

# Re:IED

Rethinking Introduction to Engineering Design

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# SYLLABUS

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# 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 thought 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, 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

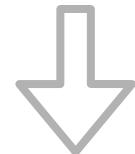
Review the Design Process PPT with students and discuss the importance of following the Design Process as well as making the Design Process your own and augmenting it to fit your needs as a designer and engineer.



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

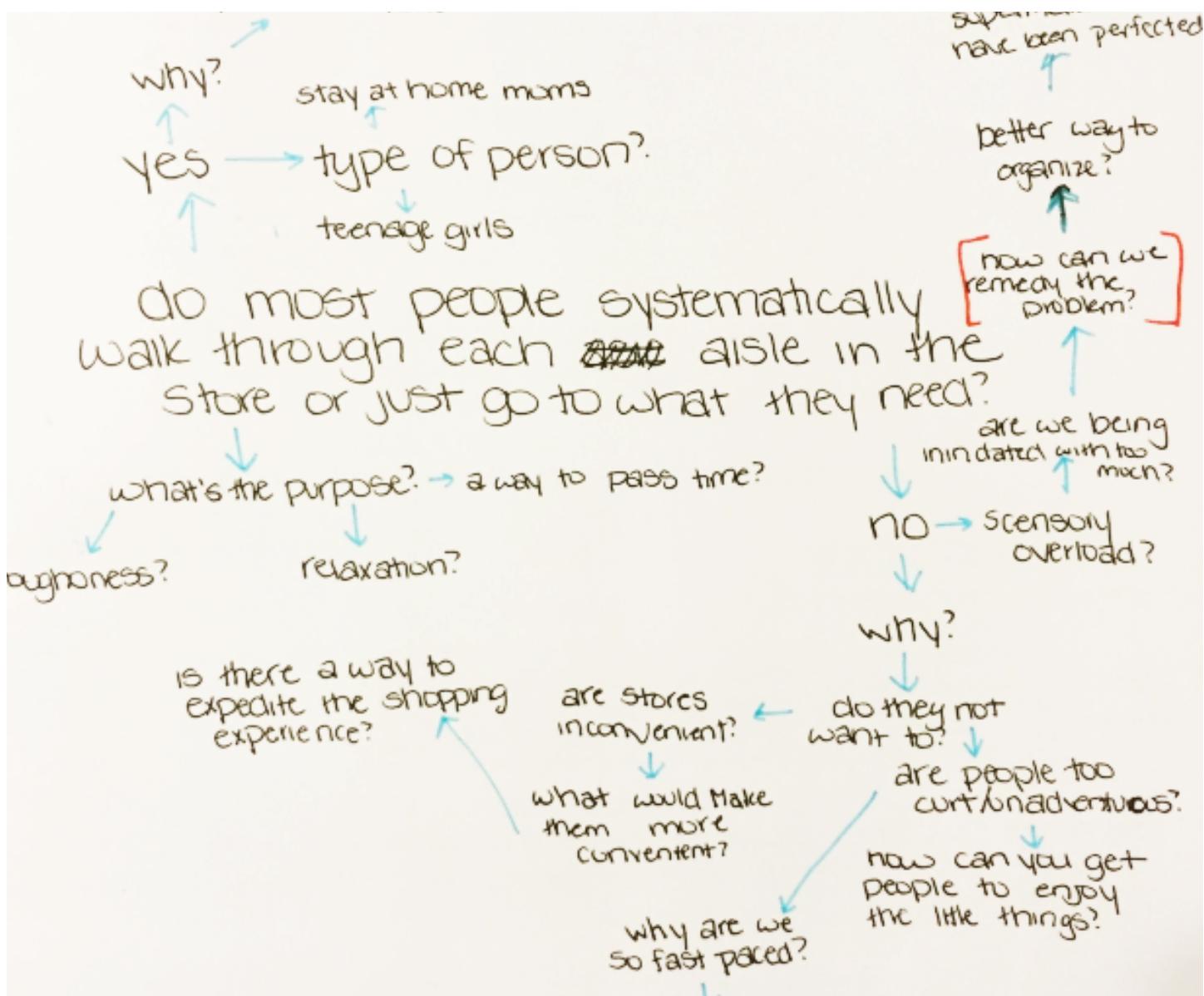
## Materials Needed

- 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.

