Design, Diversity and Digital Learning: Reframing 21st Century Education

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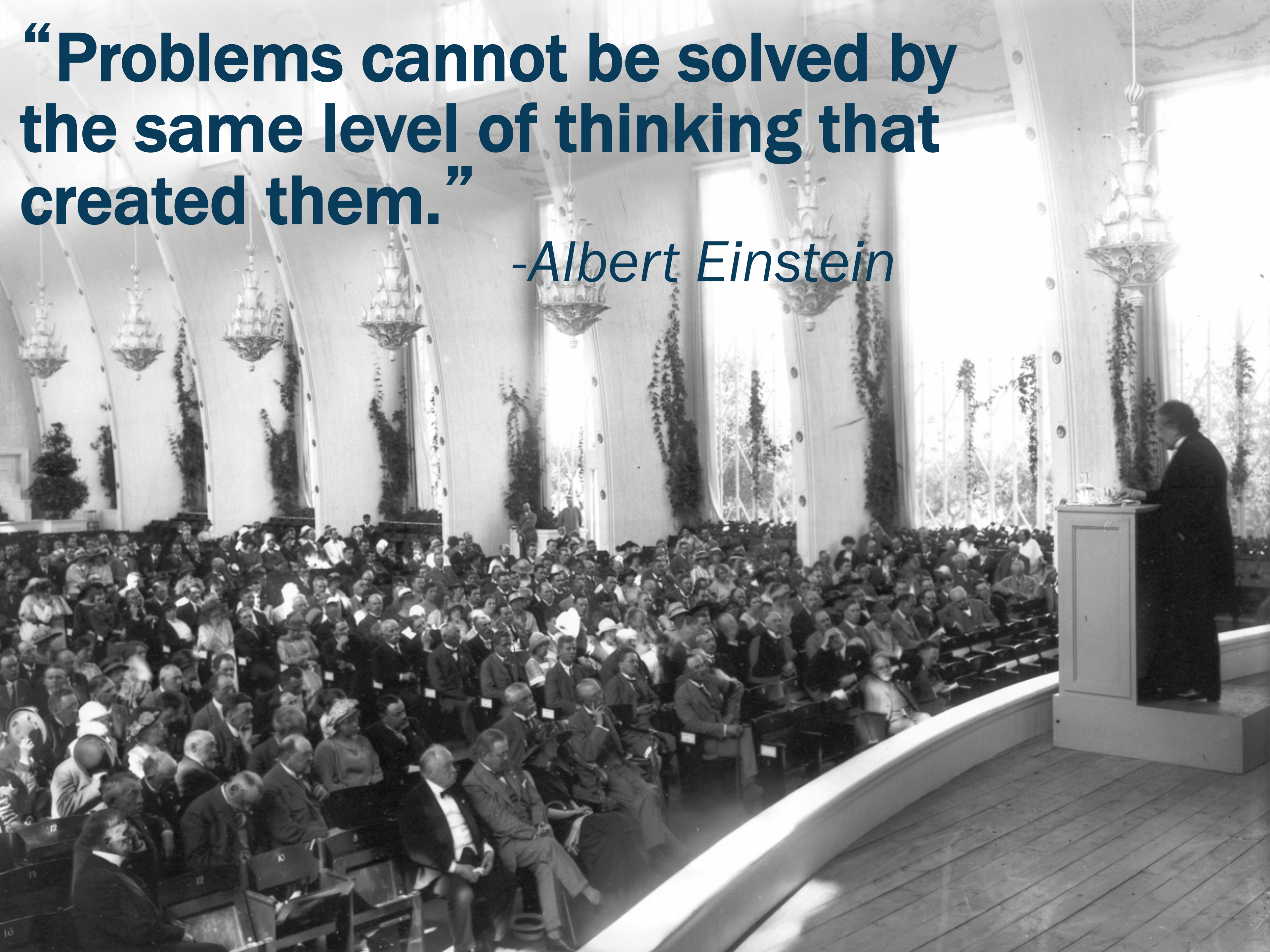

"Problems cannot be solved by the same level of thinking that created them."
-Albert Einstein

Essential Understandings

U1	Design is a verb (process) and a noun (product)
U2	Design is practiced everyday, everywhere by everyone
U3	Design can be framed by teaching and learning models
U4	Design has a growing digital 'tool box' resources
U5	Design across classroom settings from brick and mortar to the virtual world
U6	Design can be codified to track activities to award progressive recognition

Research Overview

➢ Strategies for Engineering Education K – 16 (SEEK – 16) convening held at the National Academy of Engineering in 2005.

➢ A ten-year effort to align multi-disciplinary efforts and partnerships for the:

- ✓ Development of an Engineering Design Process Portfolio Scoring Rubric (EDDPSR).
- ✓ Partnering with Project Lead the Way to create an e-portfolio (www.innovationportal.org) framed by the EDPPSR.
- ✓The launch by the College Board of an initiative to study the creation of an Advanced Placement in Engineering.
- ✓ Piloting of online tools to develop and implement design on mobile devices.

➢ Development of a hybrid educational model to align 21st century competencies, performances, skills and tasks to span the academic and workforce domains.

Mixed Method Research

- 10+ Focus Groups – (150+ Participants)
- 200+ One-on-one Interviews
- 10+ Workshops (500+ Participants)
- Pilot Courses (300+ students) – 13 Classroom; 2 Flipped; 1 Online

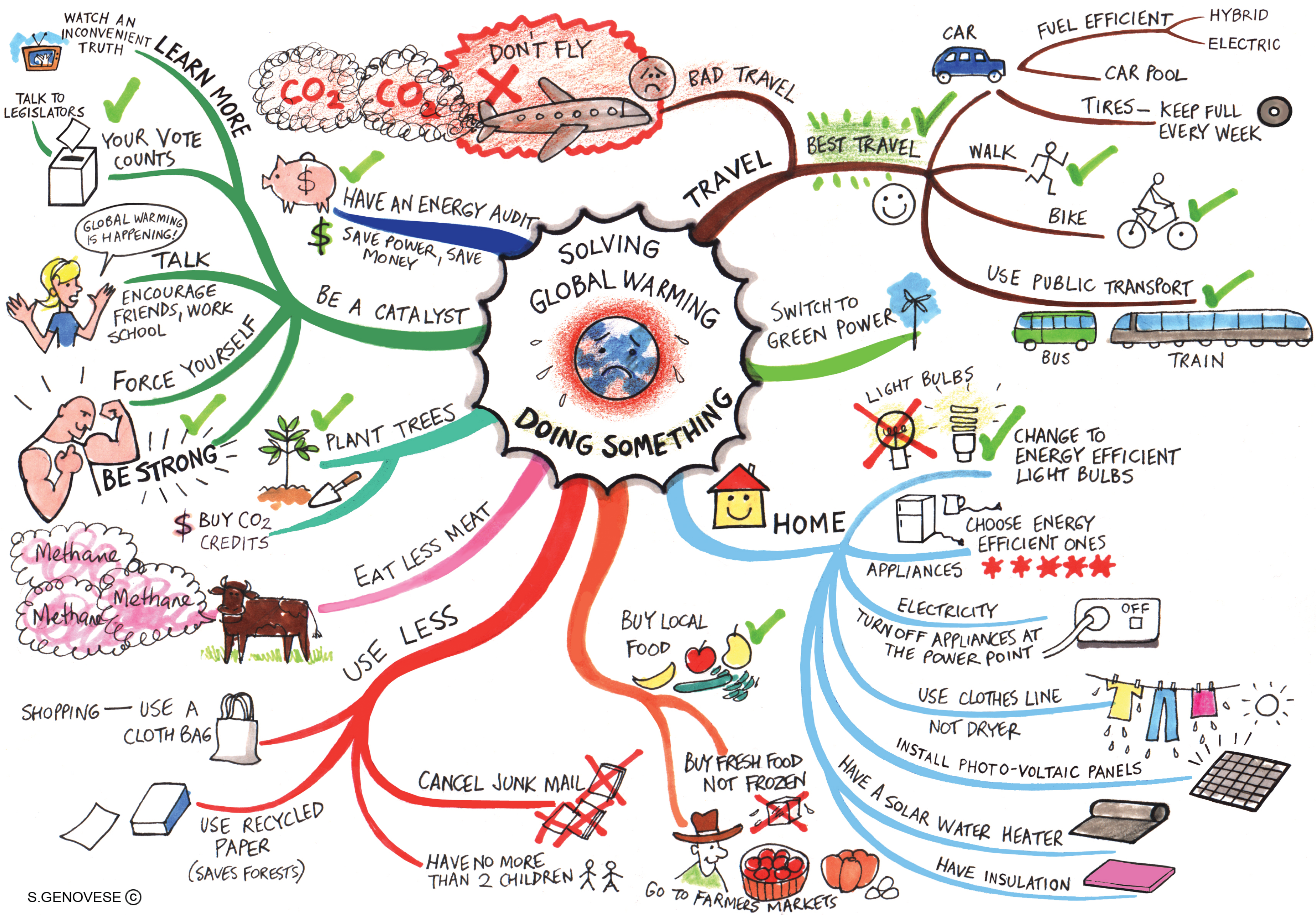
NSF PRIME, INSPIRE, ERC, SITE & Regional RETs, I-Corps Learning & Workshops; & JHU, UMD, MESA, DOE and DoD Pilots

Why Design?

It is an **action (the verb)** to “produce novel, unexpected solutions, **tolerate uncertainty**, work with incomplete information, **apply imagination** and forethought **to practical problems**” generating a **product (the noun)**.

Source: Pourdehnad, J., Wexler, E. R., & Wildon, D. V. Systems & Design Thinking: A Conceptual Framework for Their Integration.

