2017 CEEMS Research Report

The last cohort of CEEMS participants was consented for study during the summer of 2016. A full summary of the background information for the all cohorts of CEEMS research participants is given below.

N = 27 participants who began and completed at least 1 year of data gathering

Gender –	
• Male	37% (10)
• Female	63% (17)
School type: –	
• Urban	63% (17)
• Suburban	18% (5)
• Rural	18% (5)
Content –	
• Math	44% (12)
• Science	56% (15)
Grade level –	
• Middle (6-8)	44% (12)
• High (9-12)	56% (15)
Teaching experience	
• 1-5 years	37% (10)
• 6-10 years	26% (7)
• 10 plus	37% (10)

We are completing data gathering next year for Cohort 5 participants, so we do not have the total number of teachers who have completed the full two years of data gathering. However, for Cohorts 1-4, 73% have full data sets.

Specific research data gathered per participants included:

- Pre and mid-point – conceptions of teaching engineering interview
- A minimum of 2 post unit observation interviews
- Program exit interview
- A minimum of 6 observations
- One classroom resources survey
- One context checklist

In addition to the specific research data, the research team also had access to evaluation data and submitted unit plans.

The research team included three faculty members in STEM education and nine doctoral students. The doctoral students' time working on the project varied from one summer to three years. All doctoral students were trained in the specific research activities for which they were responsible for by a faculty member and all participated in research ethics training via the university's human research board training site.

Publications Since Last Annual Report

Meyer, H. (in press). Integrating Engineering into an Urban Science Classroom, *Journal of Urban Learning, Teaching and Research.*

Presentations

Meyer, H., Owens, L., & Sunny, C., (Jan. 2017). *Values and Limitations of Engineering Activities in Science Instruction: 4 Teachers' Experiences.* Presented at the Annual Meeting of the Association for Science Teacher Education (ASTE). DesMoines, IA.

Cargile, L. & Sunny, C. (2016). *Teacher Growth: How Teacher Conceptions of Engineering Change with On-going Professional Development*. Paper presented at the annual meeting of the International Conference of Qualitative Research (ICQR). Bloomington, IN.

Cargile, L. & Lyles, L. (2016). *Engineering Professional Development Plus Middle School Mathematics Plus Poverty Equals Success.* Paper presented at the biennial meeting of the International Conference on Urban Education (ICUE). San Juan, Puerto Rico.

Summary of Research Findings

The following responses from last year remain intact. Additions, extensions, and refinements are bullet pointed after the findings reported from last year. Although the Cohort 5 research participants still have a year left of implementation with observations and interviews, there are now enough research participants that we have full data sets for us to look at comparisons and trends among the different teaching sites and experience levels. This is primarily what the new findings are indicating.

Question 1: How are the teachers' gains in knowledge of engineering transferred into instructional plans?

Teachers initially viewed what constitutes engineering as a simple problem solving strategy or heuristic that leads to the 'best product' and something that can be easily encapsulated into procedural steps. This shifted over the summer institutes and implementation to being a much more complex structure which was really about a strategy to organize and manage solving complex problems that includes multiple stages and steps in an iterative process. They are significantly less focused on the production of a product and more focused on how kids decide what information to use and when, how they create and modify models, understand the required constraints and criteria and use and evaluate data based on desired criteria. The teachers see the use of CBL as a way to make their students active decision makers about issues or problems that are outside of their local experiences.

The teachers needed to improve and be much more intentional in their instruction with the students on the engineering units in order to help the students think through issues like ambiguous problems and how to decide what to do when and set priorities. They did this by improved student handouts and *explicit instruction about decision making, not just assuming the students would be able to do it. The teachers also found the students needed support and direct guidance on transferring the content they were using in the complex problems into more standard forms seen in science and mathematics curriculum. The issue of knowledge transfer from the applied form to a "school form" was frequently raised where the teachers saw kids using the knowledge in their design activities, but struggling on tests or quizzes even when the information was in a more simple form.*

The teachers found the engineering units were an excellent medium for creating opportunities for students to develop and use 21st century skills. Specifically they commented on their students' improved group/team work skills and holding each other accountable for tasks. They required students to monitor their own decision making and outcomes so they could explain why they were doing things and the presentations were good for improving communication. The teachers most often assessed how the students documented and explained their decisions and their ability to present their final ideas and products.

