ESC Evaluation Services Center

Key Evaluation Results of the CEEMS Project, Year 3

Prepared for

Dr. Anant Kukreti, PI &

Advisory Board Members

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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., M.A., Director

Results prepared by:

Jacinda K. Dariotis, Ph.D., M.A.S., M.A., Director

Catherine Maltbie, Ed.D., Research Associate

Latiera Brunson Evans, Ph.D., Research Associate

Audra Morrison, M.A., Research Coordinator

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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The CEEMS National Advisory Board met on March 25-26, 2015. They requested that the evaluation team supply the following information to them in a concise format:

Evaluation questions

Metrics used to answer those questions

Results (answers to the evaluation questions).

EVALUATION RESULTS

The current CEEMS evaluation results for the third project year are summarized in the table below.

CEEMS PROJECT YEAR 3 -- Evaluation Instruments/Metrics, Results Pertaining to Teacher and Student Results and Outcomes

Project Goal 1. Increase 7-12 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 • 87.9% of students agreed or strongly agreed that they understood how the EDP activity helped them solve the challenge.(n=4426, mean=3.23, SD=0.65) • 62.4% of students *agreed* or *strongly agreed* that the unit increased their interest in engineering. (n=4405, mean=2.79, SD=0.94) • 76.3% of the students agreed or strongly agreed that they learned about careers related to the challenge. (n=4380, mean=2.98, SD=0.81)
EDP Drawing *Student understanding of the iterative nature and ordering of 9 EDP phrases was measured using an adaptation of the "Draw an Engineer" question (Lachapelle et al., 2012) in consultation with the measure developers. The scoring rubric was informed by previous EDP student assessment articles (Achieve, 2013; Schubert, Jacobitz, & Kim, 2012). Two raters scored each drawing (inter-rater reliability 0.94-0.98).* Scoring rubric: 0= no understanding; 1=elements listed but not connected; 2=elements listed and connected but not iteratively; 3=elements listed and connected in an iterative manner but elements are not in one of many acceptable patterns; 4= comprehensive understanding of the process.	EDP understanding • Over 60% of students understood EDP elements are connected. • Over 16% of students understood both the EDP elements & iterative nature. • Nearly 10% of students could correctly draw the entire EDP model. • Nearly 20% had no understanding of EDP model. Table 1. Rubric Scores from Students' EDP Drawings: 2013-2014 Academic Year **Rubric Score** 0 | 1 | 2 | 3 | 4 All Classes (n=4300): 822 (19.1%) | 761 (17.7%) | 2057 (47.8%) | 248 (5.7%) | 412 (9.6%)
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: • 58.1% of teachers *strongly agreed* and 40.7% *agreed* (98.8% total) that their students had increased engagement in the classroom during the unit compared to non-CBL units. (n=86, mean=3.56, SD=0.57). This is an indication that the students were interested in the CEEMS units which using engineering concepts, CBL, and EDP so that students learn math and science content.

Project Goal 2. Increase 7-12 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 • 92% (70 out of 76) pre- to posttest assessment scores, measuring math and science content, significantly increased (two-tailed paired t-test; 95% CI; 0.76 effect size) • 33.9% average gains in student scores, measuring math and science content, were found for teachers with two years of program exposure (Cohort 1) compared to 26.8% average student score gains for Cohort 2 [F(1,74)=2.962; *p*=0.089)]. This is significant at 90% CI.
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 • 90.1% of students *agreed* or *strongly agreed* that they learned a lot from these units (n=4426, mean=3.23, SD=0.65) • 68.8% of students *agreed* or *strongly agreed* that the unit made them feel more confident about math or science (n=4397, mean=2.86, SD=0.85) • 84.1% of students *agreed* or *strongly agreed* that using challenges was a more effective way to learn then how they are usually taught (n=4384, mean 3.16, SD=0.75)
Teacher Post Unit Survey "Students mastered the expected material." (Scale: 4=strongly agree, 3=agree, 2=disagree, 1=strongly disagree)	Teacher Post Unit Survey • 82.6% of teachers agreed or strongly agreed that their students mastered the expected unit content (n=86, mean=3.00, SD=0.67)
Teacher End-of-Year Focus Groups *Annual focus groups (90 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 • Cohort 1 and 2 teachers both observed gains in students' critical thinking and problem solving skills. ○ Cohort 1 Teacher: "Overall learning is higher, covering all kinds. Students are more likely to take academic risks and think better on their own." ○ Cohort 2 Teacher: "Students' learning curve increased greatly compared to the way I used to teach. Students work together and implement things." ○ Cohort 2 Teacher: "With usual lessons, wrong is wrong. With the engineering design process, failure is actually a good thing. They learn something that didn't work so they can go back and redesign."