Design Noun Verb Agreements – Mind Mapping

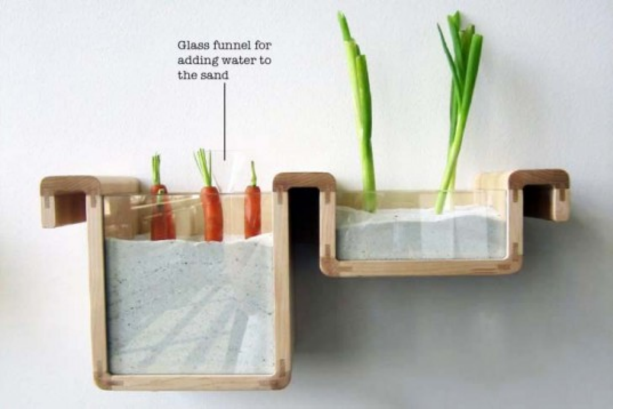


S.GENOVESE ©

Design is practiced everywhere, everyday by everyone

De-mystifying design

Design is all around

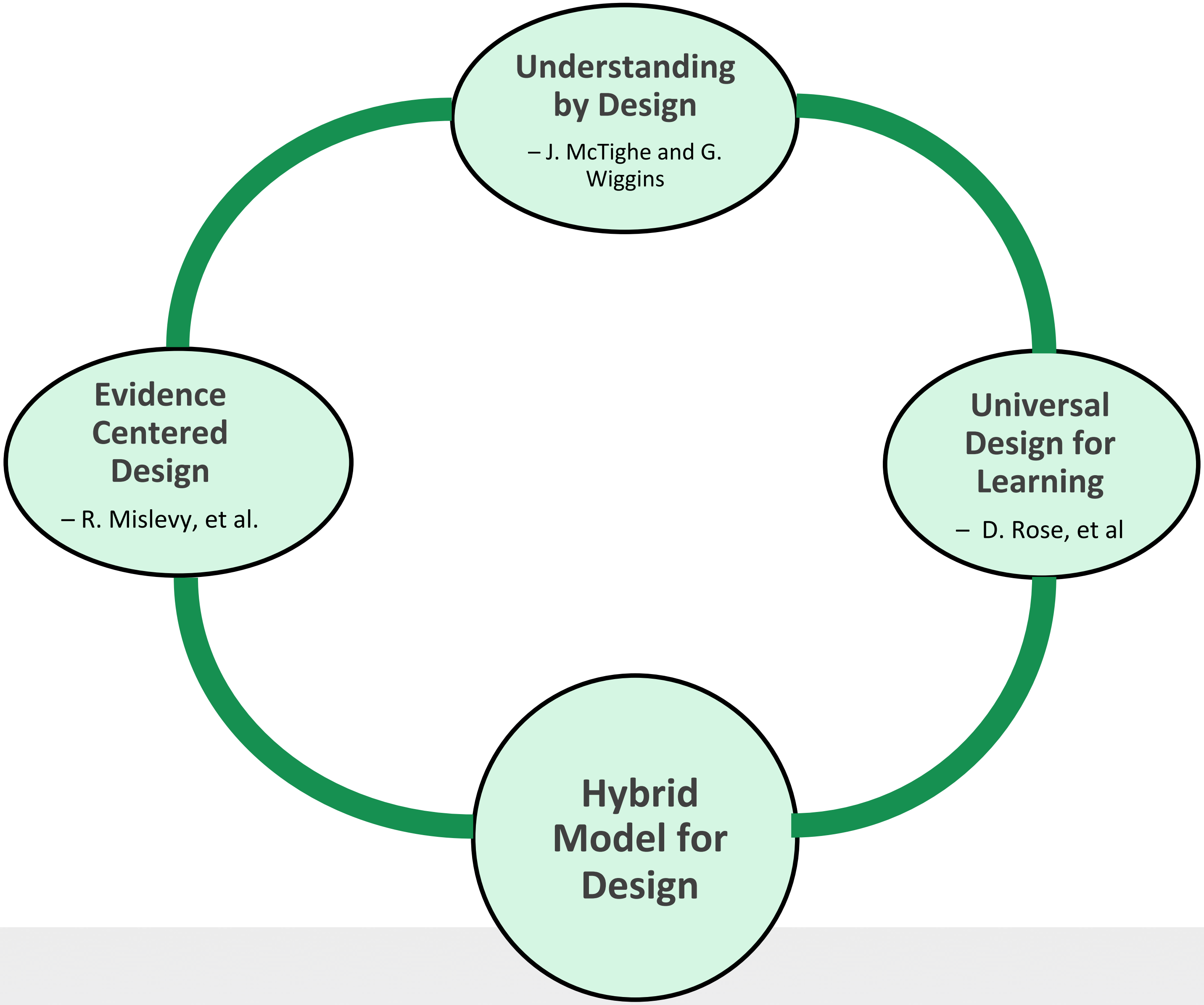


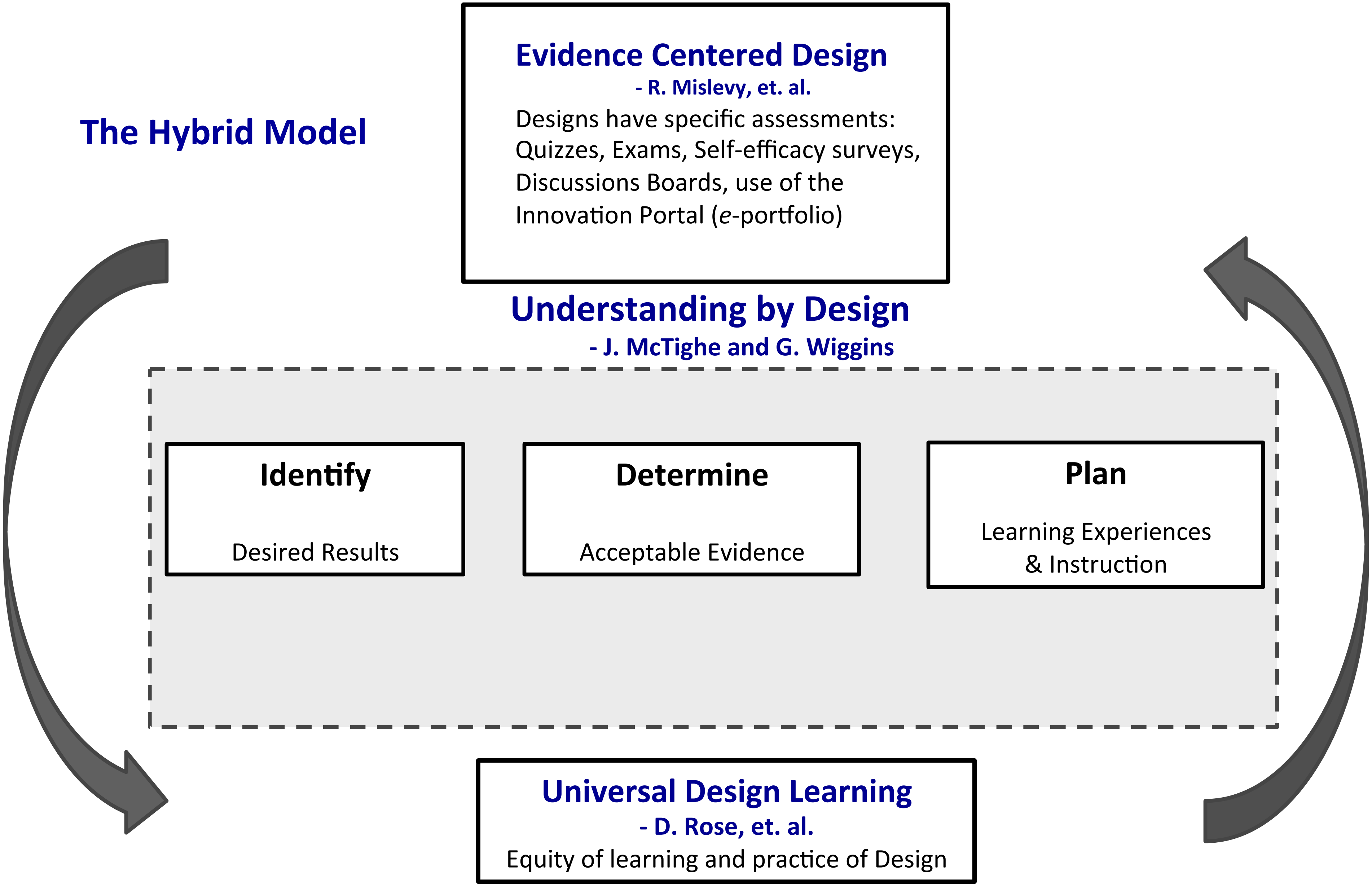
Design is an everyday happening

Design can be framed by teaching and learning models

A hybrid model to frame Design Thinking

A Hybrid Model for Education





Modified graphic developed by Dr. Laura Adolfie based on format developed with Dr. Idalis Villanueva, Dr. Rosemary Reshetar and Dr. Abts

Identify

Engineering Design Process Portfolio Scoring Rubric (EDPPSR)

Component I: Presenting and Justifying a Problem and Solution Requirements

Element A: Presentation and justification of the problem

Element B. Documentation and analysis of prior solution attempts

Element C. Presentation and justification of solution design requirements

Component II: Generating and Defending an Original Solution

Element D: Design concept generation, analysis, and selection

Element E: Application of STEM principles and practices

Element F: Consideration of design viability

Component III: Constructing and Testing a Prototype

Element G: Construction of a testable prototype

Element H: Prototype testing and data collection plan

Element I: Testing, data collection and analysis

Component IV: Evaluation, Reflection, and Recommendations

Element J: Documentation of external evaluation

Element K: Reflection on the design project

Element L: Presentation of designer's recommendations

Component V: Documenting and Presenting the Project

Element M: Presentation of the project portfolio

Element N: Writing like an Engineer

Funding provided by the National Science Foundation and the Kern Family Foundation in collaborations with PLTW, coordinated through Mr. Mark Schroll, and Dr. Gail Goldberg

Design has a growing digital ‘tool box’ of resources

Design on the ‘go’