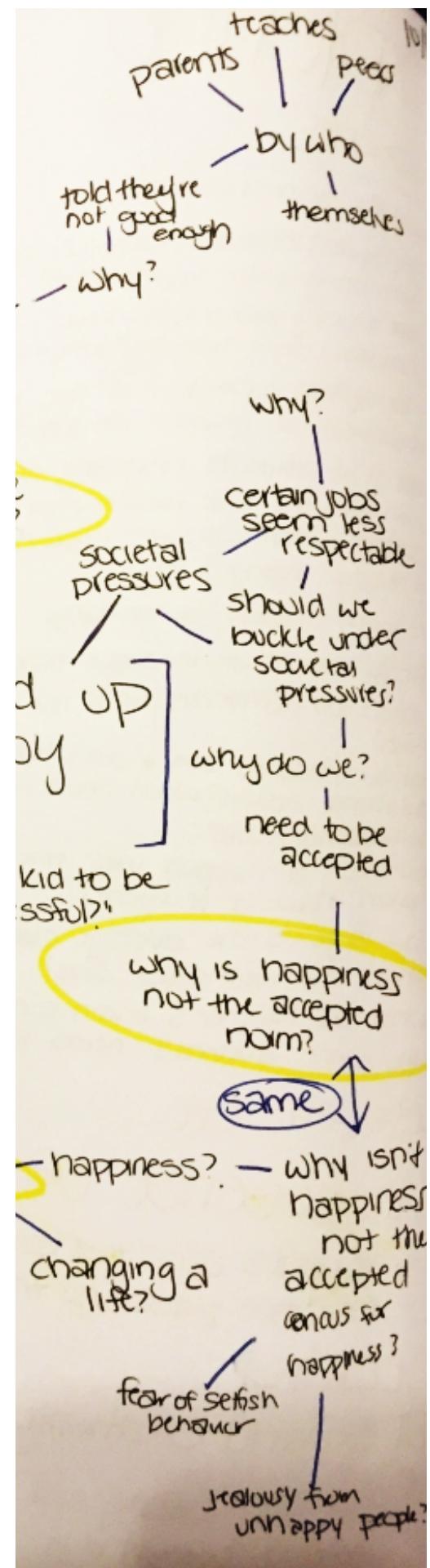
- 2 | Have students in pairs decide on a topic to mind map. Once students have decided as a pair what topic they would like to explore, have them individually map out the product or experience.
- 3 | After 10 to 15 minutes, have students combine mind maps into a larger mind map.
- 4 | Once students have 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 code 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?



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 they 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.

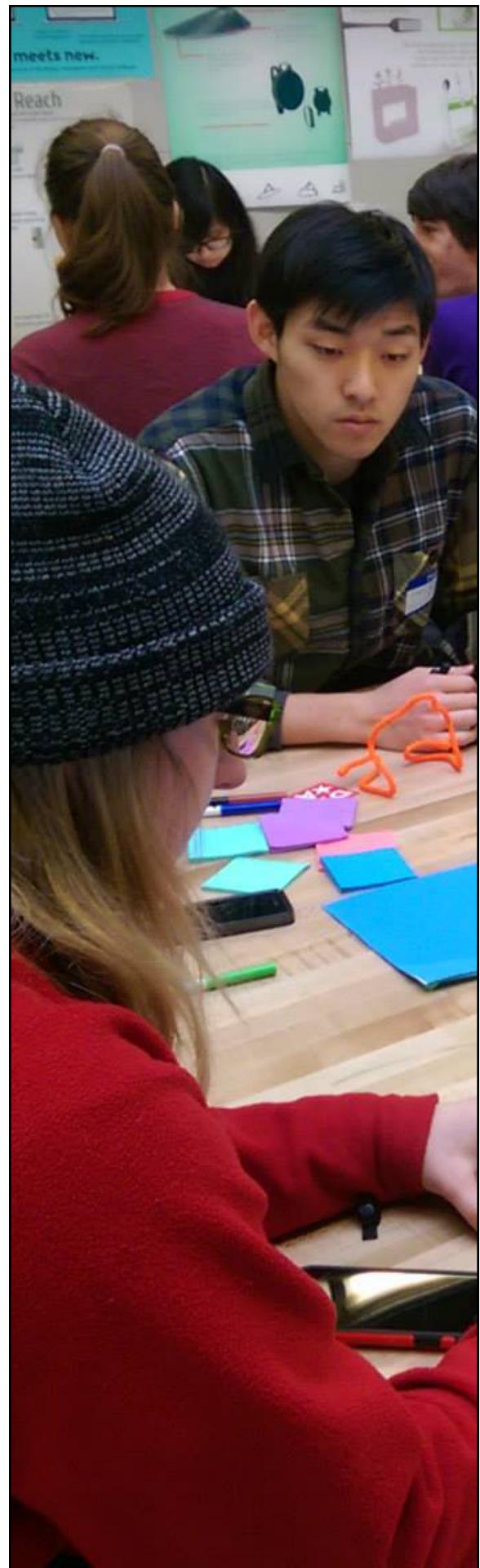
### **Part Three**

- 1 | Give students a third prompt.
- 2 | Have students conduct the same activity as above with words and pictures.

