ESC Evaluation Services Center

Key Evaluation Results of the CEEMS Project, Year 5

Prepared for

Dr. Anant Kukreti, PI

Julie Steimle, Project Coordinator

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Evaluation Services Center
P.O. Box 210175 • Cincinnati, OH • 45221
http://www.uc.edu/evaluationservices

UNIVERSITY OF Cincinnati

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Jacinda K. Dariotis, Ph.D., M.A.S., Director and Associate Professor

Report prepared by:

Audra Morrison, M.A., Assistant Director

Catherine Maltbie, Ed.D., Research Associate

Rachel Friedman, B.S., Data Analyst

PO Box 210175
Cincinnati, OH 45221-0175
Tel: (513) 556-3900
Fax: (513) 556-3516
http://www.uc.edu/evaluationservices/
E-mail: eval@uc.edu

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Key Evaluation Results of the CEEMS Project, Year 5

The CEEMS Evaluation has been guided by three primary evaluation questions that map to the project goals. To promote ease in reading, key data and results associated with the project are presented in a concise format with the following headings: Project Goals and Evaluation Questions, Evaluation Instrument/Metric, and Results and Outcomes.

Project Description

The current CEEMS evaluation results for the fifth project year, Academic Year 2015-2016, are summarized below by project goal. Overall, the CEEMS project is progressing toward attainment of these goals. Student interest in engineering is increasing, students are learning the engineering design process, and their content knowledge gains are increasing. Teachers are using CEEMS-promoted instructional practices and their usage is increasing the longer they remain in the program and has remained steady for up to two years after participation. Below are listed the Project Goals of interest for this summary.

1. Project Goal 1. Increase 6-12 student knowledge of engineering design process and STEM careers and increase interest in college study in engineering or other STEM careers.
    a. Evaluation Question 1a. To what extent have students demonstrated knowledge of the engineering design process?
    b. Evaluation Question 1b. To what extent have students demonstrated interest in STEM-based fields and careers?
2. Project Goal 2. Increase 6-12 student knowledge of math and science content when taught using engineering as a context for learning.
    a. Evaluation Question 2. To what extent do student math and science content scores increase as a result of unit implementation?
3. Project Goal 3. Develop math and science teacher knowledge of challenge-based learning, engineering, and the engineering design process as instructional strategies through explicit training and classroom implementation support.
    a. Evaluation Question 3a. To what extent and in what ways has teachers' knowledge increased in 1) CBL and 2) EDP?
    b. Evaluation Question 3b. What CEEMS project activities supported these changes?

Evaluation Results

For project goal 1, the majority of students reported that they learned about the engineering design process (EDP) and that they have an increased interest in engineering following the unit implementation. In consultation with the project team, the EDP drawing was discontinued, and a student STEM Interest survey (pre-post design) was added. Both Cohort 3 and 4, together and separately, showed increases from pre to post on student STEM interest, particularly when asked about STEM careers. Three constructs were assessed on the Student STEM Interest survey. Students had increases in items relating to engineering, 21st Century Skills, and interest in all four career areas. There were decreases related to the importance of learning science and math. This may be a byproduct of the focus of the CEEMS teachers on the engineering design process, discussing STEM careers, and using engineering principles in the classroom.

For project goal 2, teachers created pre-post assessments for each unit that were analyzed to show content knowledge gains. For CEEMS teachers, pre-post assessment scores increased 33.7% using a two-tailed paired t-test at a 95% CI. Fifteen (15) comparison teachers participated by providing equivalent pre-post assessment scores for students learning comparable material taught while not using CEEMS Units. When comparing results between CEEMS and non-CEEMS units, CEEMS teachers' students scored a mean difference of 8.5% higher than students in comparison teacher's classrooms using an ANOVA score at a 95% CI with a moderate effect size of 0.3 (eta). As seen in previous years, these content gain results were corroborated by teachers, via surveys and focus groups, and students, via surveys, both reporting that they learned from the units.

For project goal 3, changes in teachers' self-reported current instructional practices indicate that all teachers are using the instructional practices promoted by the CEEMS training. The survey items identified three constructs, CBL practices, practices related to guiding students through the process, and providing students with opportunities related to these processes. Usage of all constructs increased significantly from pre- to mid-project, pre- to post-project, and pre- to first year post follow-up. Some significant increases are also beginning to be seen in pre to second post year follow-up (n=5). For confidence constructs, there are several significant increases from mid to post; as expected, with more training and experience, a continued increase was seen between first and second between first and second year in teacher confidence (mid to post). The Current Instructional Practices constructs are detailed in Appendix A.

Teachers reported they were well trained. Consistent with results from past years, teachers also reported the resource team was their most helpful support. All open-ended comments from the Teacher Post Unit Surveys are reported in Appendix B.

Table 1. CEEMS PROJECT YEAR 5 (2015-16) - Evaluation Instruments/Metrics and Teacher and Student Results and Outcomes

Project Goal 1. Increase 6-12 student knowledge of engineering design process and STEM careers and increase interest in college study in engineering or other STEM careers. *Evaluation Question 1a. To what extent have students demonstrated knowledge of the engineering design process?* *Evaluation Question 1b. To what extent have students demonstrated interest in STEM-based fields and careers?*	
Evaluation Instrument/Metric	**Results and Outcomes**
Student Feedback Survey *Using CEEMS teacher input and piloting with students, this survey was adapted from the NSF ITEST CincySTEM Urban Initiative project (Grant #0929557) high school student survey.* "I understand how the EDP activity allowed us to solve to use the guiding questions to solve the challenge selected." "This unit made me more interested in engineering." "I learned about the careers related to this challenge and our solution." (Scale: 4=strongly agree, 3=agree, 2=disagree, 1=strongly disagree)	Student Feedback Survey • 85.0% of students *agreed* or *strongly agreed* that they understood how the EDP activity helped them solve the challenge. (n=3011, mean=3.2, SD=0.71) • 61.2% of students *agreed* or *strongly agreed* that the unit increased their interest in engineering. (n=3002, mean=2.8, SD=0.95) • 69.0% of the students *agreed* or *strongly agreed* that they learned about careers related to the challenge. (n=3008, mean=2.9, SD=0.85)

Project Goal 1. Increase 6-12 student knowledge of engineering design process and STEM careers and increase interest in college study in engineering or other STEM careers.

Evaluation Question 1a. To what extent have students demonstrated knowledge of the engineering design process?

Evaluation Question 1b. To what extent have students demonstrated interest in STEM-based fields and careers?

Evaluation Instrument/Metric	**Results and Outcomes**

Student STEM Interest Survey

This instrument was adapted from the REESE Student STEM Perceptions Survey, developed with NSF funding through the Center for Elementary Mathematics and Science Education (CEMSE) at the University of Chicago in collaboration with the Battelle Center for Mathematics and Science Education Policy at the Ohio State University and the Ohio STEM Learning Network (OSLN) and adapted with permission. This instrument is used to measure students' motivations towards entering STEM careers as well as their beliefs about their own aptitudes within the STEM areas, including their use of engineering design principles. Student participants complete this survey as a pre/post measure. The pre-measure is given at the start of the academic year in the class of a CEEMS participant. The post- is given at the conclusion of the same academic year.

