Session Number: **43**

Abstract Name: **Interconnecting STEM—Math Infusion**
MSP Project: The MSTP Project: Mathematics Across The MST Curriculum
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1. Questions(s) or issue(s) for dialogue at Learning Network Conference session:

The Center for Technological Literacy (CTL) at Hofstra University, supported by NSF grant#0314910 (*The Mathematics Science Technology Partnership* — MSTP Project), reported promising results from infusing mathematics concepts into science, technology, engineering, and mathematics (STEM) curricula at the middle school level. The mathematics is introduced into science, technology, and engineering (STE) lessons at critical points so that the infused concepts naturally fit with the concepts and skills taught in the STE content areas. The mathematics concepts are relevant, meaningful and areas which students find difficult. In addition, while our model for infusion promotes connections between the STEM disciplines, it does did not attempt to combine STEM into a curricular whole, but rather allows each subject to maintain its own perspective, while infusing mathematics throughout.

Project successes prompted us to convene the Mathematics Infusion into STEM Symposium in March 2009. This two and a half day event brought together more than 45 individuals: STEM researchers; leaders from science, mathematics, engineering, and technology education; assessment specialists; school administrators; and STEM teachers. Working effectively together they addressed and attained the goals of the symposium: exploring the advantages of connecting STEM disciplines, generating recommendations for making connections, and developing a related research agenda for mathematics infusion into STE. It became clear during participant discussions, presentations, and deliberations that more research related to interconnected teaching and mathematics infusion is essential to further develop interconnected STEM teaching and to negate the STEM silo effect which is still pervasive. Exploration of the research framework which began to evolve from this symposium forms the basis this highly interactive session.

The challenges creating a STEM interconnection research framework are similar to those faced when developing other educational research frameworks. There are a wide range of research questions that could be explored, validated outcome measures are often not easily accessed, and research designs must be developed that easily attributes outcomes to mathematics infusion. A Among the conclusions from the symposium were that there are two vital research topics that need to be explored to further mathematics infusion in STE and interconnected teaching.
First, it is necessary to characterize what mathematics infusion looks like in STE curricula across grade levels. Determining the extent to which the STEM disciplines can logically and practically be interconnected, defining the roles and responsibilities of teachers from each discipline in the development and implementation of infusion materials, and deciding whether infusion is best as a separate curriculum or as a way to supplement the existing STEM curricular materials must all be established.

Second, it is necessary to rethinking how student learning should and can be assessed when working within an infusion paradigm. Existing standardized instruments do not capture the benefits of interconnected instruction and mathematics infusion. Thus relevant, reliable, and valid assessment tools that tap into the key elements of mathematics infusion must be developed. Both areas will be elaborated on in later recommendations.

During our interactive session we will engage participants in an exploration of these two issues. After providing participants with an overview of this topic we will create "interconnected STEM" working groups (i.e., creating opportunities for those who from different STEM foci to talk with individuals from other content areas.) Using a series of guided questions, similar to those used during the Symposium, participants will explore the two issues and challenges related to design/implementation of infusion curricula and to creating meaningful assessments of infusion The session will not only provide participants with new insight into math infusion and interconnectedness across STE, but will also model a framework for working across the disciplines that was highly effective and based on the evaluation data had an impact on participants practice and own research.

As part of this session we will also share the Symposium executive summary, including research questions and recommendations that were developed.

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2. **Context of the work within the STEM education literature and within your MSP project:**

As numerous state and national reports document, students, particularly those at the middle school level, are failing to achieve the mathematical competencies needed to compete in a rapidly changing technological society. The National Council of Teachers of Mathematics (NCTM) contends one way students can increase their competency in math is to connect math tosituations from science, social science, and commerce (NCTM, 2002). Of all of the reform recommendations being made by NCTM, making mathematical connections is among the more difficult, yet, most important to achieve. Mathematical connections can help students relate math topics to their daily lives, understand math better and help them see math as a useful and interesting subject (Reed, 1995). Moreover, Czerniak, Weber, Sandmann, and Ahem (1999) suggest that connecting math and science enables students to develop a common core of knowledge, but even possibly become more interested and motivated in their science and math classes. Research shows that connected learning also appeals to educators, because it mirrors the real world, links subject areas, and fosters collaboration and networking among teachers (Kaufman, 1995).

