Abstract:

The focus of the Baltimore Research and Innovations for New-STEM (BRAIN-STEM) Partnerships is to partner STEM and education faculty at Morgan State University (MSU) with key administrators and teachers of Baltimore City Public Schools (CITY SCHOOLS).

1. Questions(s) or issue(s) for dialogue at Learning Network Conference session:

One of the primary goals of BRAIN-STEM is to develop sustainable partnerships between universities, school systems, and other organizations in order to develop, implement and evaluate interdisciplinary learning materials that will enhance high school students’ learning and achievements in mathematics and science. As an MSP Start project, we have been engaged in various activities designed to build sustainable partnerships, pilot developed interdisciplinary modules, and to determine the feasibility, sustainability and promise of systemic implementation of interdisciplinary mathematics and biology materials. Through BRAIN-STEM activities, we have encountered interesting challenges and opportunities that can generate lively discussion at the LNC. Specifically, these issues center on how to sustain partnerships between lead and core partners and effective strategies for developing new partnerships with other schools, school districts, colleges, universities, and non-profit organizations. Issues concern with obtaining school system buy-in, data collection, analysis of pilot data, and recruitment of teachers to participate in project activities will be addressed. In addition, expanding the numbers and types of schools that would participate in a systemic implementation of integrated curricula materials will also be discussed. It is the intention of the BRAIN-STEM team to add new STEM and education faculty to the BRAIN-STEM project. Discussion of effective ways to implement strategies for recruiting faculty is another issue for dialogue at the LNC. Finally, we also would like to discuss plans for developing a Targeted Partnership and solicit feedback from other MSP teams that can offer insight into the development of a fundable MSP Targeted Partnership proposal.

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

The work undertaken for the BRAIN-STEM project has been multifaceted and has many implications for STEM education. In the last few decades, many reform initiatives have shaped the teaching and learning in the STEM disciplines. Several scholars argue that STEM education is by its very nature interdisciplinary and focuses on authentic problem solving. Hence,
organizations and educators interested in developing viable STEM education programs should design curriculum materials and engage in pedagogical practices that reflect the interdisciplinary and problem-based nature of the work of scientists (Anderson, 2007; Clark & Ernest, 2006; Marshall, 2007; Paige, Lloyd & Chartres, 2008; Park-Rogers, Volkmann & Abell, 2007). Although this type of approach is widely advocated, there is limited research on the design and effective implementation of interdisciplinary learning experiences for students. There is also a shortage of empirical evidence for the effectiveness of integrated mathematics and science in enhancing student learning and achievement. Creating and sustaining the interdisciplinary partnerships required for the systemic integration of mathematics and science curricula at the high school level are formidable and largely unaddressed challenges. It is the purpose of the BRAIN-STEM project to address these issues and contribute to the literature on integrated mathematics and science curriculum development and partnership building. Issues of effective implementation and student learning and achievement are also addressed by BRAIN-STEM. As a result of preliminary work on the BRAIN-STEM project, several preliminary hypotheses that may be of interest to other MSP partnerships are offered for discussion at the LNC. These hypotheses are primarily centered on the following themes: 1) Integrated Mathematics and Science as a curriculum innovation: A Needs Analysis 2) Building Partnerships in Mathematics and Science: Challenges and Promises, and 3) Teachers as Curriculum Developers: A Case Study of a University-School Partnership for the Development of Integrated Mathematics and Biology Modules. Each of these themes is being developed into research papers designed to further explore key issues that may be relevant for other MSP partnerships, particularly MSP-Start Partnerships. Specifically, our insights into the following topics and subsequent questions will be addressed at the LNC.

**Integrated Mathematics and Science as a curriculum innovation: A Needs Analysis:** The following questions are addressed: 1) What are mathematics and science teachers’ knowledge needs in all domains of teacher knowledge? 2) How are resources for math and science distributed in the school system? 3) What classroom experiences are students having in mathematics and science classrooms in this urban school system? 4) What are the current achievement levels in mathematics and science in this school system? and 5) What are key stakeholders perceptions about the feasibility and value of integrating mathematics and biology?

**Teachers as Curriculum Developers: A Case Study of a University-School Partnership for the Development of Integrated Mathematics and Biology Modules.** Using research that suggests the benefits of integrating mathematics and science and teachers as curriculum developers, we provide critical insight into the following research questions: 1) What are teachers’ perceptions about the value and the feasibility of integrating mathematics and biology? 2) Which domain(s) of teacher knowledge drive teachers’ curriculum development work? 3) What view of interdisciplinary integration will be evident in the modules produced by teachers? and 4) In what ways might school/university partnerships facilitate the goal of giving teachers a greater stake in the curriculum development process?

**Building Partnerships in Mathematics and Science: Challenges and Promises** Using data from our project activities and conceptions of partnership building and discourse theories, we will share our preliminary answers to the following research question: 1) What conditions
facilitate effective interdisciplinary university and school partnerships? and 2) Conversely, what conditions hinder effective interdisciplinary university and school partnerships?