This survey was written with embedded constructs. Since this is the first time we are using this instrument, we measured the reliability of these constructs and found three that have acceptable reliability: Confidence in 21st Century Skills (alpha=0.717), Interest in

STEM Careers (alpha=0.700) and Confidence in and Importance of Learning STEM (alpha=0.693). The analysis will include the individual questions that were significant from pre to post CEEMS units using an independent samples t-test within these constructs.

(Scale: 5=strongly agree, 4=agree, 3=neither agree nor disagree, 2=disagree, 1=strongly disagree)

Student STEM Interest (Table A)

- Students self-reported significant differences from pre to post CEEMS Units on three survey items related to 21st Century Skills: Confidence in their ability to talk about ideas (positive), Science is useful for everyday problem solving (positive), and Applying math to everyday lives (negative). These items are shown in yellow in Table A.
- Self-reported student interest in all STEM related careers increased from before CEEMS Units to after CEEMS Units. These items are shown in green in Table A.
- There were three items related to the self-reported importance students had in learning STEM that were significant from pre to post CEEMS Units. Two of them indicated a negative change for science and math, while the engineering-related item has a positive change. These items are shown in orange in Table A.

Table A. Student STEM Interest

Item	Mean Difference (Post-Pre)	Std. Error Difference	t	df	Sig. (2-tailed)
I am confident in my ability to talk about my ideas.	0.106	0.028	3.737	5089	.000
Science is useful for solving everyday problems.	0.112	0.26	4.371	5155	.000
Math is applied in our everyday lives.	-0.080	.024	-3.344	5112	.001
I am interested in a career in science.	0.206	.037	5.554	5091	.000
I am interested in a career in technology.	0.207	.037	5.582	5118	.000
I am interested in a career in engineering.	0.225	.037	6.079	5094	.000
I am interested in a career in math.	0.145	.036	4.017	5090	.000
It is important for me to learn science.	-0.095	.023	-4.147	5142	.000
It is important for me to learn math.	-0.096	.032	-2.992	5123	.003
It is important for me to learn how to design things.	0.113	.032	3.493	5113	.000

Key

21st Century Skills
STEM Careers
Confidence in and Importance of Learning STEM

Project Goal 1. Increase 6-12 student knowledge of engineering design process and STEM careers and increase interest in college study in engineering or other STEM careers. *Evaluation Question 1a. To what extent have students demonstrated knowledge of the engineering design process?* *Evaluation Question 1b. To what extent have students demonstrated interest in STEM-based fields and careers?*	
Evaluation Instrument/Metric	**Results and Outcomes**
Teacher Post Unit Survey: *Three surveys were jointly developed by the evaluation and project teams and piloted among four teachers to document important aspects of CEEMS units (CBL, EDP, and student outcomes as reported by teachers) that were successful and inform future modifications.* "Overall engagement of my students increased during this unit compared to non-CBL units." (Scale: 4=strongly agree, 3=agree, 2=disagree, 1=strongly disagree)	Teacher Post Unit Survey: • 96.1% of teachers were in agreement (*agreed* or strongly *agreed*) that their students' classroom engagement had increased during the unit compared to non-CBL units (n=84, mean=3.5, SD=0.57). • No differences by Teacher Cohort • Teacher quotes: o *I found that students who ordinarily were not engaged actively participated and those who were forcing themselves to do the routine work actually enjoyed this way of learning. They realized that engineering is not just guessing, but requires using science and technology. This is the answer to the age old question so many students ask: "Why do I need to learn this? I'll never use it."* o *The engagement was high, students enjoyed the project, and their efforts were rewarded with their final bungee drop!*

Project Goal 2. Increase 6-12 student knowledge of math and science content when taught using engineering as a context for learning.
Evaluation Question 2. To what extent do student math and science content scores increase as a result of unit implementation?

Evaluation Instrument/Metric	**Results and Outcomes**
Student pre-post assessments of learning *Each teacher created unit-specific pre-post assessments of students' change in math and science content knowledge associated with the unit.*	Student pre-post assessments of learning • A total of 31 CEEMS teachers and 15 comparison teachers returned pre/post assessment scores for their students. • For all CEEMS Teachers: Students' scores increased 33.7% from pre- to post-test, measuring math and science content, for combined Cohort 3 and 4 teachers (n=3354). There is a significant difference in student gain scores at a 95% CI ($t_{(3353)}$=71.33, p<0.001). • Each CEEMS cohort also showed significant differences in score gains from pre to post: At a 95% CI ($F_{(1,3401)}$=272.04, p<0.001), Cohort 3 students' scores increased 29.8% from pre to post (n=1711) and Cohort 4 students' scores increased 36.1% from pre to post (n=1687). • For CEEMS vs comparison teachers: CEEMS teachers' students showed a higher mean difference in knowledge gain of 8.5% on the post-test than comparison teachers' students (CEEMS teachers' student scores: n=1478 (58% of total pairs); comparison teachers' student scores: n=1070 (42% of total pairs)). There was a significant difference on post-tests between comparison teachers and CEEMS teachers at a 95% CI ($F_{(1,2546)}$=87.65, p<0.001).
Student Feedback Survey "I learned a lot." "This unit made me feel more confident about math or science." "I feel using challenges is a more effective way to learn than the way we are usually taught." (Scale: 4=strongly agree, 3=agree, 2=disagree, 1=strongly disagree)	Student Feedback Survey • 89.6% of students *agreed* or *strongly agreed* that they "learned a lot" from these units. (n=3015, mean=3.3, SD=0.68) • 69.6% of students *agreed* or *strongly agreed* that the unit made them "feel more confident about math or science." (n=2989, mean=2.9, SD=0.87) • 82.8% of students *agreed* or *strongly agreed* that using challenges was a "more effective way to learn" than how they are usually taught. (n=2996, mean 3.2, SD=0.79)

Project Goal 2. Increase 6-12 student knowledge of math and science content when taught using engineering as a context for learning.
Evaluation Question 2. To what extent do student math and science content scores increase as a result of unit implementation?

Evaluation Instrument/Metric	**Results and Outcomes**
Teacher Post Unit Survey "Students mastered the expected material." (Scale: 4=strongly agree, 3=agree, 2=disagree, 1=strongly disagree)	Teacher Post Unit Survey • 79.5% of teachers *agreed* or *strongly agreed* that their students mastered the expected unit content. (n=83, mean=3.1, SD=0.68) • No differences by Teacher Cohort • Teacher quotes: o *My students benefited from participating in this unit. They were able to connect a real-world problem and linear relationships. It was nice for them to finally connect mathematical topics to things they know about in the real-world*. o *They not only mastered the content (exponential functions), but their financial literacy increased. Many of them had no idea what college, cars, and houses cost, let alone what interest rates and loans were. So, just by completing this unit, they have gained REAL WORLD knowledge that will help them in their individual lives one day.* o *They were given time to explore and answer their own questions through scientific inquiry. That is a freedom rarely granted in the classroom. They mastered the content as demonstrated by the post unit test scores. The unit was also cross curricular in that it had them practicing some basic algebra, rates, etc.*

Project Goal 2. Increase 6-12 student knowledge of math and science content when taught using engineering as a context for learning.
Evaluation Question 2. To what extent do student math and science content scores increase as a result of unit implementation?