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).* Questions asked about the extent to which teachers provide students with opportunities to: 1. Gather information about important problems or issues. 2. Explore multiple solution pathways for problems. 3. Test their solution pathways. 4. Refine and retry a solution pathway. 5. Communicate their solution pathways and results to others. 6. Take responsibility for the decisions they made about the processes used in solving complex problems. (Item categories: Use Regularly, Use Occasionally, Have Tried It, Never Used)	Teacher Current Instructional Practices Survey: • 100% of teachers (Cohort 1 and 2) used instructional practices promoted by CEEMS programming to at least some degree after one year of CEEMS (mid-CEEMS). • Teachers increased their use of six EDP practices (chi-square $p<0.05$ for each) from pre-CEEMS to one year of programming (mid-CEEMS). • Increases varied by EDP practice in 34 teachers' regular usage. **Table 2: Comparison of Pre- and Mid-CEEMS EDB Instructional Practices** Chi-square indicates significant differences (at 95% CI) from pre- to mid-project distributions for all questions.
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* for: (1) refining pedagogy (mean = 3.56, SD = 0.50), and (2) creating CBL units (n=34, mean = 3.69, SD = 0.47)
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 • 97.7% of teachers agreed or strongly agreed that they had enough understanding of CBL to effectively guide their students through the experience. (n=86, mean=3.58, SD=0.54) • 100% of teachers agreed or strongly agreed that they had enough understanding to effectively guide their students through the EDP activity and unit implementation. (n=86, mean=3.67, SD=0.47)

Instructional Practice	**% Use Regularly**		**% Never Used**	
	PRE	**MID**	**PRE**	**MID**
Gather information about important problems or issues.	12%	38%	9%	0%
Explore multiple solution pathways for problems.	18%	53%	6%	0%
Test their solution pathways.	9%	46%	6%	0%
Refine and retry a solution pathway.	3%	48%	18%	0%
Communicate their solution pathways and results to others.	6%	47%	12%	0%
Take responsibility for the decisions they made about the processes used in solving complex problems.	3%	38%	26%	0%

<table>
<tr><td colspan="2">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?</td></tr>
<tr><td><u>Resource Team Communication Log</u>
Resource Team members tracked communications with CEEMS teachers via a 12 question (9 closed-ended, 3 open-ended) online log.</td><td><u>Resource Team Communication Log</u>
Of 1005 entries, the most-mentioned communication topics were related to unit/lesson/activity implementation (22%), observations (19%), planning school visits (12.6%), and/or unit/lesson/activity development (10%).</td></tr>
<tr><td><u>Teacher end-of-year focus groups</u>
Annual focus groups (90 minutes) were conducted at the end of each implementation year by cohort. Teachers were asked about project activities and what they learned.</td><td><u>Teacher end-of-year focus groups</u>
All CEEMS teachers learned CBL and EDP within the SIT courses and received support during the academic year from the resource team members.
Cohort 1 Teacher: "I just taught one of the units I used last year. Last year when I taught it I was so focused on the project, challenge based and STEM and this year I was able to focus on the content that I needed to teach and that they understood all that they needed to -- Both the math piece and the project piece. I also wasn't afraid to jump in with another math lesson in the middle of doing the project just so they could really be confident with the math."
Teachers reported resource team interactions as the most effective in supporting their content knowledge and pedagogical skills
Cohort 1 Teacher: "I could not have done it without my mentors [resource team members]."</td></tr>
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