- The teachers stated in interviews that improving student decisions making ability was an important aspect of the CEEMS program and using engineering. As a result, this year we explored in more details what the decisions looked in practice. The following trends are emerging:
    1. Urban teachers allow the students more freedom to make decisions that connected to items outside of the school curriculum and explicitly relevant to social issues of the students' lives. These frequently connected to local social and political issues. Suburban teachers were more likely to focus on supporting and connecting student decision to personal choices, development and growth. There was no clear pattern in the rural teachers' opportunities.
    2. Middle grades teachers were more likely to be explicit with students about when they were making decisions and having students clearly document these decisions than high school teachers. This pattern, moving from more explicit to less explicit support was evident within school type, so that the 6th grade teachers were more explicit than 8th grade teachers; and 9th grade teachers were more explicit than AP or 12th grade teachers. This suggests the teachers were working with an implicit developmental model in mind.
    3. All teachers paid more attention to students creating a record of the decisions that they (the students) made as they progressed through the 2 years of CEEMS.
    4. We are currently analyzing if there are differences between how the mathematics teachers and science teachers framed and engaged their students in decision making. Based on data gathering experiences, we are hypothesizing that the math teachers allowed the students fewer decisions about the content and/or procedures to be used in the design problem while the science teachers offered the students more freedom to engage with content from beyond the science topic at hand.
- In regard to the development of 21st century skills, particularly around communication, female middle school teachers were interested/concerned about the group composition and how this impacted the work. In post observation interviews several suggested they tried different grouping combinations, single gender and mixed gender groups, random or strategic, in order to

make sure all the students were fully involved. High school teachers did not discuss specific group strategies other than for managing student to student issues.

- Although still in the analysis phase as to specifics, by the end of one year, the teachers felt they were better able to select units that would provide the right "content" for engineering units. Content being rather loosely defined since in most instances the timing of a particular topic coming up was included as a reason for 'good' content. By the end of the second year, the teachers could articulate what units and content were better for the different aspects of the EDP and for preparing the students for full and more complex design activities. At this time, we only have a rough idea of the criteria the teachers are using for this and if there are patterns across the teachers.

Question 2: *What supports and barriers do teachers encounter as they implement their plans with students?* (Items in bold were considered supportive by all teachers in the research, non-bold by some)

Supports:

- *School/administration*
- *Other teacher team members*
- ***Students' engagement***
- *Content/curriculum – some science disciplines were much easier to work with than others, specifically, middle school science, physical sciences, physics and upper level math classes; biology was particularly difficult so some units were a larger leap from the traditional school standards in biology. Math teachers also found developing units more challenging as it was more different than standard math instruction,*
- ***Resource team***
    - *Suggest materials and resources*
    - *Trouble shoot problems*
    - *Provide a sounding board*
- ***Previous CEEMS cohorts plans and meetings***

Barriers:

- ***Time in all facets***
    - ***Daily schedules***
    - ***Testing***
    - ***Curriculum pacing guides***
    - ***Lost days***
    - ***Student attendance issues***
- *Content/curriculum*
- *School administration/materials and class period length*

<u>Learning</u>

- ***Managing pace of groups***
- *Students' skill levels*
- *Content and transferring to tests*

In addition to the lists above, general patterns are beginning to emerge:

1. Teacher confidence in their own teaching ability serves as a support or a barrier depending on where the teacher falls on this. The more confident the teacher was that they were a "good teacher" the more likely they were to say their CEEMS units were not a problem to implement. Teachers who were less confident in their ability were more critical of their teaching of the CEEMS units. However, it is important to note that based on our observations, confidence in teaching ability did not necessarily correlate to quality of the unit or the teaching and learning taking place in the unit. Tentatively we believe that teachers with high confidence and a lower quality of instruction were less interested in continuing to use engineering units. Teachers with lower confidence but higher quality instructions expressed a desire to continue using their engineering lessons and/or adopting the CBL or parts of it in other areas of their instruction.
2. Newer (1-3 years) teachers faced more challenges and expended a great deal of effort in creating their lessons. They were open to the instructional strategy but struggled more than experienced teachers.
3. The continuity of the students' experience with CBL mattered. The teachers in schools where there was either a school-wide commitment to problem-based learning and/or other CEEMS teachers felt they were supported in the approach and the students were less resistant and more proficient with the practices and processes. Teachers who were either in very big schools or the only teacher doing CEEMS and/or PBL found they had to spend more time either overcoming student resistance and/or preparing them to be independent learners.

Plans for the next year

We will complete the data gathering for year two with Cohort 5 research participants and create individual teacher change profiles for all research participants. Beyond this, the primary work will be in closer analysis of specific trends across all the research participants over the cohorts. This will include items such as the impact of teaching context on different aspects of the EDP. We are also looking at trends across the participants in how they define engineering and what the activity of teaching with engineering involves and how this has changed and emerged over the course of the program. Specific code items will be examined in greater detail, such as the role of assessment, student learning, or the framing of the challenge or problem.