Capturing and archiving designs

Systematically and comparatively

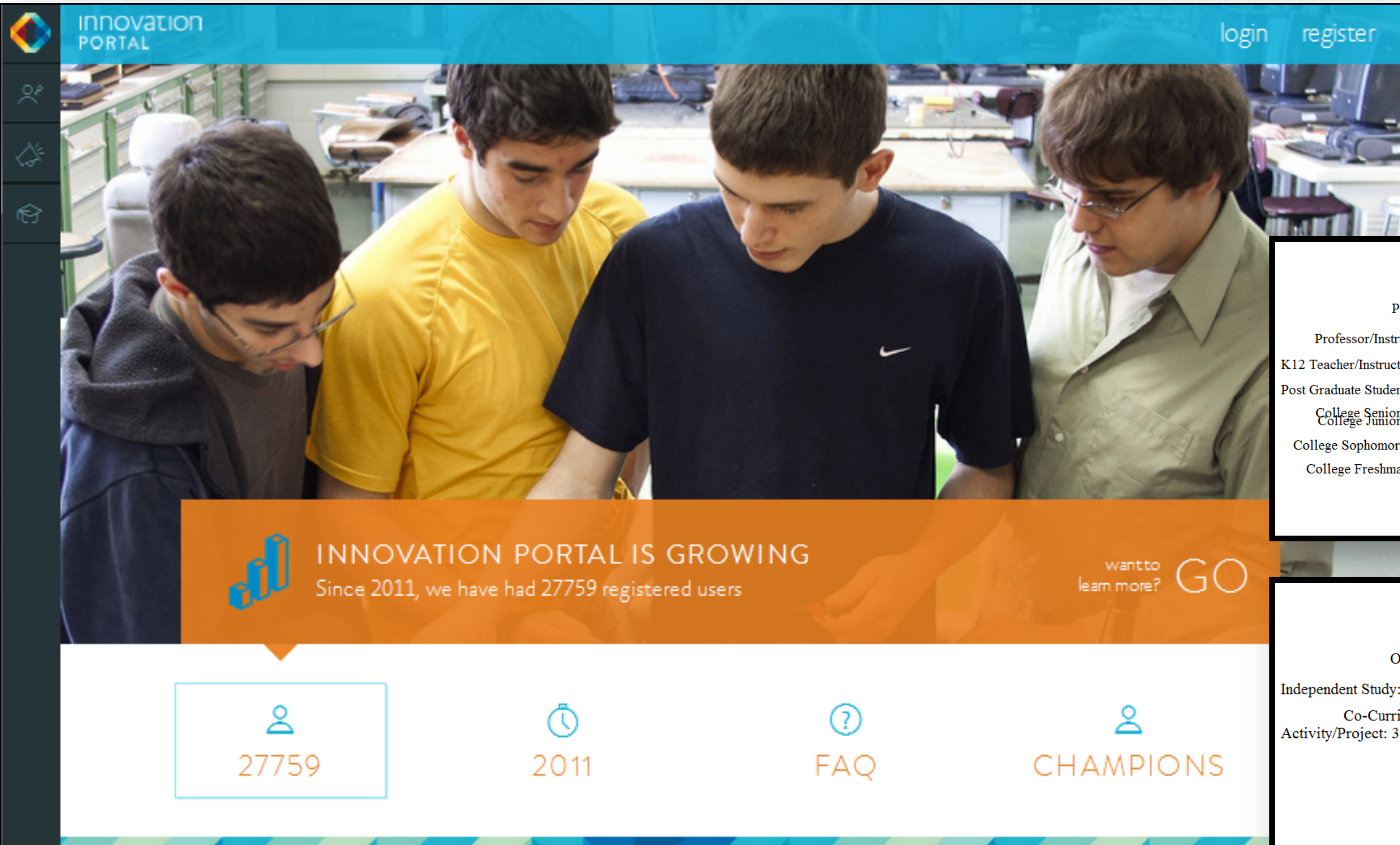
The InnovationPortal

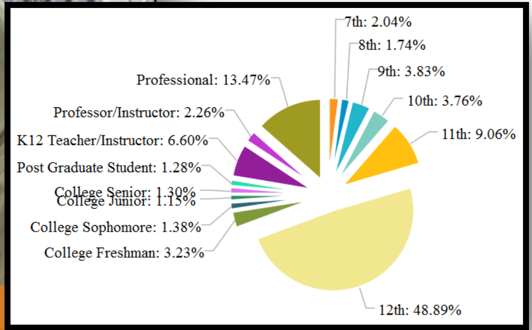
An *e*-portfolio for design

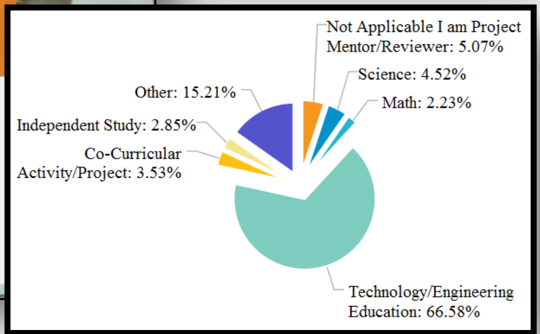
Innovation PORTAL

https://nnovationportal.org

Identify a Problem. Go after a solution. Document your work. Connect with Opportunities.







Free , open , and secure for use by students, teachers and mentors - everywhere

PROJECT LEAD THE WAY PLTW

Kern | FAMILY FOUNDATION

Chevron Human Energy

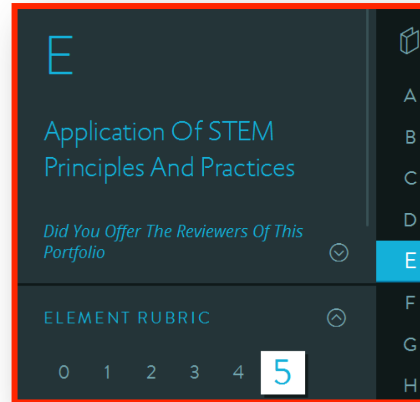
Courtesy of PLTW

Portfolio Snapshot

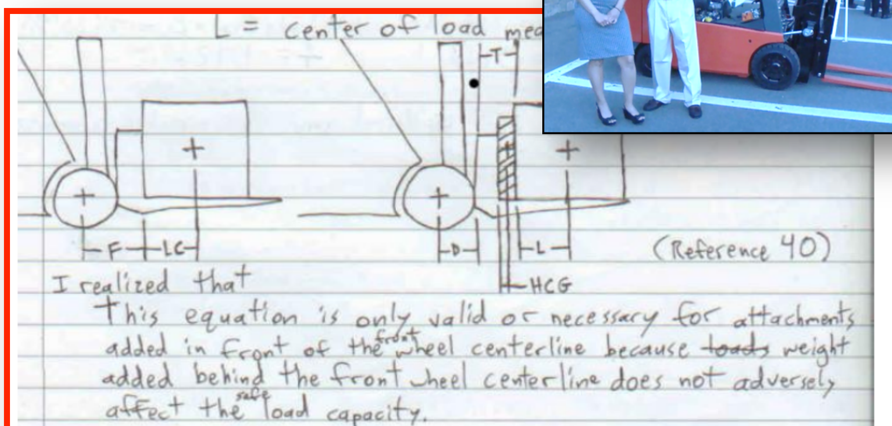
innovation PORTAL

APPLICATION OF STEM PRINCIPLES AND PRACTICES E

"The proposed solution is well-substantiated with STEM principles and practices applicable to all or nearly all design requirements and ……"



Forklift Safety



Forklift Stopping Distance Calculations

The following calculations determine an approximation for the distance that it takes for a forklift to stop.

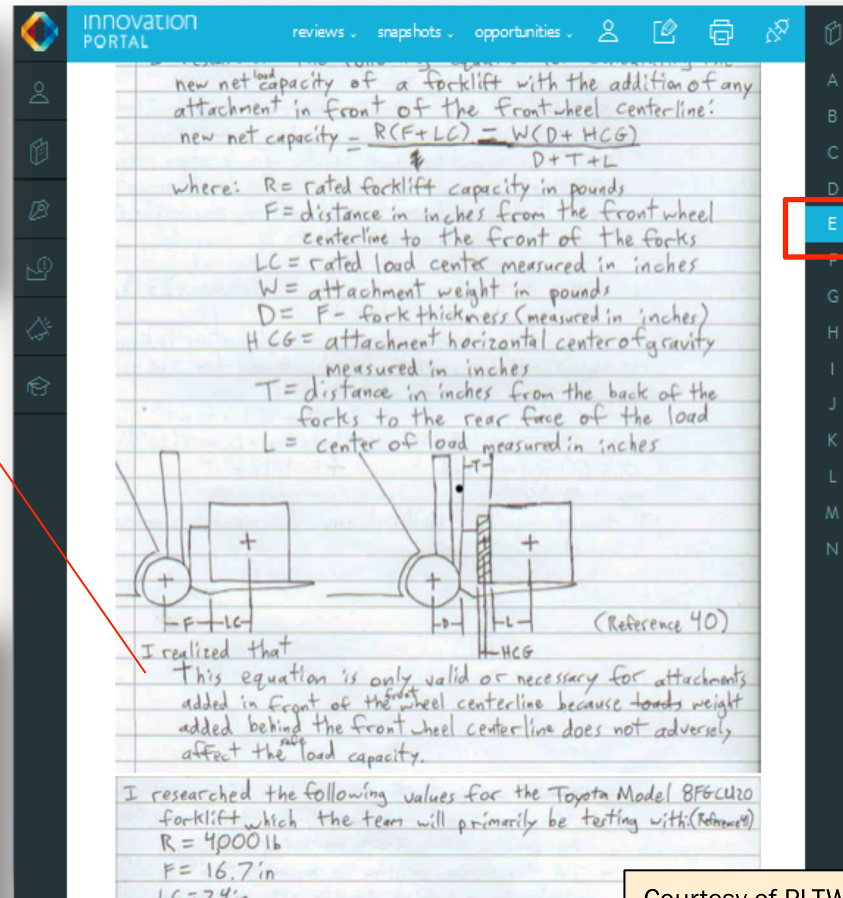
"It takes about 1.3 feet for each mile per hour for a panic stop."

(Miller, Barrett C. "Forklift Safety by Design." Safety-Engineer.com. 1998. Web. 12 Nov. 2012. <http://www.safety-engineer.com/forklift.shtml>.)