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### 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 will 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.

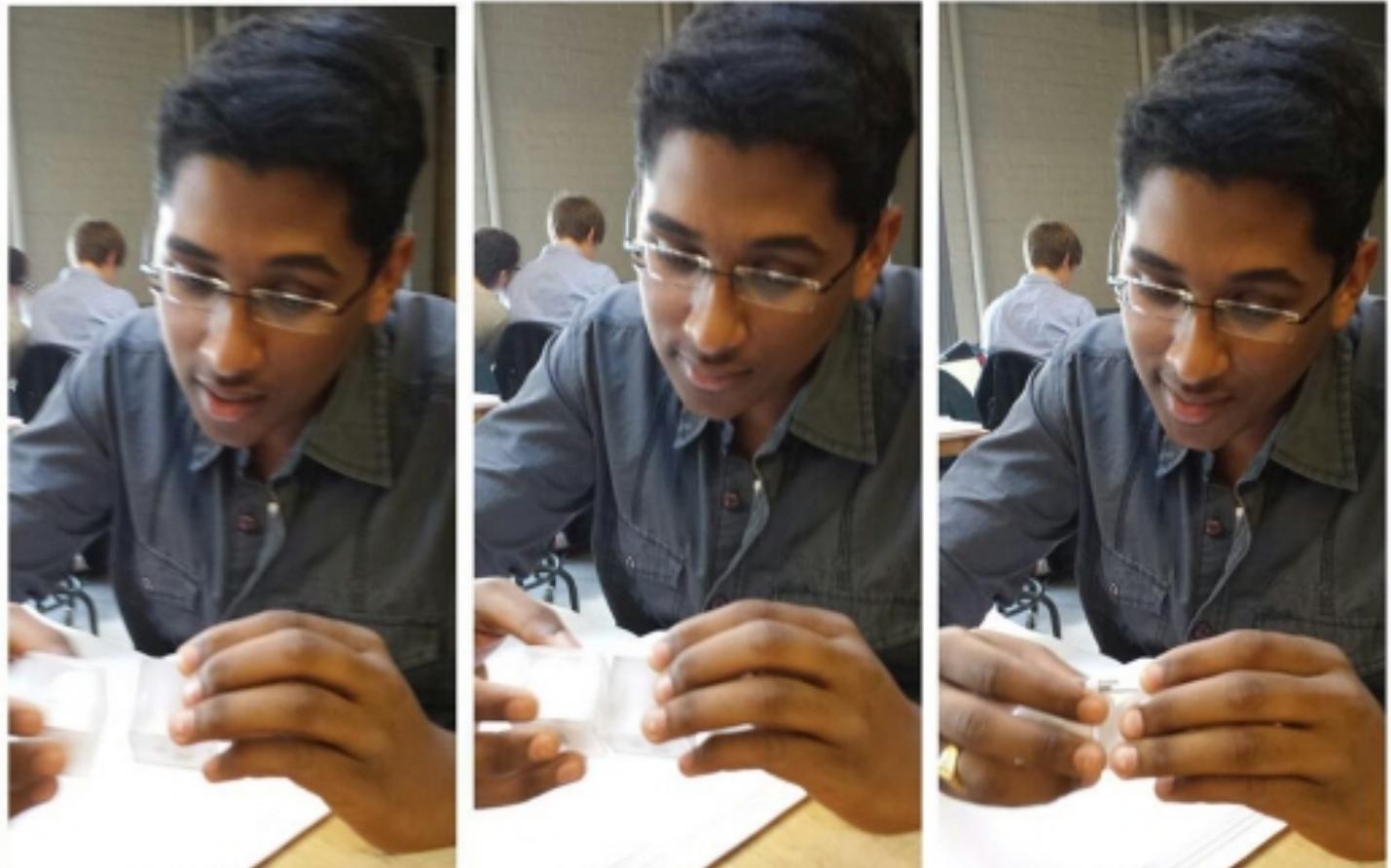
## Learning Objectives

- 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





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## Pre-Class Prep

Readings in design intent, testing, and product agency.

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## 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.

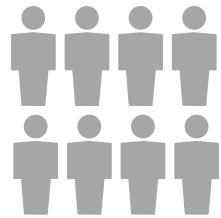
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## Debrief Questions

- 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 be 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.

