Session Title:
Studying the Impact of Interconnected STEM Learning: Lessons Learned from the
Mathematics Infusion into Science Project

MSP Project Name:
Math Infusion into Science Project Phase II

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Project Session

Strand 3

Summary:
As educators increasingly focus on interconnected STEM learning, there will be
increased demand for new assessment procedures that capture the richness of these
learning experiences while simultaneously assessing the core learning required within
each content area. Measuring the implementation of these interconnected learning
experiences creates new challenges for evaluators and researchers. This session will
explore both the challenges of assessing these new learning paradigms and the types of
academic and attitudinal changes that need to be considered. Assessment tools and results
from a mature MSP will be shared and discussed through this interactive session.

Section 1: Questions framing the session:
This presentation will explore the following key questions which guided our work:
• How do we define implementation when working within an interconnected STEM
  learning framework?
• How must traditional approaches to assessment of implementation and outcome be
  enhanced or changed when working within this framework?
• How can evaluators account for the context within which learning occurs as part of
  interconnected learning?
• How can the unique data analytic challenges encountered when studying
  interconnected learning be addressed?
• How can data about interconnected STEM learning be used to better understand
  student learning and inform instruction?

Section 2: Conceptual framework:
        This presentation will explore the challenges of studying interconnected STEM
learning for MSP researchers and evaluators. We propose a session that clearly fits
within the conference strand: **Evaluation, Research and Implementation: The**

Feedback Loop and specifically addresses the questions related to *Measuring and monitoring implementation. How do we know if we are making a difference? How do we know what aspects are contributing to the difference?*

The presentation will be based on work accomplished as part of the Mathematics Infusion into Science Project (MiSP), a three-year MSP project conducted by Hofstra University's Center for STEM Research. We studied the application of interconnected learning within the middle school classroom. Specifically, MiSP worked to improve middle school science and math learning and interest by infusing mathematics into middle school science curriculum. This work followed a five year MSP Partnership Project, *Mathematics, Science, and Technology Project* (MSTP), also conducted by Hofstra University, during which time a model for connecting mathematics into Science, Technology and Engineering content areas at the middle school level was developed along with procedures for assessing this model.

The MiSP model of interconnected learning involves infusing math into various middle school eighth grade science curricula (i.e. living environment, earth science, and general eighth grade science.) Math infusion serves as a way to contextualize science, provides needed additional opportunities for students to apply math, and deepens the science learning by allowing for more complex work with data during lab experiences. Throughout the lessons, students are also provided with an understanding of the interconnectedness among science and math. In our study, complicating the work was the fact that numerous science topics needed to be available to teachers since schools varied in their sequencing of topics (and in some cases the topics themselves differed), and teachers wanted a choice of science lessons into which math was infused. Each MiSP teacher taught six different weeklong math infused lessons over which time the math increased in complexity.

To study the impact of interconnected learning as presented in MiSP, a multi-method approach was used with data collected from infusion and comparison students, teachers and programs. Data included state test results (7th and 8th grade, math and science); pre/post content assessments of the math that was infused; pre/post attitudes and self-efficacy assessments related to math and science infusion; individual science unit assessments (infusion students only), do now activities (quick snapshots of current math infused understanding); teacher and student feedback surveys; teacher logs following implementation; focus groups; structured observations; and reviews of student work. On-line and paper assessments were used. For this presentation, we will describe our model of assessment which provided the controls we put in place to assure implementation was evaluated on a timely basis. Furthermore, our complex assessment model helped us define learning outcomes within the context of interconnectedness and allowed for examination of student change at multiple levels (e.g., relative to science learned, math learned, classroom, school, etc.) Data analyses had to be used that were responsive to the unique characteristics of interconnected learning. Through a process of carefully designed assessment tools and sophisticated analyses, we are able to identify changes in student learning while controlling for different aspects of the context of the experience. The data analysis procedures and assessment tools used within the interconnected learning context will be examined through group discussions and small group activities.

Section 3: Explanatory framework:
Although the data are still being analyzed, key findings to date with a pre-post experimental (infusion vs. control) study with over 2,000 student participants are extremely encouraging. During the process, we learned a great deal about both our model of infusion and the assessment of interconnected learning. Highlights of what we learned about math infusion into science include: it is highly doable in "regular" eighth grade classes; Compared to a similar group of students who were part of a control group, students who participated in math infused science lessons demonstrated increased math content knowledge, increased student reasoning skills, an ability to apply their knowledge to unfamiliar situations or contexts, higher scores on the New York State Eighth Grade Math Assessment, and improved self-confidence in using math within science. These findings were most evident for students who initially scored in the lowest quartiles on the math content knowledge.

We also learned a great deal about assessing interconnected learning. Data must be collected from multiple sources (e.g., teachers, students, school records), and to assess multiple levels of complexity of interconnectedness. Interconnected STEM learning is best assessed within a framework of cognitive complexity, with greater complexity evident in deeper interconnectedness. Implementation of interconnected STEM lessons requires a teacher to make explicit connections between the content areas. Since most teachers perceive themselves from a silo-based perspective of education (i.e., as a science teacher who is adding some math), assessment of implementation must focus on not only completing all parts of the lesson, but also the degree to which unanticipated "teachable" opportunities for infusion arise. Furthermore, assessments, whether examining content knowledge, attitudes or general feedback must address the content areas separately and connected, and this connectedness must be clearly described to students. Finally, statistical modeling of impact must account for the context of the data, as well as look for the latent characteristics which underlie the observed data. Through MiSP, we developed models and data reporting systems that presented data in ways that are easily understandable and applicable to teachers as well as ways that are optimally useful to researchers for theory building.

Section 4: Discussion:
What we have learned about assessment of interconnected learning will likely be relevant to many MSPs that are trying to break down the STEM silos and build connections between STEM areas. Furthermore, as attention focuses upon the Next Generation Science Standards and the role of engineering within science, there will be increased need to understand how to best assess implementation and outcome of interconnected STEM learning. Collection of implementation data can be challenging since it must account for both content areas, the context of the lesson delivery (e.g. in the case of MiSP the math was taught within a science class), and differences due to teacher, school or student factors. Thus, assessment of interconnected learning is more than a summative impact of adding to content assessments together (in our case we did not combine a math assessment and a science assessment.) Rather, it required rethinking of what is assessed and when. When two STEM areas are combined, the expectation is that the student will be able to use each as a tool for problem solving and that the solutions that students present will be contextualized in ways that demonstrate their knowledge of the

connections between the two or more STEM areas. We have created strategies to help in these efforts which should be relevant to other MSPs as they try to make similar connections. Our own MSP continues to explore how students benefit from these interconnected learning experiences.

Section 5: How will you structure this session? What is your plan for participant interaction?
We believe the most productive and useful sessions are ones in which participants are able to think and interact with materials. Although the presentation is very brief, we will encourage participant interaction by presenting components of our assessment model and encouraging participants to reflect on what is presented. We will describe our model for exploring impact and encourage participants to offer other alternatives. We will also encourage participants in small group activities to break away from the silo approach to education, challenging them to explore assessment data and statistical results in ways most aligned with the study of interconnected learning.   Handouts of our model will allow participants to better visualize the design and provide alternative roadmaps for studying impact.