An approximation of the stopping distance was calculated based on this fact:

$$\frac{5\,mi/hr}{1}\left(\frac{1.3\,ft}{1\,mi/hr}\right)\left(\frac{12\,in}{1\,ft}\right)\left(\frac{2.54\,cm}{1\,in}\right)\left(\frac{10^{-2}\,m}{1\,cm}\right) = 1.9812\,m$$

org/portfolio/6154/element/C

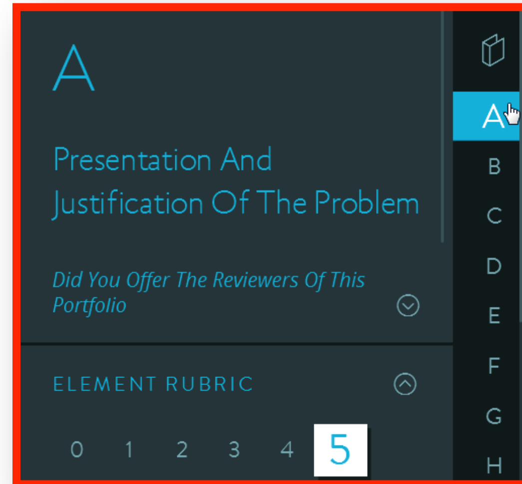


Courtesy of PLTW

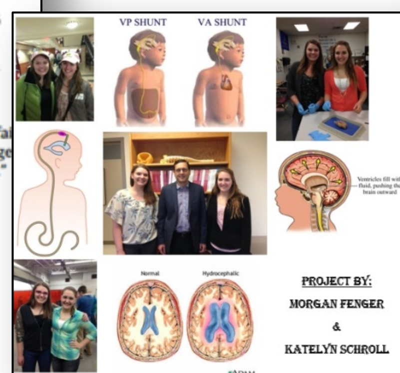
Portfolio Snapshot innovation PORTAL

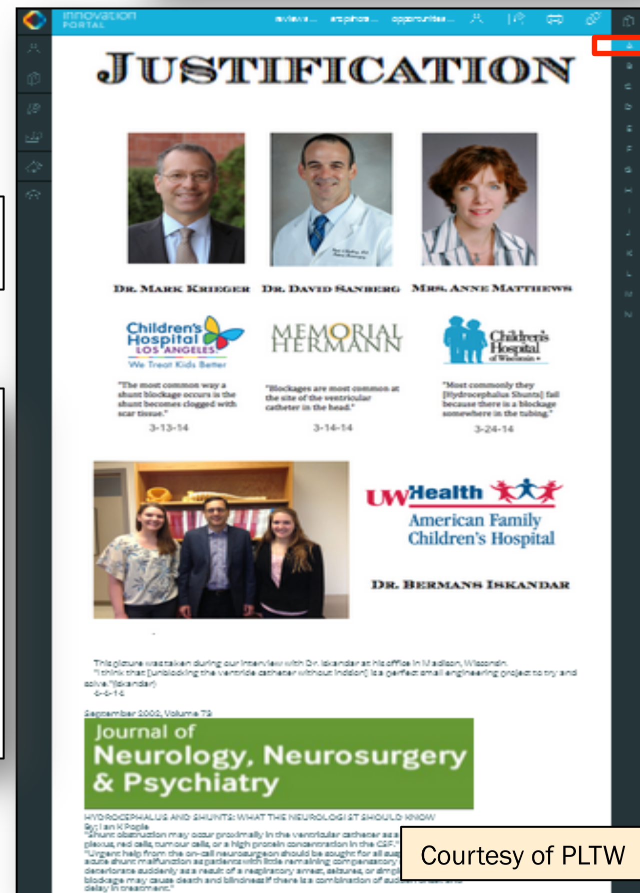
PRESENTATION AND JUSTIFICATION OF THE PROBLEM A

"The problem is clearly and objectively identified and defined with considerable depth, and it is well elaborated with specific detail; the justification of the problem highlights the concerns of many primary stakeholders and…"



TECHNOLOGY FOR UNBLOCKING A HYDROCEPHALUS SHUNT



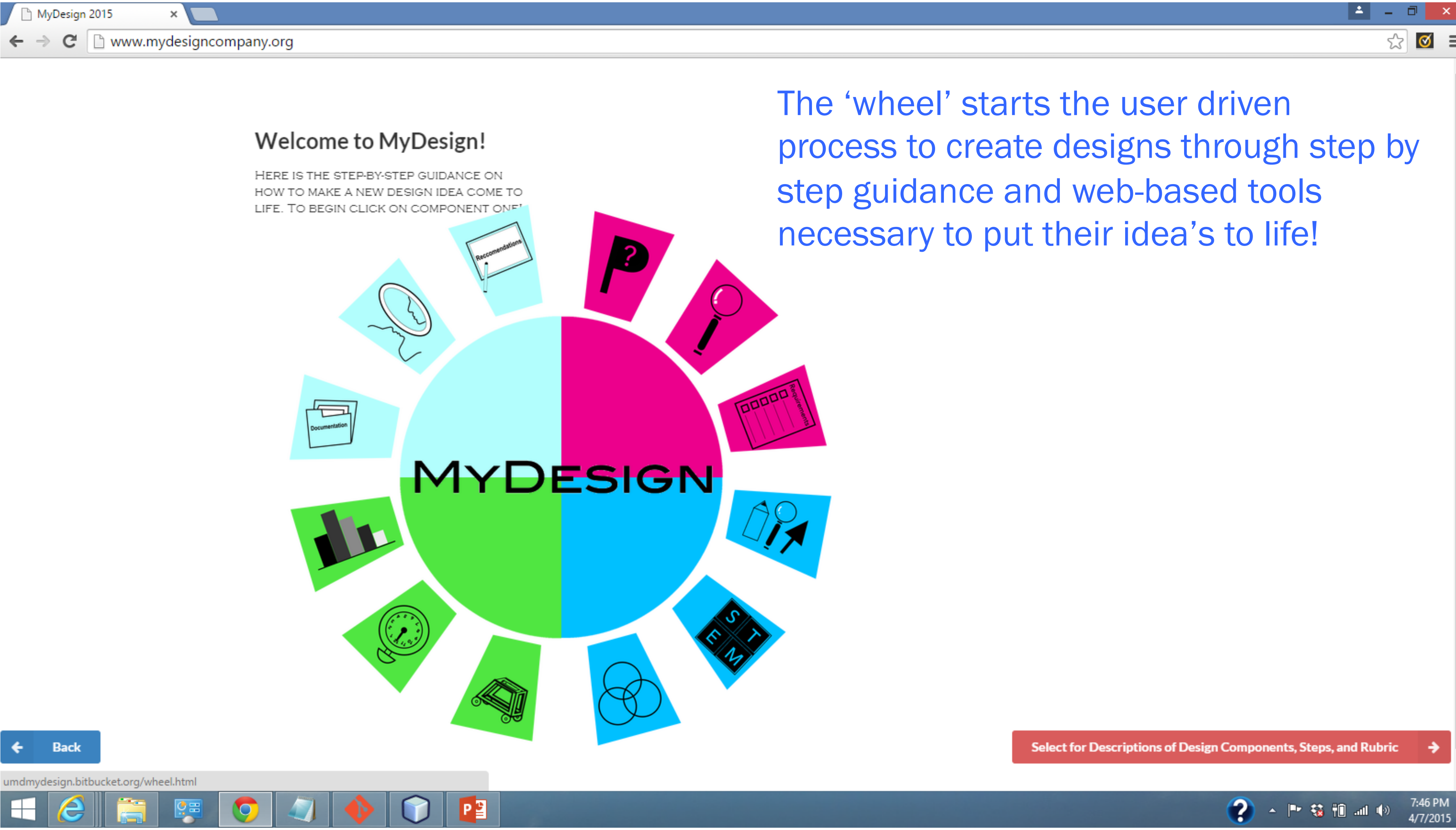


Courtesy of PLTW

MyDesign

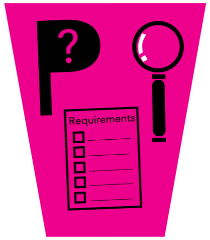
Creating designs ‘on the go’

Supported by National Science Foundation and A. James Clark School of Engineering
Collaboration with Ms. Cheryl Bitner, Mr. Mike Bitner, Ms. Mohini Goel,
Ms. Toby Ratcliffe, and Mr. James Turner



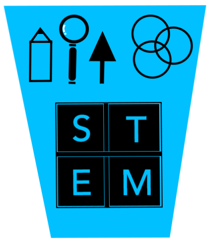
The 'wheel' starts the user driven process to create designs through step by step guidance and web-based tools necessary to put their idea's to life!

Icons developed by Ms. Mohini Goel



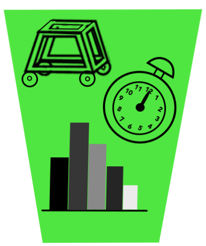
Component I: Presenting and Justifying a Problem and Solution

This component consists of Defining a Problem, Analyzing prior and existing solutions to the problem, and creating a list of design requirements that your solution must meet to be successful.



Component II: Generating and Defending an Original Solution

This Component consists of creating sketches of all possible solutions applying STEM principles to the design. After sketches are made, each should be analyzed in order to choose the best design.



Component III: Constructing and Testing a Prototype

This component consists of construction of a prototype, prototype testing, and data collection of testing. The data should be analyzed. If changes are necessary, the prototype should run through repeated testing, until it is successful.

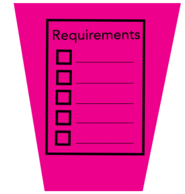
Component IV: Evaluation, Reflection, and Reccomendations

This component consists of expert evaluation of the product, student reflection on each major step Of the Project, reccomendations of improvements on the design, and how those improvements could be implemented.