Evaluation Instrument/Metric	**Results and Outcomes**
Teacher End-of-Year Focus Groups *Annual focus groups (60 minutes) were conducted at the end of each implementation year per cohort. Protocol was developed to assess student learning and future program modifications for improvement.*	Teacher End-of-Year Focus Group Quotes • Teachers observed gains in students' skills and content knowledge: o Students learned that failure is okay as long as you continue to refine and improve toward a successful solution. o I linked science into statistics—how crops are destroyed, using stats to analyze date—I had kids who didn't know people used statistics in the real world—their attitude changed radically from pre to post. o Students developed 21st century skills but still need work on collaboration with peers. They were given a self-reflection and many were able to identify they needed to work on it. *(Note: quote from Teacher Post Unit Survey)* o This unit provided a great opportunity for students to practice working in teams and assume real world roles as part of a team. It allowed students to take their science knowledge and apply it to a real-world problem as well as developing knowledge along the way. • Teachers had suggestions for program improvement: o Have small role play units—CEEMS teachers get exposure to how a unit is actually designed and taught during class time with someone there to create the unit. o Every unit's unique—get out of the mindset that there's one single template that "works." o Focus more on reflection instead of planning—we spend too much time planning—reflection will help units later on.

Project Goal 3. Develop math and science teacher knowledge of challenge-based learning, engineering, and the engineering design process as instructional strategies through explicit training and classroom implementation support.
Evaluation Question 3a. To what extent and in what ways has teachers' knowledge increased in 1) CBL and 2) EDP?
Evaluation Question 3b. What CEEMS project activities supported these changes?

Evaluation Instrument/Metric	**Results and Outcomes**
Teacher Current Instructional Practices Survey *Teacher challenge based and design based learning instructional practices were assessed via a modified version of a pre-post survey developed by researchers at the Evaluation & Assessment Center for Mathematics and Science Education at Miami University, Oxford, OH, using an EDP-related construct consisting of 6 practices (alpha = 0.84).* The Current Instructional Practices survey has two batteries of 15 questions listing the same challenge based/design based learning practices. One battery of questions asks about participants' incorporation (USE) of these practices into instruction and the second battery of questions asks participants to indicate their level of confidence (CONFI) when using these instructional practices.	Teacher Current Instructional Practices Survey (Tables B and C) • Across the four cohorts of teachers (n=68), all teachers increased their use of EDP practices from **Pre**-CEEMS to one year of programming (**Mid**-CEEMS) and increased their confidence in these practices. • For Cohort 1, 2 and 3 teachers (n=41), there was an increase in regular use of EDP practices and in teacher confidence from **Pre**-CEEMS to two years of programming (**Post**-CEEMS). As expected, with more training and experience, a continued increase was seen between the first and second year (Mid to Post, n=38) in teacher confidence (see Table C). • Through two years of follow up, teachers maintained significant increases compared to Pre-CEEMS usage and confidence (n=10 for Cohorts 1 and 2, n=6 for Cohort 1).

Project Goal 3. Develop math and science teacher knowledge of challenge-based learning, engineering, and the engineering design process as instructional strategies through explicit training and classroom implementation support.
Evaluation Question 3a. To what extent and in what ways has teachers' knowledge increased in 1) CBL and 2) EDP?
Evaluation Question 3b. What CEEMS project activities supported these changes?

Evaluation Instrument/Metric

Teacher Current Instructional Practices Survey (cont'd)

Within the USE battery, there are three constructs identified: CBL, which includes all 15 questions in the battery; Guide, which includes the questions related to the teacher guiding CBL& EDP in the classroom; and Provide, which consists of teaching practices related to providing opportunities for EDP implementation.

Results and Outcomes

Table B. Teacher Instructional Practices - USAGE

Construct Over Time	Mean Difference (Time 2-Time 1)	Std. Deviation	t	df	Sig. (2-tailed)
PreUSE_CBL to **Mid**USE_CBL	0.86	0.630	11.258	67	.000
PreUSE_Guide to **Mid**USE_Guide	0.89	0.700	10.466	67	.000
PreUSE_Provide to **Mid**USE_Provide	0.91	0.736	10.210	67	.000
PreUSE_CBL to PostUSE_CBL	1.07	0.553	12.345	40	.000
PreUSE_Provide to PostUSE_Provide	1.16	0.668	11.129	40	.000
PreUSE_Guide to PostUSE_Guide	1.06	0.658	10.365	40	.000
PreUSE_Provide to Post1USE_Provide	1.33	0.503	8.381	9	.000
PreUSE_Guide to Post1USE_Guide	1.36	0.645	6.668	9	.000
PreUSE_CBL to Post1USE_CBL	0.79	0.626	3.997	9	.003
PreUSE_CBL to Post2USE_CBL	1.03	0.636	3.958	5	.011
PreUSE_Guide to Post2USE_Guide	0.93	0.653	3.500	5	.017
PreUSE_Provide to Post2USE_Provide	1.28	0.899	3.483	5	.018

Key

Cohorts 1, 2, 3, and 4 (1 year of use)
Cohorts 1, 2, and 3 (2 years of use)
Cohorts 1 and 2 (1 year post follow up)
Cohort 1 (2 years post follow up)

Note: Constructs for both the USE and CONFI batteries are contained in Appendix A.

Teacher Current Instructional Practices Survey (cont'd)

Within the CONFI battery, there are three constructs identified: CBL, which includes all 15 questions in the battery; Guide, which includes the questions related to the teacher guiding CBL& EDP in the classroom; and Provide, which consists of teaching practices related to providing opportunities for EDP implementation.

Table C. Teacher Instructional Practices - CONFIDENCE

Construct Over Time	Mean Difference (Time 2-Time 1)	Std. Deviation	t	df	Sig. (2-tailed)
PreCONFI_CBL to MidCONFI_CBL	0.84	0.654	10.468	66	.000
PreCONFI_Guide to MidCONFI_Guide	0.93	0.615	12.428	66	.000
PreCONFI_Provide to MidCONFI_Provide	0.93	0.671	11.315	66	.000
PreCONFI_CBL to PostCONFI_CBL	1.12	0.754	9.472	40	.000
PreCONFI_Guide to PostCONFI_Guide	1.26	0.578	14.006	40	.000
PreCONFI_Provide to PostCONFI_Provide	1.29	0.623	13.278	40	.000
PreCONFI_CBL to Post1CONFI_CBL	1.40	0.293	15.087	9	.000
PreCONFI_Guide to Post1CONFI_Guide	1.42	0.676	6.640	9	.000
PreCONFI_Provide to Post1CONFI_Provide	1.22	0.672	5.730	9	.000
PreCONFI_CBL to Post2CONFI_CBL	1.13	0.818	3.370	5	.020
PreCONFI_Guide to Post2CONFI_Guide	1.30	0.590	5.398	5	.003
PreCONFI_Provide to Post2CONFI_Provide	1.67	0.408	10.000	5	.000
MidCONFI_CBL to PostCONFI_CBL	0.28	0.662	2.572	37	.014
MidCONFI_Guide to PostCONFI_Guide	0.23	0.511	2.744	37	.009
MidCONFI_Provide to PostCONFI_Provide	0.21	0.443	2.871	37	.007

Note: Constructs for both the USE and CONFI batteries are contained in Appendix A.