Although MSTP has data to demonstrate the value of this approach, this work also suggests addition research is needed to fully understand the value of this approach.

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3. Claim(s) or hypothesis(es) examined in the work (anticipating that veteran projects will have claims, newer projects will have hypotheses):

Infusing mathematics in STE at the middle school will improve student learning in mathematics and student disposition towards mathematics.

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4. Evaluation and/or research design, data collection and analysis:

The MSTP project has information, based upon experiences introducing mathematics infusion in middle school classrooms that attests to the importance of interconnected STEM learning. A range of data, including classroom based quasi-experimental studies, teacher and student feedback, classroom observations, teacher learning communities, and expert reviews of student work attest to potential and value of this approach.\

In addition to other research efforts during the MSTP project, two proof-of-concept studies were conducted: the first in fall 2007, the second in fall 2008. In both, a pre-post quasi-experimental design was used in which classes of 7th and 8th grade students were taught with up to 20 days of infusion lessons and compared with 7th and 8th grade classes of students not receiving math-infused instruction.

Student and teacher change was examined using teacher surveys, math content knowledge assessments adapted from NYS math and science tests, an attitudinal assessment, classroom observations, and focus groups. These data were collected from experimental (infusion) teachers and their students and from comparison teachers and students. The first proof-of-concept study (fall 2007) included six math infusion teachers with over 600 students, and five comparison teachers with 400 students. Infusion teachers, with MSTP Project team support, developed 20 days of math-infused science lessons. In the fall 2008 study, eight math infusion teachers (500 students) and four comparison teachers (350 students) participated. The 2008 study used infusion lessons that were more refined than those used in the 2007 study.

Statistically significant differences between the infusion and comparison students' post scores were found on four items dealing with enjoyment of math during science, interest in math, math not being a waste of time, and math not being boring. In all cases, the infusion students expressed more positive attitudes than the comparison students.

For Infusion students, a paired samples t-test was conducted to see if there were statistically significant differences from pre-test to post test on students total content assessment score. Results revealed a statistically significant average increase of 7.16 percentage points for the11-items. For comparison students, results were also significant; however students increased 3.02 percentage points on the 11-item. Therefore, students in the infusion group, on average, experienced more improvement than the comparison students. Results can be seen in Table 1.

When compared to comparison students in an independent samples t-test, infusion students felt that math was more important and they felt more confident in their mathematical skills at post-test after controlling for their pre-test scores. Results can be seen in Table 2.

Table 1. Comparison of Total Scores by Group

	Infusion Classes (N = 454)			Comparison Classes (N= 319)			**Infusion v. Comparison**		
	Mean Pre	Mean Post	Mean Difference	Mean Pre	Mean Post	Mean Difference	**Inf.**	**Comp.**	**Diff.**
Total	49.30 %	56.46 %	7.16%**	45.27 %	48.29 %	3.02%**	**56.46 %**	**48.30**	**8.16%** **

Note: *p < .05, **p < .01

Table 2. Means at Pre/Post Test by Group

	Infusion			**Comparison**			**Inf Vs. Comparison**
FACTOR	Pre	Post	Change	Pre	Post	Change	**Difference**
Math Importance	3.65	3.67	0.02	3.47	3.48	0.01	**0.19***
Confidence in Math Skills	3.84	3.98	0.15*	3.70	3.75	0.05	**0.23***

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5. Key insights (retrospective for veteran projects, prospective for newer projects) that have value for the Learning Network:

In terms of the value of math infusion:--The results from studies involving over 1000 students in science and technology education indicate a statistically significant improvement in student mathematics ability and attitude improvement towards mathematics. In general, there was greater improvement for the bottom one-third of the students in math infused classes. It is necessary to provide additional classroom support to science and technology teachers to help them embed mathematics more effectively. Peer collaboration allows for enhancing mathematics in science and technology. Science assessment items that require mathematics should be identified to assist science teachers in reinforcing salient math.

In terms of expanding the acceptance of math infusion and interconnections among STE: Rigorous research and valid assessments are needed to assure this work has real impact on student instruction and learning. --The STEM Symposium demonstrated an interest in interconnected STE at multiple levels, with a goal of increasing student learning. A framework for facilitating interconnected communication among STEM researchers and practitioners was

used during the STEM Symposium, which based upon participant feedback and post-symposium collaborations was highly successful.