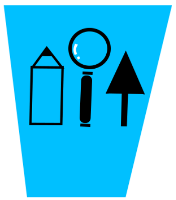
Icons developed by Ms. Mohini Goel

Define a Problem

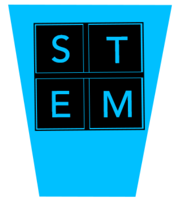
Document and analyze prior solution attempts



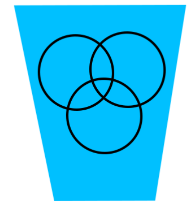
Present and Justify solution design requirements



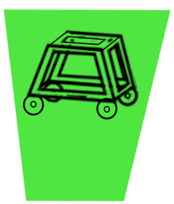
Sketch All Possible solutions, Analyze, and select best



Apply STEM principles and practices

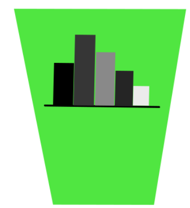


Consider design viability



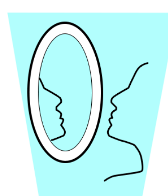
Construct a testable prototype

Create Prototype testing and Data collection plan

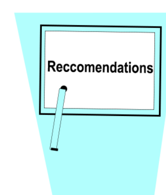


Testing, Data Collection, and Analysis

Document external evaluation

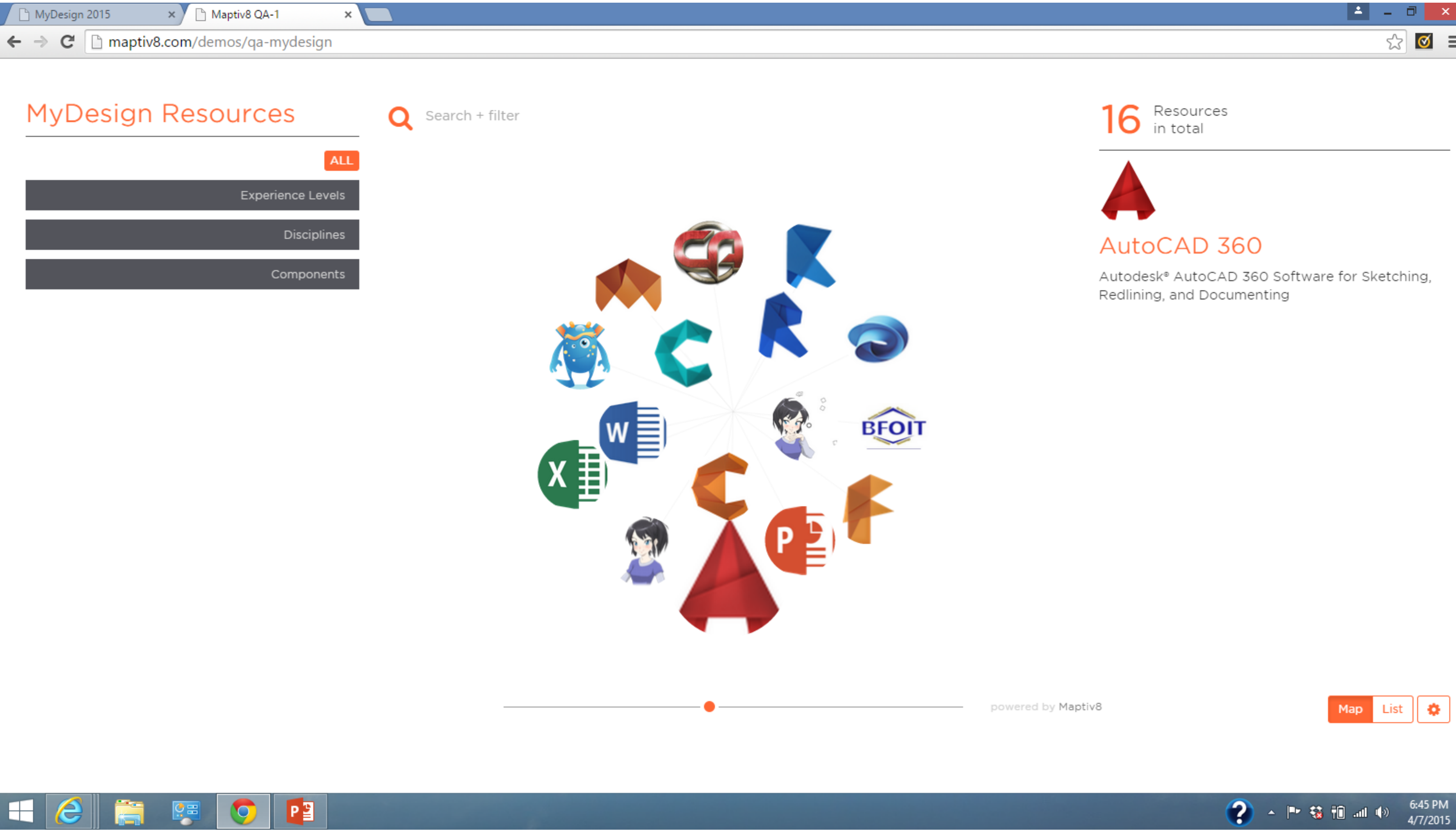


Reflection on the design project



Presentation of Designer's reccomendations

Icons developed by Ms. Mohini Goel



Working with the teams at Maptiv8 & Familian, LLC

MyDesign

MyDesign

Progress

Dashboard

- MyHome
- MyApps
- MySketches
- MyExamples
- MyResources
- MyCollaborators
- MyMentors
- MyProgress
- MyMessageBoard
- MyRubric
- MyPortfolios