Key

Cohorts 1, 2, 3, and 4 (1 year of practice)

Cohorts 1, 2, and 3 (2 years of practice)

Cohorts 1 and 2 (1 year post follow up)

Cohort 1 (2 years post follow up)

Chi-square indicates significant differences (at 95% CI) from pre- to post-project distributions for all constructs. Results are cumulative across all matched and available data for Cohorts 1, 2, 3, and 4. Cohort 4 does not have post-data in Year 5.

Project Goal 3. Develop math and science teacher knowledge of challenge-based learning, engineering, and the engineering design process as instructional strategies through explicit training and classroom implementation support.
Evaluation Question 3a. To what extent and in what ways has teachers' knowledge increased in 1) CBL and 2) EDP?
Evaluation Question 3b. What CEEMS project activities supported these changes?

Evaluation Instrument/Metric	**Results and Outcomes**
Summer Institute for Teachers (SIT) Evaluation Survey *Teachers rated the usefulness of various SIT interactions and workshops.* (Item categories: 1= very useless, 2= useless, 3=useful, 4 = very useful)	Summer Institute for Teachers (SIT) Evaluation Survey • 100% of teachers reported overall interactions with resource team were *useful* or *very useful*. (n=34, mean = 3.7, SD = 0.45)
Teacher Post Unit Survey "I felt I had enough understanding of the CBL approach to guide my students so they got the most from this experience." "I felt I had enough understanding of the engineering design process (EDP) to guide my students so they got the most from the EDP activity or activities implemented in this unit." (Scale: 4=strongly agree, 3=agree, 2=disagree, 1=strongly disagree)	Teacher Post Unit Survey • As expected, with more training and experience, Cohort 3 teachers (two years) showed higher means than Cohort 4 teachers (one year). o Regarding understanding CBL to effectively guide their students, Cohort 3 teachers had a mean of 3.6 compared to Cohort 4 teachers, with a mean of 3.3 (F1 = 4.833, p=0.031, with a moderate effect size of 0.06). o Regarding understanding of the EDP process to effectively guide their students, Cohort 3 teachers had a mean of 3.6 compared to Cohort 4 teachers' mean of 3.4 (F1 = 3.767, p=0.056, with a moderate effect size of 0.04). • 96.4% of teachers *agreed* or *strongly agreed* that they had enough understanding of CBL to effectively guide their students through the experience. (n=84, mean=3.4, SD=0.57) • 96.4% of teachers *agreed* or *strongly agreed* that they had enough understanding of the EDP process to effectively guide their students through the EDP activity and unit implementation. (n=84, mean=3.5, SD=0.57)

Project Goal 3. Develop math and science teacher knowledge of challenge-based learning, engineering, and the engineering design process as instructional strategies through explicit training and classroom implementation support.
Evaluation Question 3a. To what extent and in what ways has teachers' knowledge increased in 1) CBL and 2) EDP?
Evaluation Question 3b. What CEEMS project activities supported these changes?

Evaluation Instrument/Metric	**Results and Outcomes**
Teacher end-of-year focus groups Annual focus groups (60 minutes) were conducted at the end of each implementation year by cohort. Teachers were asked about project activities and what they learned.	Teacher end-of-year focus groups • Teachers learned new ways of approaching teaching science and math. o I have grown as a teacher—I am more hands off, kids are doing stuff on their own and keeping each other in check. o As a teacher, I learned to help with the frustration. They could stick with it. o Kids who did not participate before were involved and participating - hands on • CEEMS teachers learned how to think about and teach CBL and EDP to students: o Let kids develop the lessons; they get the concept and engineering parts down while the content often more of a struggle. But there are no behavior problems; students developed in their communication skills over the year and came up by themselves with "this is what we need to know." This structure also makes it easier to have differentiated instruction—able to step ahead for more advanced students. o Communicate and collaborate processes with other teachers in the building. We as science teachers try to drill the EDP process into them so they get it; they can take EDP one step one further if they have prior exposure to another [CEEMS] teacher.

Appendix A. Current Instructional Practices Instrument – Constructs

Current Instructional Practices Instrument – Constructs

In order to document changes in teacher content knowledge, attitudes, and behaviors in the classroom, an overall repeated measures survey was developed that documents participating in-service teachers' self-reported current instructional practices that are associated with challenge based and design based learning. This survey is based on an instrument developed by researchers at the Evaluation & Assessment Center for Mathematics and Science Education at Miami University, Oxford, OH and was modified with their permission.

The Current Instructional Practices survey measures self-reported changes in the instructional practices of the CEEMS teachers. The survey has two batteries of 15 questions listing the same challenge based/design based learning practices. One battery of questions asks about participants' incorporation of these practices into instruction (USE) and the second battery of questions asks participants to indicate their level of confidence when using these instructional practices (CONFI).

In May 2014, a factor analysis was conducted on the survey and three factors were identified using data collected from pre-project administration of the surveys to CEEMS teachers. The first factor is the entire battery: "CBL". The second factor consists of the practices that start with the word "Provide" (questions 8, 9, 11, 13, 14, 15) that relate to EDP implementation. The last factor consists of the statements starting with "Guide" (questions 5, 6, 7, 10, 12) that are related to the teacher guiding the CBL and EDP process in the classroom.

Table A1. Survey Items in Each Construct (Both USE and CONFIDENCE)

Item	Construct CBL	Provide	*Guide*
1. Explicitly connect class content to complex problems or issues with global impact	X		
2. Explicitly connect class content to real world examples and applications	X		
3. Explicitly connect these real-world applications to STEM careers	X		
4. Explicitly connect class content to how people in STEM careers use their knowledge to address societal impacts	X		
5. Guide students to break complex global problems in to their local and more actionable components	X		*X*
6. Guide students in refining problems	X		*X*
7. Guide students in planning investigations to better understand different components of problems	X		*X*
8. Provide opportunities for students to gather information about problems or issues of importance	X	**X**	
9. Provide students with opportunities to explore multiple solution pathways for problems	X	**X**	
10. Guide students in weighing the pros and cons of different solution pathways	X		*X*
11. Provide opportunities for students to test their solution pathways	X	**X**	
12. Guide students in evaluating the results of their solution pathways	X		*X*
13. Provide students with opportunities to refine and retry a solution pathway	X	**X**	
14. Provide opportunities for students to communicate their solution pathways and results to others	X	**X**	
15. Provide opportunities for students to take responsibility for the decisions they made about the processes used in solving complex problems	X	**X**	

*Items in bold denote "Provide" construct, and items in italics denote "Guide" construct.

Reliability of the scale used on the survey was analyzed using Cronbach's alpha statistic and it was determined that all administrations of the surveys had a high level of reliability for the entire group of usage statements and the usage survey questions that are included in the "Provide" factor. The "Guide" factor usage statements had a higher, but not good, pre-project administration reliability but then the reliability for the questions in these factors decreased to very low levels in the mid-project administration. By contrast, overall survey and statements related to all factors had acceptable reliability scores for the Confidence questions. Cronbach's alpha is a coefficient of reliability based on a 0 to 1 scale. For social science research, scale reliability values greater than or equal to 0.7 are desirable. A summary of Cronbach's alpha statistics that were run for this report (July 2016) are shown in Table A2 below. These survey scale analyses indicate that the survey should continue to be used to gauge teachers' self-reported instructional practices related to CBL and EDP.

