, & Rebecca Radparvar