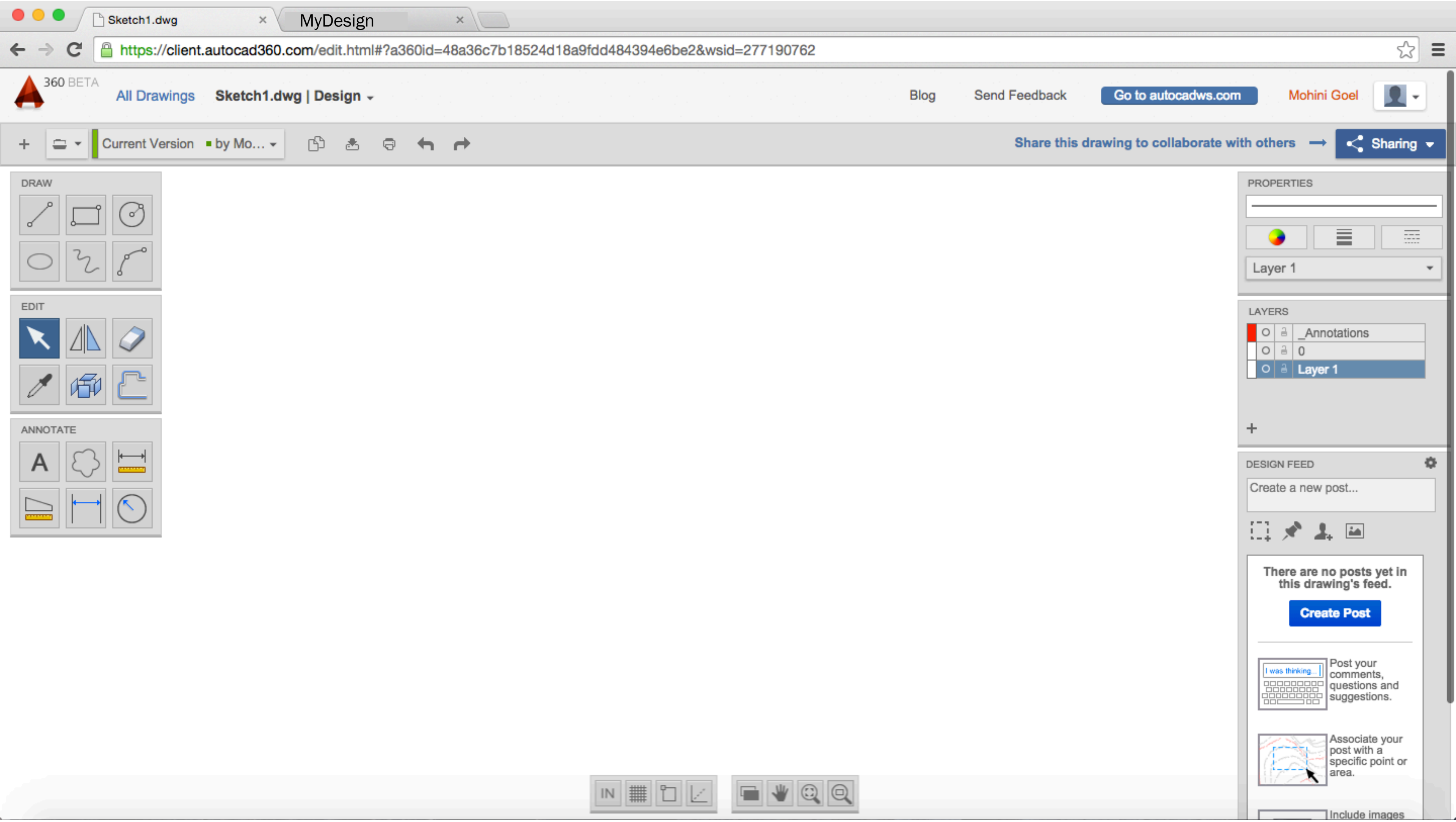
App Library

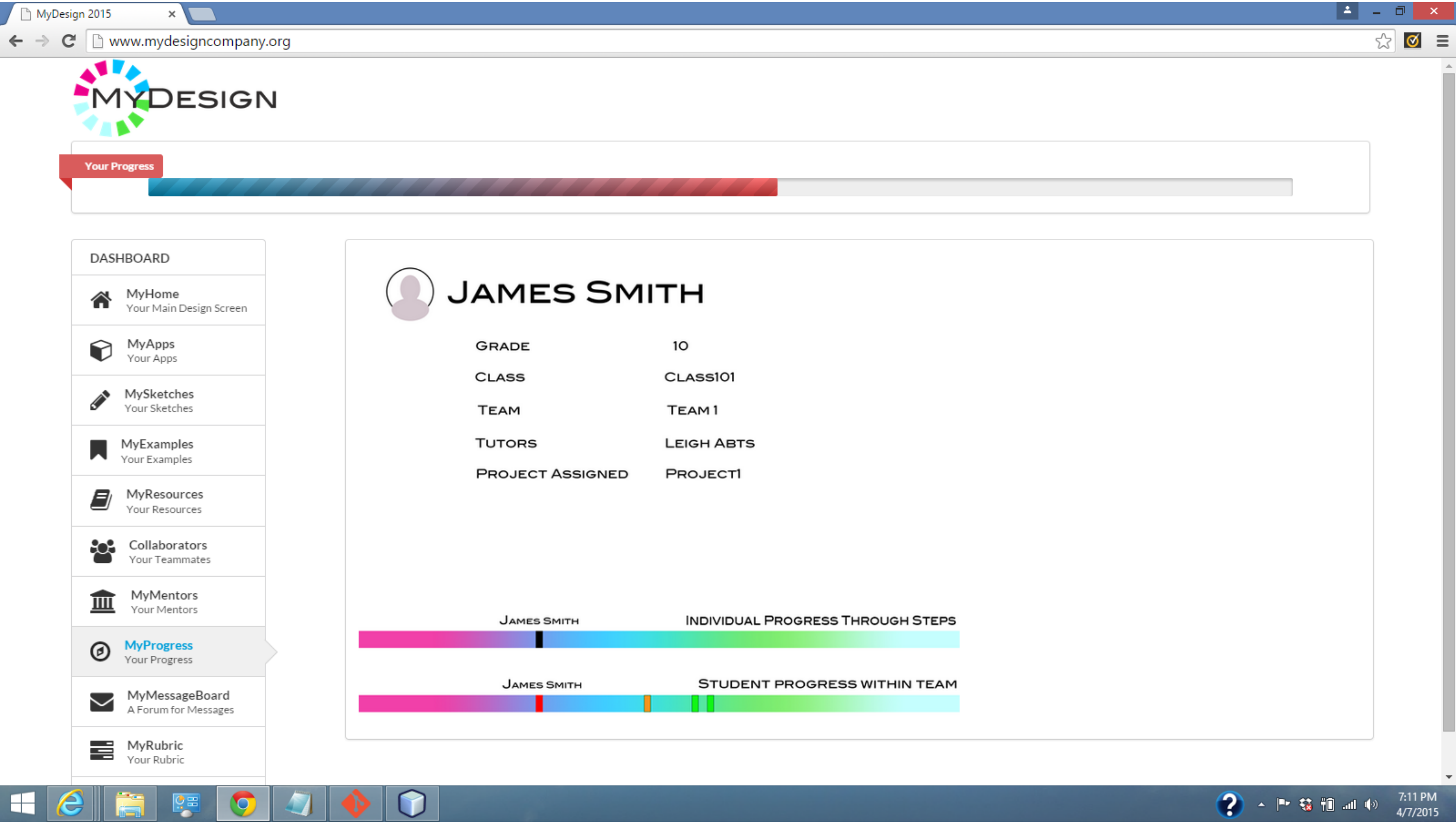
AUTOCAD 360

https://client.autocad360.com/createaccount.html

CLICK LINK

User can create sketches in AutoCAD 360





Developed by UMD Students Jeffrey He, Danny Catacora, Jonathan Reyes and Allison Thompson guided by Mike Bitner

Design across classroom settings from brick and mortar to the virtual world

Design is progressive and iterative

UbD – UDL – ECD Template Model

Unit 4: Stage 1 – Desired Results	
Established Goals **Course and unit goals are tied to the Energy Literacy Alignment Tool, from the US Department of Energy's publication:** *Energy Literacy - Essential Principles and Fundamental Concepts for Energy Education - Framework for Energy Education for Learners of All Ages.* **Unit 4 Goals from the Energy Literacy Alignment Tool** 1. Energy is a physical quantity that follows precise natural laws. 1.4 Energy available to do useful work decreases as it is transferred from system to system. 1.5 Energy comes in different forms and can be divided into categories. 1.7 Many different units are used to quantify energy. 2.2 Sunlight, gravitational potential, decay of radioactive isotopes, and rotation of the Earth are the major sources of energy	**Transfer** ***Students will be able to independently use their learning to:*** • Solve authentic engineering problems using logarithms and exponents • Gather and analyze information for a design project • Use the properties of logarithms and exponents to model a physical system, compile and plot data, and estimate an unknown variable. • Use independent research to understand physical realistic values of voltage, current, and resistance. ***What kinds of long-term independent accomplishments are desired?*** When presented with an authentic real-world problem represented mathematically as a function with logarithmic or exponential behavior, the student will be able find reasonable solutions to the problem.

Common Core Standards Addressed in Unit 4

Standards for Mathematical Practice

MP.1	Make sense of problems and persevere in solving them.
MP.2	Reason abstractly and quantitatively.
MP.3	Construct viable arguments and critique the reasoning of others.
MP.4	Model with mathematics.
MP.5	Use appropriate tools strategically.
MP.6	Attend to precision.
MP.7	Look for and make use of structure.
MP.8	Look for and express regularity in repeated reasoning.

What specifically do you want students to understand? What inferences should they make?

Students should understand how an engineering problem can be represented, mathematically, as a logarithmic or exponential function. Students should be able to infer the properties of an exponential and/or logarithmic function by analyzing the graphical representation of that function.

Students should understand that gathering and analyzing information is the second step of the Design Process

Acquisition	
Students will know: The laws of exponents Properties of exponents Properties of logarithms The difference between the design process and the scientific method	***Students will be skilled at:*** Finding the exact values of logarithmic and exponential equations Solving engineering word problems by accurately representing the scenario as an exponential or logarithmic

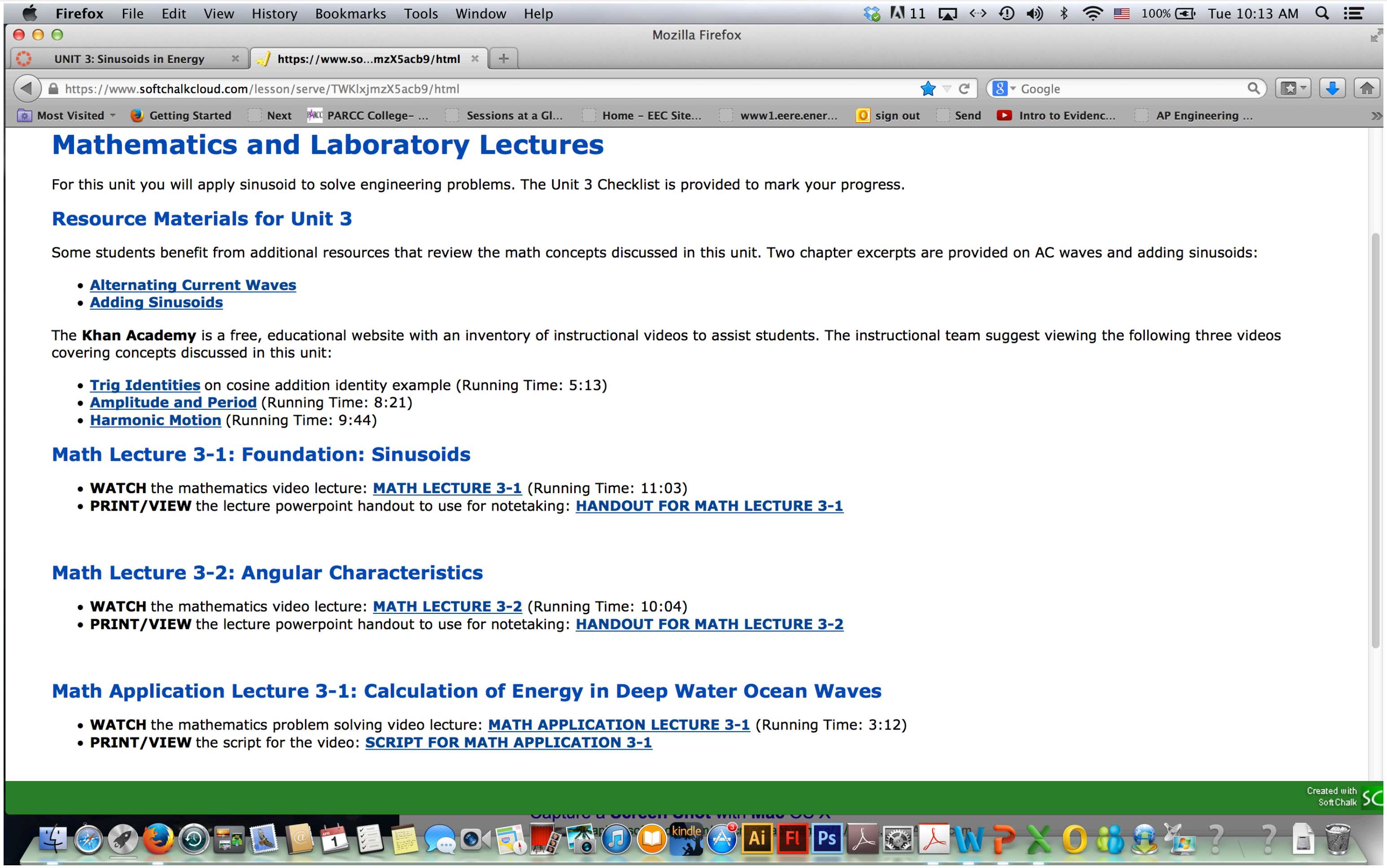
Stage 2 - Evidence		
Evaluative Criteria	PERFORMANCE TASK(S):	**UDL**
What criteria will be used in each assessment to evaluate attainment of the desired results? Accuracy of the final answer, demonstration of the correct order of mathematical problem-solving steps, and use of appropriate engineering units. The Innovation Portal	**Students will show that they really understand by evidence of:** 1. Being proficient at graphing a logarithmic function and an exponential function 2. Being proficient at changing a logarithmic expression into an equivalent expression involving an exponent, as well as changing an exponential expression into an equivalent expression involving a logarithm 3. Demonstrating the use the change of base formula to evaluate a logarithm 4. Demonstrate the gathering and analyzing of information for a design process **What tasks / assignments might a student be given to demonstrate their understandings?** Homework on logarithms and exponents, and word problems where the students need to determine a realistic solution to a science or engineering problem involving logarithmic and exponential behavior. Development of a mind map to identify a problem to be addressed through the design process Gather and analyze information to justify a compelling need that	**Are there multiple ways these tasks / assignments might be represented? (For example, besides a task requiring a student to mark a chart on paper, how else might a student complete this task?)** Students will see and hear both video and audio demonstrations of problem solving, both in the context of the lecture and with authentic real-world problems. Students will learn to use and apply an electronic portfolio to document their designs

Template Unit 4

Work by a team led by Ms. Toby Ratcliffe, Dr. Rosemary Reshetar, Dr. Stephanie Moore, Dr. James Ellsworth and Dr. Leigh Abts

Aligned to CC Standards by Dr. Sarah Koebley of DoDEA

Funded by Advanced Distributed Learning Laboratory (Army) and the National Science Foundation.



Mathematics and Laboratory Lectures

For this unit you will apply sinusoid to solve engineering problems. The Unit 3 Checklist is provided to mark your progress.