Table A2. Current Instructional Practices – Cronbach's Alpha Reliability Analysis

Cronbach's Alpha - Scale Reliability, July 2016		
	Use Statements	**Confidence Statements**
PRE-Project		
CBL	0.908	0.940
Provide	0.887	0.905
Guide	0.780	0.858
MID-Project		
CBL	0.832	0.933
Provide	0.862	0.908
Guide	0.601	0.815
POST-Project		
CBL	0.864	0.934
Provide	0.871	0.885
Guide	0.641	0.784

Appendix B. Open Ended Responses from Teacher Post Unit Survey

Question: How did your students benefit from participating in this unit?
Apply/real world knowledge
Students really ran with the idea of it being a real world scenario. Students benefitted from being able to test a floatation device within the classroom setting. Teams benefitted from being able to come up with their own design.
They learned real-life applications for the usage of calculating slope and length measurements.
They were able to experience firsthand some of the things that are involved in running a business. They had a clear understanding of competition, advertisement, mark-ups and discounts. They had good conversations about their products and what could be one to help boost sales. They learned about reliability, and the results of what happens when some people are not reliable. The largest benefit was seeing how what they are learning in class applies to real-life.
They say how math applied to the real world through roller coasters. They gained experience working in teams. They gained experience being challenged through design.
They were able to apply solutions to a real world problem. They had to figure it out the hard way. :)
They were able to apply the mathematics to real life through analyzing authentic data.
They were able to see a practical application of something that they were learning in class and see how it is used to affect the safety of car production.
They were able to do the hands on activity and really take part in a real world engineering activity.
They had the opportunity to see real world applications for academic content. They collaborated in groups to find and implement a solution.
They were able to have hands on activities and field trips dealing with a real world problem. They relate what they learned with current events and the weather.
This unit provided a great opportunity for students to practice working in teams and assume real world roles as part of a team. It allowed students to take their science knowledge and apply it to a real-world problem as well as development knowledge along the way.
They were able to see how solar energy is an effective energy source and how it could be used in everyday life. They were also able to work with materials and have a hands on approach to the concepts of reflection absorption and insulation of heat energy
Also, they were able to see how the math they were learning in class applied to real-life.
They really enjoyed coming up with an application that was applicable to them. I have several students that live or work on farms. They also loved being able to apply knowledge learned throughout the year and a culminating activity.
As expected, they were able to connect the Pythagorean Theorem in a real life context not just in the abstract.
I believe my student benefited most by being made aware of the realities of the business world and how much effort and money is required to start and maintain a business. Students received a reality check of how much detail is involved in small businesses and even more so in corporations in order to run successfully.
I believe that the most beneficial aspect of this lesson was the students' ability to increase their critical thinking skills. I also believe that this lesson more than any other lesson in the past gave the students a chance to connect the skills that they were working on in the classroom to skills that would be required for a career.
My students benefitted from this unit because it allowed them to make a real world connection to earthquakes and how they affect houses. Ohio students do not directly see the effects of earthquakes and I think the simulated shake table helped them visual ow catastrophic they can be. The students were very engaged and practiced all aspects of team work.
Students gained valuable hands-on experience with fluid systems AND were able to work towards solving an actual Real-world design challenge.

Question: How did your students benefit from participating in this unit?
My students benefited from this unit because they were able to complete a hands-on challenge that was applicable to the content we were discussing. It allowed them to make connections between the mathematics involved, and the purpose of such calculations in real world scenarios.
Students saw the connection to what they are learning to applications in the real world.
My students benefitted from participating in this unit. They were able to connect a real-world problem and linear relationships. It was nice for them to finally connect mathematical topics to things they know about in the real-world.
My students benefited from seeing how the curriculum could fit into a real world scenario. Often times when students are given problems about abstract mathematical concepts they struggle to see how this could apply to real life. In this particular unit students were exposed to how the Pythagorean Theorem could be used in real life as they could physically identify the triangle hypotenuse length they were solving for. The hands on approach that this unit incorporates is particularly beneficial to my student.
My students used knowledge of potential energy and energy transfer to make Rube Goldberg Machines. They used what they learned in class and how to maximize and minimize potential energy in order to make their machine work. They explained to 6th graders ow their machine works by using science vocabulary words.
They really grasped the true concept of volume as opposed to just punching numbers into a calculator and getting a "number cubed."
My students received a presentation by an Architectural Engineer who showed them the connections to their work and several STEM careers. Students saw how linear functions/equations and slope are a huge part of their lives. They engaged in a challenge base learning project that allowed them to work as Engineers to solve a problem. They worked as a team to think and build and present their findings.
Engagement
As many other teachers mentioned in the summer classes, I found that students who ordinarily were not engaged actively participated and those who were forcing themselves to do the routine work actually enjoyed this way of learning. They realized that engineering is not just guessing, but requires using science and technology. This is the answer to the age old question so many students ask: "why do I need to learn this? I'll never use it."
My students were very engaged during this unit. Just at hearing they would be allowed to drop Barbies from a high height using only rubber bands made them excited. They were very engaged in collecting data so could produce a great final result. For most of my groups, they had their Barbie reach within 10 cm of the ground. They is way better than my expectations coming into this unit!
Students who were usually shy and never worked with others began to enjoy their partnerships as they designed and built their catapults. Students who did not show leadership on a normal day began offering some of their insight into the project.
Their level of engagement was much higher than non CEEMS units this year.
They "learned by doing" rather than watching a video and completing some worksheets.
My students were able to take rather boring topic of Pythagorean Theorem and apply it with success. They developed ideas and solutions without me having to tell them how to get to the answer. It was really nice to see them take charge of their education and work well in groups.
They were engaged and they learned about creating budgets, interest rates, and how to code a google spreadsheet. They financial literacy knowledge and skills were increased. Also, they were introduced to financial planning, coding, and how to work with real clients.
My students as a whole benefited from overall engagement. Because more students were active in the creation and simulation there was more dialog.

Question: How did your students benefit from participating in this unit?
My students benefited from this unit by using their knowledge they obtained from forces and motion and creating a new product that they has never done before. The balloon rocket car provided a fun way for students to show their knowledge and participate in a challenge.
The students loved getting to come up with the idea and later testing it. I have students ask me weekly, "when are we doing another engineering project?"
Collaboration/21st Century Skills
Students developed 21st century skills. They still need work on collaboration with peers. They were given a self-reflection and many individuals were able to identify they needed to work on this skill. My students were able to use scientific terminology correctly as well as application of the terms.
The students were given the opportunity to explore many alternatives. This opened up the room for debates. It was interesting to see their reactions to one another. In the past, most of the students were closed-minded to other's views but this time I could tell they were willing to listen to the team members.
This unit enable students to communicate effectively. In the past, there was a lot of arguments and disagreements about designs. Students are doing a better job at creating procedures and evaluating alternative solutions. They still struggle with following the design the created.
Students benefited from working collaboratively to get to a solution (replicating their partner's tattoo design correctly). They experienced the importance of communicating effectively by giving clear, correct, understandable instructions. They were also able to evaluate themselves and their peers, which gave them the opportunity to express ideas on how to best work together to come to a working solution.
They benefited from working in teams with specific responsibilities. These team roles held them responsible for their effort and product.
Their collaboration increased as well as their understanding of how to use feedback.
Improved on peer evaluation at the end of the unit.
Had to pull out their creativity
They were able to work on their communication skills as well as collaborative learning
They were able to work as a team to accomplish a goal. They learned how to navigate new technology.
Students learned that failure is okay as long as you continue to refine and improve toward a successful solution.
Worked well with others
Enjoyed the CBL process. Engaged in the activities. Worked well in teams.
In this first unit, students benefited from being exposed to Challenge Based learning which improves their overall ability to think critically and come up with various solutions to a given problem. Students also received an exposure to a topic that they may have never been exposed to before, that being the field of space exploration.
Hands on application, they were puzzle solvers
I believe the students benefited in several ways. First, they had to review content to make the game accurate and appropriate. They also received content when they played other teams' games and they worked on their team work skills and abilities throughout the unit.
They learned about how to debate and about public speaking. They also learned how to stand up for their educated beliefs.
Learned how to be part of a team
Practice presenting ideas and working as a team
Students demonstrated success with the challenge--all groups were able to come up with a solution except for one. They benefitted from being able to successfully create their own number "tricks" using algebra.