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

One BRAIN-STEM hypothesis is that integrating of concepts from discrete mathematics and molecular biology in the high school curriculum will result in improved student learning and achievement in Biology and Algebra. Preliminary analysis of data suggests that teachers understood the utility of integrating mathematics and biology and believed that this integration was important, particularly since both of these subjects were tested in the High School Assessment given by the state. Several teachers saw that integrating mathematics and biology concepts in their classroom instruction could deepen students’ understanding of the content and contribute to increased performance on standardized tests. Teachers’ perceptions of the feasibility of the integration of mathematics and biology in the high school curriculum were mixed. Some teachers identified structural barriers related to scheduling and teacher competency. Several pointed out that since different students would be in different classes, it would be very difficult to implement integrated lessons systemically or even school-wide, unless administrators would be willing to address these student scheduling issues. In addition to these structural barriers, teacher content knowledge was also another key concern for teachers. Many teachers felt that they lack sufficient content knowledge, particularly in the subject that they are not certified to teach, that would be required to teach interdisciplinary modules. Hence, increased professional development opportunities, particularly those that allowed teachers to be a part of sustained learning communities, would be critical to the successful implementation of integrated curricula. Teacher data also suggests that they believed strongly that the challenge to integrated curricular implementation was worth the potential gains to student achievement, which contradicts earlier research that suggested that teachers are resistant to implementing integrated mathematics and science curricula.

Analysis of integrated mathematics and biology modules developed by teachers revealed that the teachers in this project adopted a view of integration in which one of the subject areas always appeared to be dominant. In most cases it was the science that was dominant and the mathematics was secondary. This is consonant with teachers expressed view that mathematics is a tool of science. The four modules developed in this workshop related to inheritance of family characteristics in humans, rate of spread of disease in flu epidemics, inheritance in horse populations, and incidence of asthma in an urban population

Some of the major challenges of creating and sustaining interdisciplinary partnerships reflect the differences in the communities of practice of each of the disciplines and between those of scientists and educators. We have found that in order to successfully build interdisciplinary partnerships, there must be a concerted effort to build a “mutual discourse” at every phase of partnership building activities. One of the major challenges we faced is sustaining partnerships with school systems when school structures and administrations change, which is particularly an issue in the current climate of school reform in both mathematics and science. We are currently creating strategies that can address these challenges in order to continue to build and sustain the BRAIN-STEM partnerships. We will share some of our initial strategies at the LNC.
4. Evaluation and/or research design, data collection and analysis:

One of the goals of the BRAIN-STEM partnership is to conduct a needs analysis by collecting and analyzing student achievement and teacher characteristic data in K-12 mathematics and science. In order to conduct this analysis, the team is interested in the following: 1) Understanding mathematics and science teachers’ current conceptions of integrated mathematics and biology curricula, 2) Key stakeholders’ perceptions about the value of integrating mathematics in biology, and 3) The feasibility of integrating these subjects at the high school level. As part of the BRAIN-STEM data collection procedures, surveys on teacher characteristics and perceptions of the integration of mathematics and science were administered to the CITY SCHOOLS teachers. In addition, focus groups were conducted in order to understand teachers’ conceptions about integrating mathematics and biology curricula and the perceived feasibility of implementing mathematics and biology at the high school level. The results of these focus group interviews have been transcribed and are currently being analyzed to reveal themes related to the evaluation of the BRAIN-STEM project.

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

The BRAIN-STEM team has learned many lessons that have implications for the MSP Learning Network. First, MSP Start projects should not expect major instructional changes during their project. The focus of an MSP Start project must be building trust, mutual respect and commitment from each of the partner organizations and specifically the teachers. We have learned that the relationship that the partnership builds with teachers is one of the key elements to the sustainability of the partnership. Since teachers have a key role in implementing the interdisciplinary curricula materials, we found that their perception of the need for integrated mathematics and science materials, their input in the designing and implementing of the materials, expertise and commitment shapes the extent to which the partnership will be sustained. This is particularly important given the transient nature of many of the school-based administrators and systemic instructional leaders. Second, effective interdisciplinary partnerships must address the need to transcend disciplinary boundaries that may impede understanding between partnership members from different disciplines. For example, the ways in which STEM and educational researchers view “research” can be very different. In some cases, different understandings of what constitutes research and the value of educational and scientific research can cause challenges. In order to address these challenges, in the early phases of partnership building, there must be frequent meetings between all stakeholders. One of the major intentions of these meetings must be to identify areas that may cause conflict or differences and develop shared understanding of content and processes that are critical to the partnerships’ goals and activities. Thirdly, we have found that sustaining university and school system partnerships is based on the extent to which the school system sees the partnership responding to their needs, particularly their needs regarding accountability and student achievement. Although we found administrators and teachers very receptive to the idea of integrating mathematics and science in the classroom, this interest was not sufficient to sustainability of the partnership. How they see
the partnership responding to their needs was critical to their willingness to continually engage in partnership building activities.

Some key insights gained from working with the CITY SCHOOLS teachers on an integrated approach as recommended by the teachers are as follows. The integrated approach is likely to enhance student achievement and applicability of learned knowledge in a real world situation. However, they perceived some potential problems with an integrated approach. For example they expressed concern with establishing collaboration between administrators and teachers around an integrated approach, development of an effective integrated curriculum, training and planning of classroom teaching with integrated curriculum, and the availability of additional resources if needed. The teachers provided some suggestions on how to overcome these problems. The following recommendations have been suggested: 1) Hold meetings and seminars with administrators and teachers to explain the benefits of integrated approach, 2) Develop effective integrated curriculum, 3) Provide training to teachers who will be teaching and using the integrated curriculum, and 4) Develop teaching materials based on an integrated approach.