Resource Materials for Unit 3

Some students benefit from additional resources that review the math concepts discussed in this unit. Two chapter excerpts are provided on AC waves and adding sinusoids:

- Alternating Current Waves
- Adding Sinusoids

The **Khan Academy** is a free, educational website with an inventory of instructional videos to assist students. The instructional team suggest viewing the following three videos covering concepts discussed in this unit:

- Trig Identities on cosine addition identity example (Running Time: 5:13)
- Amplitude and Period (Running Time: 8:21)
- Harmonic Motion (Running Time: 9:44)

Math Lecture 3-1: Foundation: Sinusoids

- **WATCH** the mathematics video lecture: MATH LECTURE 3-1 (Running Time: 11:03)
- **PRINT/VIEW** the lecture powerpoint handout to use for notetaking: HANDOUT FOR MATH LECTURE 3-1

Math Lecture 3-2: Angular Characteristics

- **WATCH** the mathematics video lecture: MATH LECTURE 3-2 (Running Time: 10:04)
- **PRINT/VIEW** the lecture powerpoint handout to use for notetaking: HANDOUT FOR MATH LECTURE 3-2

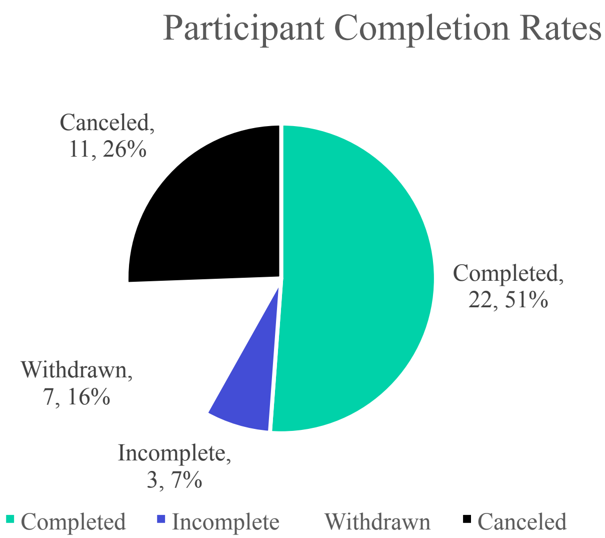
Math Application Lecture 3-1: Calculation of Energy in Deep Water Ocean Waves

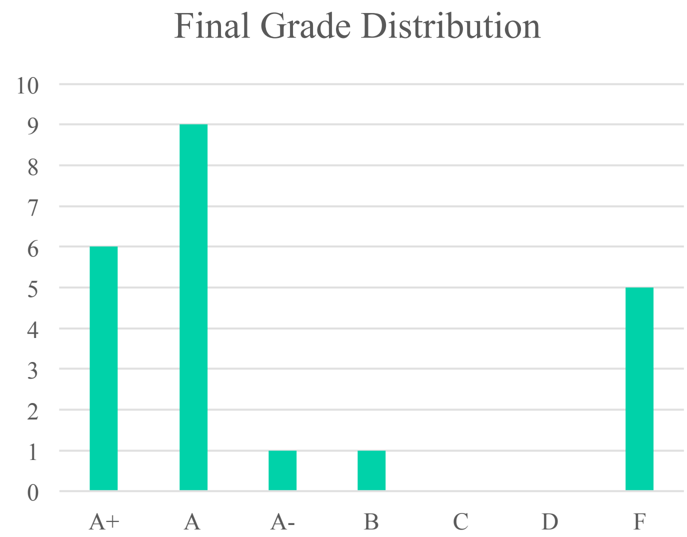
- **WATCH** the mathematics problem solving video lecture: MATH APPLICATION LECTURE 3-1 (Running Time: 3:12)
- **PRINT/VIEW** the script for the video: SCRIPT FOR MATH APPLICATION 3-1

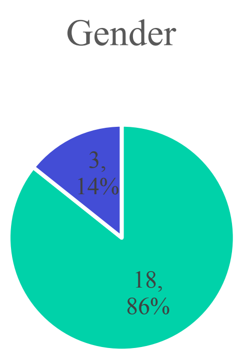
https://umd.instructure.com/courses/1084346

Funded by Advanced Distributed Learning Laboratory (Army) and National Science Foundation.
Dr. Ian White, Dr. Jennifer Wolk, Dr. Danny Barnes, Ms. Emily Hauser, Ms. Gail Wyant, Ms. Toby Ratcliffe, Mr. Mark Schroll, Vanderpool Films, Center for Workforce Development, and the UMD Office of Extended Studies.

Course Completion & Performance







Out of 22, 16 received A's, 1 B's, and 5 F's

Dr. Stepanie Moore, Dr. Rosemary Reshetar and Dr. James Ellsworth

Funded by Advanced Distributed Learning Laboratory (Army)

Pre & Post Confidence

Unit 1

Objective	Average "Pre"	Average "Post"	Average Gain	Significant Gain?
1. Graphing in the Cartesian Coordinate System	8.93	8.79	-0.14	
2. Cartesian Coordinate Quadrants	8.76	8.62	-0.14	
3. Slope of a line	8.31	8.23	-0.08	
4. Calculation of the slope of a line	8.52	8.45	-0.07	
5. Solving a linear equation	8.17	8.32	0.15	
6. Solving a linear equation with fractions	8.55	8.48	-0.07	
7. Finding the equation of a line, its slope, and y-intercept (mathematically)	7.86	8.24	0.38	
8. Finding the equation of a line, its slope, and y-intercept (graphically)	7.38	7.80	0.42	
9. Finding the equation of a line	7.38	7.80	0.42	
10. Sketching a graph using the equation of a line and Ohm's Law	6.69	7.27	0.58	
11. Finding the equation of a line for voltage/current application	6.31	6.98	0.67	
12. Solving the equation of a line, its slope, and y-intercept	6.31	7.31	1.00	YES

Objective	Average "Pre"	Average "Post"	Average Gain	Significant Gain?
1. Monomials and polynomials	7.63	8.20	0.57	
2. Monomials and polynomials (multiple variables)	7.47	8.19	0.72	
3. Multiplying binomials using the FOIL method	8.00	8.29	0.29	
4. Roots of a quadratic equation	7.47	8.04	0.57	
5. Identifying the constants in a quadratic equation in order to use them in the quadratic formula	7.63	8.49	0.86	
6. Solving a quadratic equation using two different methods	6.89	8.47	1.58	YES
7. Multiplying binomials	6.47	8.33	1.86	YES
8. Solving a quadratic equation using the quadratic formula	6.84	8.27	1.43	YES
9. Writing a quadratic equation in standard form	6.68	8.54	1.86	YES
10. Represent a geometry problem using a quadratic equation	6.32	8.17	1.85	YES
11. Represent an electric circuit scenario using a quadratic equation	5.74	8.31	2.57	YES
12. Solve a quadratic equation using three methods	6.00	8.29	2.29	YES

Unit 3

Objective	Average "Pre"	Average "Post"	Average Gain	Significant Gain?
1. Frequency and period	4.43	8.29	3.86	YES
2. AC Voltage and Current Wave	3.86	8.29	4.43	YES
3. Sinusoidal Motion	3.71	7.71	4.00	YES
4. Sinusoidal Motion (Rotation)	3.57	7.43	3.86	YES
5. Trigonometric Identity	5.43	7.86	2.43	YES
6. Addition of Two Sine Waves	4.71	8.00	3.29	YES
7. Amplitude, Frequency, Period Phase Angle, Time Shift	4.43	8.00	3.57	YES
8. Plotting a Sine Wave	4.29	7.57	3.28	YES

Unit 4

Objective	Average "Pre"	Average "Post"	Average Gain	Significant Gain?
1. Solving Logarithmic Equations	6.00	8.57	2.57	YES
2. Express the sum of Two Logarithms as a Single Logarithm	6.00	8.43	2.43	YES
3. Change of Base Formula	5.13	8.70	3.57	YES
4. Solving Real-World Problems Modeled Using Exponents	5.50	7.79	2.29	YES
5. Sum and Difference of Logarithms	4.75	8.46	3.71	YES
6. Determine an Exponential Function From a Graph	4.88	7.88	3.00	YES
7. Solving Exponential Equations	5.25	8.68	3.43	YES
8. Changing Exponential Expressions to Logarithmic Expressions	5.37	8.66	3.29	YES
9. Changing a Logarithmic Expression to an Exponential Expression	5.75	8.46	2.71	YES
10. Represent a geometry problem using a quadratic equation	5.75	8.32	2.57	YES

Unit 5

Objective	Average "Pre"	Average "Post"	Average Gain	Significant Gain?
1. Difference Quotient	4.78	7.92	3.14	YES
2. Finding the derivative using the Difference Quotient	5.78	8.63	2.85	YES
3. Finding the Limit of a Polynomial Function	6.22	8.36	2.14	YES
4. Finding the Derivative by applying the Power Rule	6.67	8.52	1.85	YES
5. Finding the Derivative by applying the Product Rule	6.11	8.68	2.57	YES
6. Finding the Derivative by applying the Quotient Rule	5.22	8.79	3.57	YES
7. Finding the Derivative by applying the Chain Rule	5.22	8.65	3.43	YES
8. Derivatives in a Dynamics Problem	5.67	8.24	2.57	YES
9. Current and Charge	4.44	7.30	2.86	YES

Unit 6

Objective	Average "Pre"	Average "Post"	Average Gain	Significant Gain?
1. Indefinite Integral	7.00	8.40	1.40	
2. Integrating Polynomial Functions	6.83	8.63	1.80	
3. Finding the Anti-Derivative	6.80	8.30	1.50	
4. Applying the Constant Multiple Rule in Integration	5.83	8.63	2.80	
5. Applying the Sum Rule in Integration	5.83	8.63	2.80	
6. Applying the Difference Rule in Integration	5.83	8.63	2.80	
7. Evaluating a Definite Integral	6.67	8.47	1.80	
8. Evaluation of a Definite Integral to Determine Work Done	5.67	8.07	2.40	
9. Finding the Voltage across a Capacitor using Integrals	5.17	7.57	2.40	YES

Dr. Stepanie Moore, Dr. Rosemary Reshetar and Dr. James Ellsworth

Funded by Advanced Distributed Learning Laboratory (Army)

Summary of Observations

Application of the Pareto Rule

20% of students are responsible for 80% of the time and resources.

Online

Instructional versus Case Management – the triaging of students based on their needs, such as barriers to learning or obstacles to practice specific KSAs.

MyDesign[1]

Mobile Applications Platform – facilitate the design process and inter-connect Applications.

Coding[1]

A hybrid process to create unique, rule-based coding – similar to healthcare Procedural (Instructional) and Diagnostic (Assessment) codes – could be facilitated by an mobile app icon and template format.

Case Management[1]

Models for the structuring of curricular, instructional, and assessments to guide learning and practice for individual students and cohorts.