Question: How did your students benefit from participating in this unit?
They have never had a hands on science class due to teacher problems the last 2 years. They really struggled with doing a hands on project that was not guided. They were very frustrated at times but at the end saw the value of the frustration. They learned "stick-to-it-iveness" and perseverance. Many wanted to quit at various times. There was actual screaming in the hall when they were finally successful - tons of celebration!!!
Students worked in teams-- this was very hard for some of them, but they persevered. They were able to work through many problems with their "team". They were also given ample opportunity to use the scientific language and vocabulary associated with the unit.
Over half of my students pushed through and did a great job of going through the EDP. Several students were successful in mastering the concepts of related rates through the activity.
They learned to persevere through difficult work, and to communicate effectively with others to get a common goal accomplished.
Implementation
I have been struggling with this question since I implemented this unit. They got to look up different designs for solar cooking and see the benefits and advantages of solar cooking over using other more traditional methods. I feel that the students looked at this more as a fun project and did not really get that it was more about the engineering design process and the real world connection that it had. This probably had more to do with my delivery of the unit and my lack of up front preparation.
They made educational board games which can actually be used by teachers. Completing a product was a challenge for them as they wanted to quit several times. Some of the students are non-compliant. This was hard on me as a teacher but I believe the students grew from it.
My students liked the activity, but many did not use the rubric to create their presentations. Because of this many students did not use any statistics in their results which was a requirement.
Content Knowledge/CBL/EDP
They were given time to explore and answer their own questions through scientific inquiry. That is a freedom rarely granted in the classroom. They mastered the content as demonstrated by the post unit test scores. The unit was also cross curricular in that it had them practicing some basic algebra, rates, etc.
My students showed so much growth in knowledge and understanding of t-test and two sample t-test. They also better understood the use of hypothesis testing because they were using it with data that they compiled themselves. It had more meaning to them because they gathered their own data rather than using random data they were not invested in.
They learned to use math to do research on a biology topic, and how the EDP works. They learned the difference between engineering and "tinkering"- which is using science to design engineering solutions vs trying things blindly to see what happens.
Understanding of how to think using the EDP process. Developed team building skills.
My students were able to link what they know about EDP and what they learned about Calculus and Physics to combine all that content to create a working Rubens Tube and check if the theoretical sound was the same as the experimental!
Students learned, through many avenues, about potential and kinetic energy. They also showed great creativity in developing a toy, made from trash, that converted potential into kinetic energy.
They learned there are many answers to one specific problem.
The students were introduced to a new way of learning, they are unfamiliar with discovering solutions to problems on their own.
Once they built their catapults they were able to use them to calculate PKE based on what they designed. I think this gave them a better understanding of the equation because they had to find all the variables themselves.

Question: How did your students benefit from participating in this unit?
They not only mastered the content (exponential functions), but their financial literacy increased. Many of them had no idea what college, cars, and houses cost, let alone what interest rates and loans were. So, just by completing this unit, they have gained REAL WORLD knowledge that will help them in their individual lives one day.
It was a great visual unit. They saw video from an earthquake and up-to-minute data on the world's earthquakes. Finally, they designed and used a seismograph.
They enjoy building and testing seat belts. 8th graders are close to the driving age. So it also brings an awareness on why they should always wear seat belts
Students showed improvement on the post test.
Their pre and post test averages increased by 20% and they scored better on post tests than other non CEEMS classes. They were able to draw force diagrams better after the unit.
their score after the post test increased by almost 50%
they did very well on the content
All Others
They were able to take an issue that involved the school, and come up with a solution. They were also able to make a proposal to resolve the issue.
The students benefit and society gains a benefit due to the nature of the unit. Students have to research ways that gases found in our atmosphere are created or depleted in an attempt to modify another planet for habitation.
They learned about the importance of tutorials, they created their own tutorial, they learned how to use animation software, they learned more about the topic they were teaching in their tutorial.
They also learned enough about metabolism to make more effective food choices for themselves.
Understood roles that project managers hold and learned to adapt.
By working together and hands-on evidence of chemical bonding.
I believe my students benefitted in a wide variety of ways with this unit. Students increased their knowledge of research techniques and resources. Students developed better communication skill because they were required to work with a team and present in front of the class. Finally, students benefitted because they became more knowledgeable on a highly controversial topic in GMOs.

Question: If you were to teach this unit again, what specific modifications or adjustments would you make?
I had a huge problem with absences. I would do the assignment of groups differently. I also would encourage students to think of different types of crops to use. I also would not provide the paper copy of the EDP worksheet for students to fill out. Their brainstorming and ideas seem to be hindered as soon as I introduced that paper.
**Use clients from local businesses and send a letter to their employer **Have clients Skype in, fill out feedback form, and respond to emails. **Have students estimate cost first using math and then use online calculators. **Add budget creating lab.
have students brainstorm their budget constraints and what they wanted to ask their client *take away the calculators and have students do the calculations by hand* *instead of the car loan lab, I would have students discuss different loans and interest types.
Allow more of the CBL and EDP process to work. My biggest struggle is letting the process work and not stepping in to guide or control the progress.
Give them more time to refine their projects.
Have some rock profiles already made for lower level students to analyze. The creation process was too difficult for them.
Honestly, I would not make the rain barrels with the current materials. Working with the materials were a major frustration for every student and took away from the concept being taught. Instead, I would have students design the barrel using a program such as Google Sketch up and have them somehow digitally test efficiency.
I allowed this unit to change and develop with student input as Physics Concepts is an elective without a state test or state curriculum. Students wanted to propel their cars in other ways than mousetraps as I had originally planned. I decided to let them Projects ended up inclining CO2 cartridges, balloons, rubber bands, mousetraps and a combination. I had never worked with CO2 cartridges and it was fun to learn together. It completely changed the whole project but it became real to the students and me s I saw them make up their own plans and revise multiple times. It took twice the time I had planned but they learned far more since they made everything up. I did a small project first to introduce them to the process but in the future I would spend more time on it. I would also not allow the huge variety of choices as it cost a lot of money and multiple trips to the store. I would use the constraints of the mousetrap to keep it more focused. I will change how I introduce the unit to keep them more focused instead of the students thinking so broadly.
I already made them.
I changed my challenge during the unit implementation. I would have students determine if the existing wheelchair ramps met the ADA codes and then to determine what needs to be done to meet the codes and to determine if it's feasible to do so.
I did the unit with my most challenging class, which was very challenging and frustrating due to the lack of productivity from some of the groups. I would teach it again to all classes, increase the class time devoted to it (we were cut short due to testing), and reduce some of the requirements of the survey. For example, I would have groups create a much shorter survey to administer.
I don't think I would make any other adjustments to it. It worked really well this time around and I found that the students actually had fun doing this. They were excited to present their catapults and had fun during that presentation.
I need to establish a consistent method of student accountability
I will adjust the flow of the testing day, the EDP guide and overall content I want them to understand from the challenge.
I will have the students do more formal research on bomb calorimetry before they begin their design. I will also make the rubric less stringent due to the complex nature of this project.
I will modify the instruction time prior to the unit (increase). I will modify the time frame I present the unit (not during a Christmas break split).

Question: If you were to teach this unit again, what specific modifications or adjustments would you make?
I would add a time constraint with a timer running down constantly to give the students a sense of urgency for saving the human population. I would add in more direct instruction for virtual labs.
I would add another trail run for each group so they would get more feedback. I would also adjust when I taught this unit in my yearly timeline so that I could teach it earlier. Finally, I would not limit the game to just evolution, I would open it to all content areas.
I would allow more materials for students to use when building their solar house models.
I would allow more time for the teams to create their balloon rocket cars. I would have a final competition between the winners of each class to crown a grand champion.
I would allow students to use the Sketch-up software to create their scale model I would stress the math content more. i would allow more time before building
I would assign a daily role with task to complete
I would bring in speakers on the front end of the unit, rather than at the end of the unit. I would also try to have more stipulations for what type of businesses were realistic to explore with our resources and time. I may also include more direct instruction on the content with applications in business to emphasize the connection to mathematics in a deeper manner.
I would certainly familiarize my students with genetic modification techniques more before I implemented the unit. Even though one of the intents of the unit is to do this, having some base knowledge of genetic modification would have given everything more meaning. I also would have given the students more time to practice in a debate setting, possibly by having a debate over a different subject earlier in the year so they were familiar with the process.
I would change some the logistical aspects of the implementation of the challenges, specifically having something for the students that finished their coaster while other groups were still working.
I would change the time of year I presented it. This year we did it in April and most of our test days were rained out. Next time I would do this in early fall so the weather is more cooperative
I would change up the brochures and probably not use Microsoft Publisher. Familiarizing the students with the technology took time and students could not finish the work at home.
I would complete more information prior to the implementation of the unit
I would definitely give the students more content knowledge prior to implementation, I would also assign definite team member assignments and stick to time constraints.
I would definitely teach all the content before starting the unit instead of starting the hook and essential questions before the content and the project after. I would also make sure that I hold the students more accountable for the writing and communication pieces. I was in a rush to complete the unit so I also rushed through those steps.
I would ensure access to many equal powered motors fit the challenge.
I would figure out better ways to manage time, cutting back on some activities. I would figure out better ways to deal with classroom clean up.
I would give more time for the final challenge and set up different ways to present the information.
I would give students another day to test their machines and practice their presentations to the 6th graders.
I would give them more opportunities to test their structure on the shake table. I would make the webquest a bit shorter. I would give them more time to sketch and come to a consensus as a team.
I would have adjusted the final challenge to incorporate the use of string to help accurately measure the distance traveled by the marble.
I would have more vocabulary workshops. I would make use of a timer to help us stay focused on our use of time. I would acquire a student teacher for an extra set of eyes and hands.

Question: If you were to teach this unit again, what specific modifications or adjustments would you make?
I would have ordered more bean beetles and I would have tried to breed them myself to save on cost.
I would have purchased more 20 and 35 ml syringes and tubing and nuts and bolts. Less 70ml syringes are needed.
I would have some measurement activities before the unit began.
I would have the research part more guided. The students struggled with how to incorporate the research findings into their designs. They need to do the research activities, then have a whole class discussion about how to use this info to design their challenge.
I would have used a propane tank vs the gas from the science lab.
I would incorporate more formative assessment along the way and better define the constraints on the building and shaking portion that is the science part of the unit.
I would learn how to use technology better.
I would limit the materials given to the students. I would possibly eliminate cardboard completely because all groups relied on the cardboard which made the designs very similar.
I would limit the product to non-edible items. I would totally create the test myself. I modified the one from the unit that I modified. I felt it should have been a little more basic. I would try to find a way to shorten the unit. Teaching the concepts prior to implementation, and then teaching the unit, took up quite a bit on instructional time. I am now behind in my pacing. I would try to present the challenge earlier. The art teacher worked with the students on advertisement, and it did not allow him much time to have students create they billboards. I would try to find a young entrepreneur to come to speak with the class. I would be sure to spend more time discussing the difference between "profit" and "income." Some students felt they were one in the same.
I would make a better template for the creation of their presentation poster so that students understood that they had to incorporate their personal statistical findings into their poster.
I would make modifications to the timing of the Unit, I would have liked their background knowledge of slope equations to have been stronger prior to the Unit implementation. I would have ordered a few more supplies.
I would make more materials available to students.
I would make this a strict photosynthesis unit and not try to fit in cellular respiration.
I would manage the clock more wisely.
I would not allow students to use casein as a binder type. I also would not have more than three people in a group.
I would only but certain materials. I would modify the unit to streamline the building.
I would probably attempt to decrease the amount of class time required to implement the unit.
I would remove the bubble membrane activity. This activity can be implemented during a different unit on cells and organelles. I would also have students design a functioning model of the kidney instead of creating a filter that functions like a kidney.
I would shorten the time I took on the background information. I would give stricter time constraints on each step.
I would spend less time having students create their own rubrics, I would spend more time allowing students to present their work and explanations to the class in preparation for their video recordings.

Question: If you were to teach this unit again, what specific modifications or adjustments would you make?
I would try to make more copies of the software available or in fact purchase another robot that would be available for use.
I've taught it twice and I feel it is very good. I would be sure to have a variety of "trash" available for students to use in their prototypes.
If I were teaching this unit again, I would integrate the content more, rather than covering most content before the unit began. I would also research more practical and specific ways in which students could analyze their measurements. I also think students would benefit from a speaker in a related field.
If I were to teach this unit again I would modify the way that my students presented their results. While they had prompting on what questions to answer, the delivery did not seem organic and as a result I do not believe that students got as much as they could out of it.
If I were to teach this unit again the main adjustment that I would make is that I would focus in on my content. What I mean by that is that doing this unit as an introduction to slope was not as effective as it could have been at the end of the unit on lope because students would have had more exposure to the content and as a result would have done better on the challenge as a whole.
If I were to teach this unit again, I would probably remove the bouncing tennis balls lab. It was a good preview of how to collect data, but it took a very long time to complete. I believe I could make or find another activity that was just as beneficial that did not take as much class time.
If I were to teach this unit again, I would teach it to my 8th grade students as well as my integrated math 1 students. I think that all 4 of my classes would benefit from this, not just a few.
Less on putting all information in Engineering notebook and more on completing testing labs to get information for solution.
MAKE IT AN INDIVIDUAL PROJECT
More conversation about team expectations, practice presentations, more time (end was very rushed)
More formal reflection of the design process and buy bigger scissors.
More structure for the "Challenge" by providing the storyboard and gallery walk up front. Being explicit that the gallery walk is the "refining" part of the EDP. Also, figuring out how to get the students to "buy in" by having a resource officer explain he challenge in a video and using that as a hook
Not as much class time spent on building of the base structure. Use a different material like Tinker Toys.
Not sure I would make that many changes. It was a good starting the year project. I might like to test the projects outside instead of in my classroom. We had a lot of water on the ground.
One specific modification I would make is to provide students with the materials they could use. I provided some of the materials students were allowed to use, but I allowed them to bring in materials of their own. This was an unfair advantage to some groups because they brought in mirrors, glass, etc.
Provide more laminated paper to reduce the amount of tape.
Show some exemplars Allow students to bring in own materials/bottles Try to partner up with the art teacher for aesthetic design Being sure students don't spend too much time on the aesthetic part of the first design because all of the students had to redesign Spend more time on charting and graphing their data and going over it as a class. Lay down newspaper for use of insulation foam because it caused some damage.
Since I was unable to implement the Excel component of the unit, I would adjust it to use Google Sheets or some other program that my students have access to.
Spend more time on the unit. Not so rushed