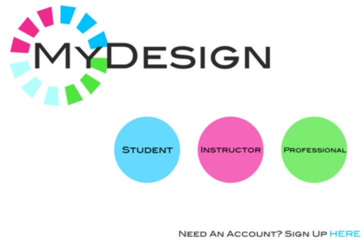
1. UMD Patents Pending and Provisional Patent filed.

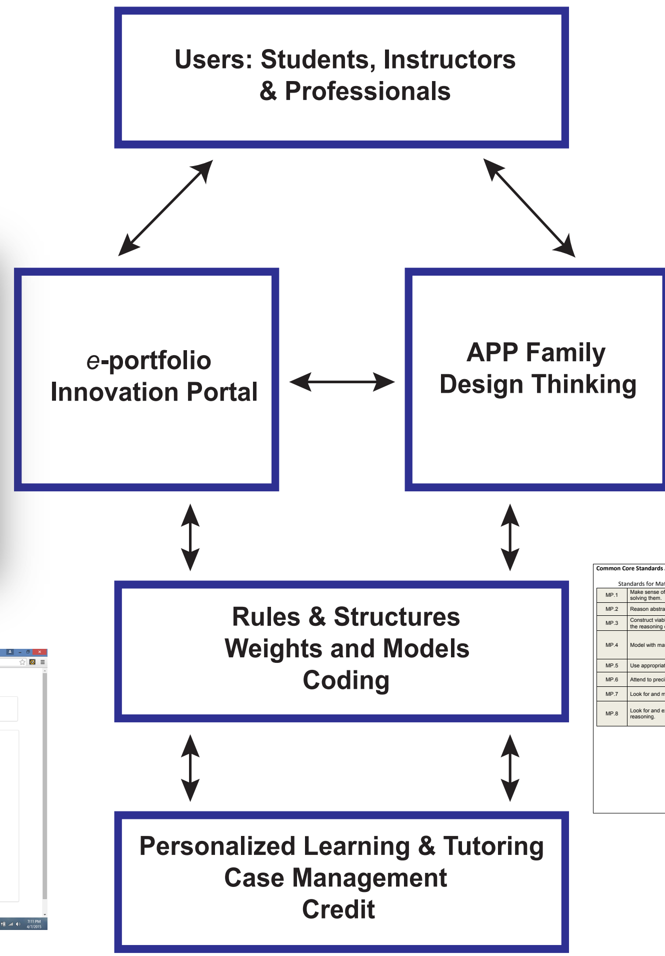
Design can be codified to track activities to award progressive recognition

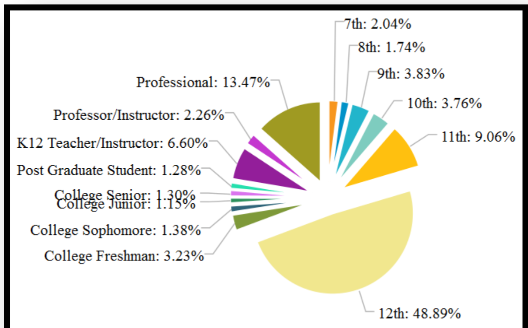
Modeled after healthcare

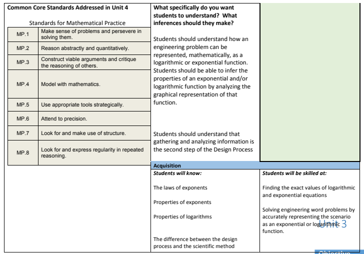
An Evolving Strategy

Summary Overview









Common Core Standards Addressed in Unit 4

Standards for Mathematical Practice

MP.1	Make sense of problems and persevere in solving them.
MP.2	Reason abstractly and quantitatively.
MP.3	Construct viable arguments and critique the reasoning of others.
MP.4	Model with mathematics.
MP.5	Use appropriate tools strategically.
MP.6	Attend to precision.
MP.7	Look for and make use of structure.
MP.8	Look for and express regularity in repeated reasoning.

What specifically do you want students to understand? What inferences should they make?

Students should understand how an engineering problem can be represented, mathematically, as a logarithmic or exponential function. Students should be able to infer the properties of an exponential and/or logarithmic function by analyzing the graphical representation of that function.

Students should understand that gathering and analyzing information is the second step of the Design Process

Acquisition

Students will know:	***Students will be skilled at:***
The laws of exponents Properties of exponents Properties of logarithms The difference between the design process and the scientific method	Finding the exact values of logarithmic and exponential equations Solving engineering word problems by accurately representing the scenario as an exponential or logarithmic function.

Unit 3

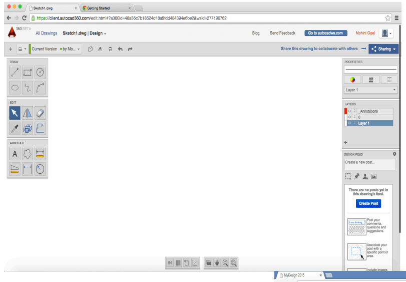
Objective	Average "Pre"	Average "Post"	Average Gain	Significant Gain?
1. Frequency and period	4.43	8.29	3.86	YES
2. AC Voltage and Current Wave	3.86	8.29	4.43	YES
3. Sinusoidal Motion	3.71	7.71	4.00	YES
4. Sinusoidal Motion (Rotation)	3.57	7.43	3.86	YES
5. Trigonometric Identity	5.43	7.86	2.43	YES
6. Addition of Two Sine Waves	4.71	8.00	3.29	YES
7. Amplitude, Frequency, Period Phase Angle, Time Shift	4.43	8.00	3.57	YES
8. Plotting a Sine Wave	4.29	7.57	3.28	YES

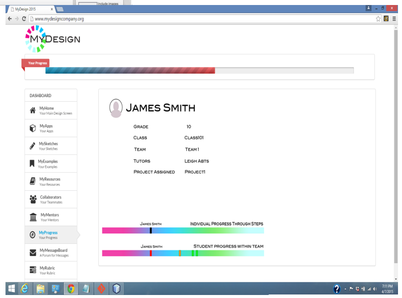
NSF PRIME and INSPIRE Award

Coding

Design Steps 1 - 12

Sketch, Video, Text





Individual / Team

Unit 3

Objective	Average "Pre"	Average "Post"	Average Gain	Significant Gain?
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2. AC Voltage and Current Wave	3.86	8.29	4.43	YES
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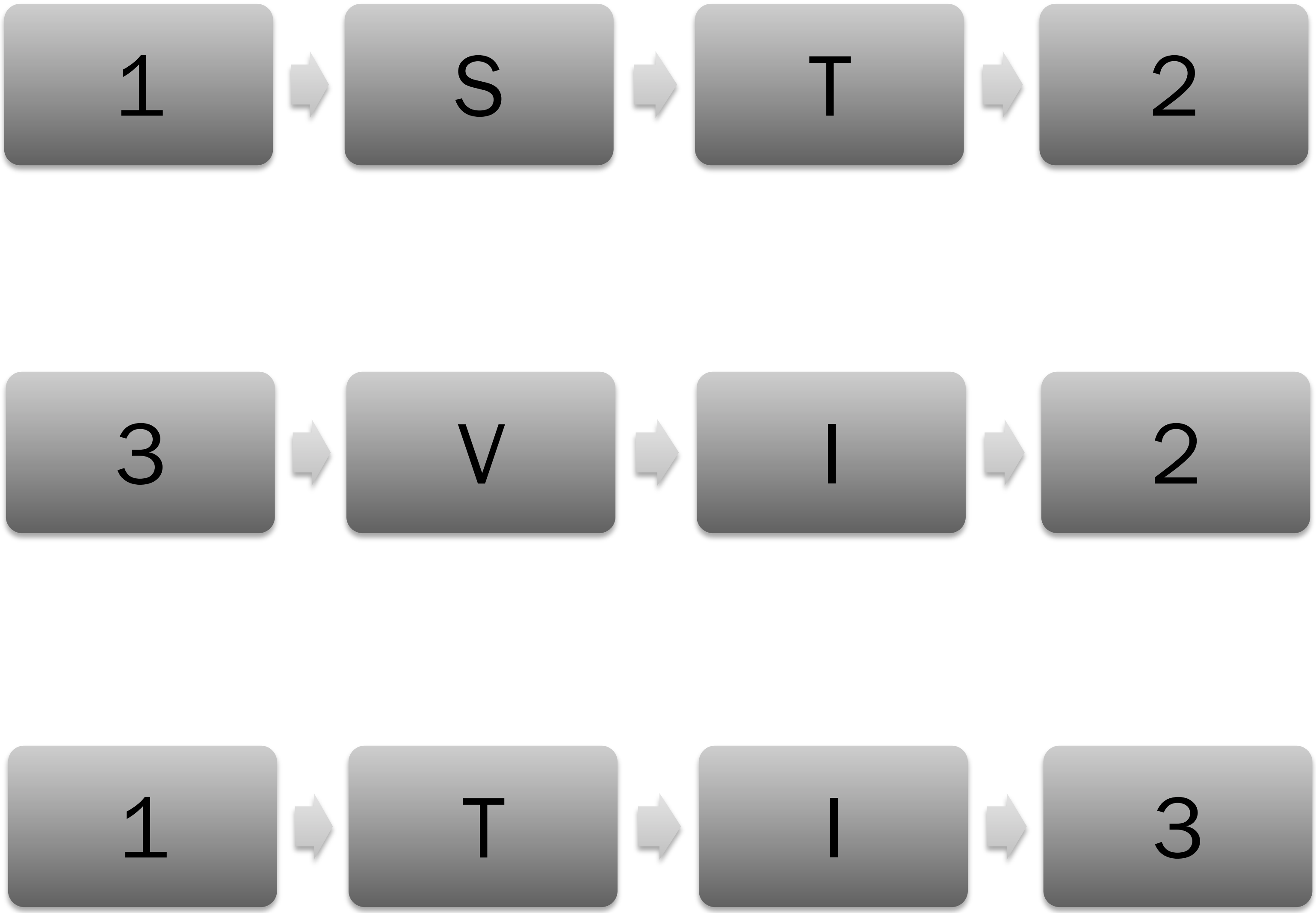
6. Addition of Two Sine Waves	4.71	8.00	3.29	YES
7. Amplitude, Frequency, Period Phase Angle, Time Shift	4.43	8.00	3.57	YES
8. Plotting a Sine Wave	4.29	7.57	3.28	YES

Score: 0 to 5

Coding



Can Design be both the process and the product leading to a universally accepted credit?

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