Question: If you were to teach this unit again, what specific modifications or adjustments would you make?
Student product presentations would change to a gallery walk verses presentations.
The anticipated essential question would change from "How does soil filter pollutants out of water?" to "How can we filter pollutants out of water? Have the container be uniform because more time was spent on the construction of the container instead of the filter itself. When students had to determine the porosity and permeability of their filter, we didn't use information from the learning activities. When planning for the next time, students should use the prior data to calculate the expected porosity and permeability of their filter. They will need to be able to use rates and proportions in this part of the activity. Incorporate a essay piece to the final presentation. I would suggest using the RERUN method. I had to change the presentation piece from a Six Slide Presentation to a Foldable Poster Presentation due to technology issues.
The content goes beyond Physical Science standards, so I would teach it at the end of the semester. I would try to relate it to the standards better.
The eighth grade standard for this content also has an element of identifying the impact on coordinates in the coordinate plane. I would definitely add this as a focus in the future.
Time for more refinement.
Use the online simulator as part of the hook before I show the video. Use graphing calculator instead of excel Being sure to have other areas students can record. Students can not all record in one room.
When we tested out cylinders for strength I would have liked to have a better method to do this. It did not seem consistent so I would have liked to create a standard for the size of the cylinders as well as a clearer method for the strength test
Where to begin :) I would make my hook more "fun" and not force the math. I would change the hook activity to a lab activity. I would embed more math into this lab. I would make the hook activity a pure building activity. I would tell students that they were not allowed to make PowerPoints for their presentations. I would have students practice their presentations.

Please share any additional thoughts or feedback.
Overall I think the unit went well.
Absences and lack of productivity were issues for a few teams.
Allow students more time on this project
Basically I am asking students to play with and design toys. Students love this unit from the hook to the presentation of their products. It also include a humanitarian side as well.
Great unit, would definitely do it again. The Goanimate software was an excellent addition to my unit.
I am really having difficulty with this EDP process. I feel like I don't have a good enough grasp of how it is supposed to work that there is no way I can teach my students how to do it. I am not sure if this is something that I just need to practice with or if there is some way that I can get more experience with it but I feel like I am not confident in my implementation of these units.
I enjoyed having the help of the coaches and graduate fellows throughout this entire process.
I enjoyed having the option to revise a unit and hone in on the development and implementation of this unit.
I enjoyed working with the coaches and graduate fellows with my units.
I felt like the activities that were done leading up to the challenge were in fact helpful. In an AP class, it seemed like too much time was taken away from instruction of the AP content.
I know that this whole program is funded by NSF and that there has to be proper documentation to support the funding but I feel that the amount of paperwork is very overwhelming and stressful. This may be just because it is my first unit but I have felt large amount of stress over getting all of it done. I am not sure if anything can be done or not but I just wanted to voice my opinion.
I like the unit, but it needs tweaking.
I really enjoyed the unit work, however, the time constraints didn't always allow for redesign
I really was hoping that the changes would have made this unit better, however, I felt like the students did not take it seriously. Next year I will do this again with more work on finding their own personal statistics rather than research on the internet.
I think if I revisit this unit, I would like to change up the challenge.
I think this unit was really good. Score did rise from pre to post test and I could see the kids really enjoying themselves while they were learning
I thought it went really well, but felt like students used math minimally while using engineering principles mostly. I think this could be changed in regards to how I word the challenge.
It was interesting to see the connection the students made. I even had one student connect the force to the chapter we covered on plate tectonics. This was outstand.
It was very helpful to have the resource people in the classroom during implementation to both receive input and confirm mine findings as we proceeded through the unit.
My students are confused about the term receiving guidance. Many times they want me to give them an answer instead of probing or asking them more questions. When I answer their questions with additional questions they feel I am not helping them. I feel the challenge would have went better if it was to make a model or diagram.
My students loved this as a final culminating project! It also only took 5 instructional hours for me because I did this project with the AP Physics teacher, who had those same students in class. It worked perfectly!!!
My students loved this project and were very engaged the whole time!
My Unit 1 was successful, but I know there are still some gaps that need to be filled from looking at their Post-Assessment data.
Next year this unit will be awesome. I only have 40 min. bells and I rarely get through any unit in a fulfilling manner. In 2016-17 we will have 90 min. classes which will allow me to teach my content.

Please share any additional thoughts or feedback.
Older students are hard to get engaged, especially those who are credit deficient or are in the class because they have to be.
On the last day of the unit, I asked for a show of hands "Should I do this with next year's Chem classes?" Out of 40 total students, only 3 or 4 kept their hands down- they had very positive comments and expressed how much they enjoyed doing the project!
Overall, I loved this unit. The engagement was high, students enjoyed the project, and their efforts were rewarded with their final bungee drop!
Rob R. was a big help and cheerleader with this unit. He gave my great feedback verbal and written. He also provided me with lots of pictures and video.
Sometimes while doing units, there is too much "down" time. I need to figure out how to keep ALL students engaged during group work.
Students have trouble with 3D designs and drawing them on 2D surface. Need to just let them build, draw then redesign. Sometimes cannot build what they drew due to limitations.
The level of engagement and energy in the classroom was definitely elevated. It was encouraging to see that excitement. Some students do not work well with others. This made some groups less effective than others.
The skill of measuring plays a big part in this unit. I underestimated the amount of time it would take for students to measure various shapes. They didn't initially measure precisely without my tutelage.
The students had a great time with this project. I would suggest using a 1 liter or 2 liter bottle for the container. I felt too much time was spent on the construction of the container instead of the soil filter. If students didn't have to plan that component, they would have more time to critical think about what type of soils to use and how much of each. They would have to think more about permeability and porosity.
The students loved the debate and keep asking to do more debates.
The students really enjoyed the unit. Ideally, I would like to present one unit per quarter. However, I need to find a way to get the timing down so that it does not throw us too far off the pacing.
This class is a general level 11th and 12th grade class with many resistant learners. Many days several will refuse to work and can be non-compliant. For them to complete a major project is a great success. This shows the value of STEM for under-achieving students.
This is an amazing program and I am so thankful I had the opportunity to be part of CEEMS.
This was a process not a product and I was extremely happy with the results. I learned that students don't have to be hands on building to learn!
This was one of my best units in the program. I'm very happy with how it turned out. I would have loved to have more time with the students running one or two more experiments on the beetles.
Unit definitely went better this second time around.
Was really not a very good use of time.