Infusing Mathematics into Science and Technology at the Middle School Level:

A Professional Development Model

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Introduction

It can be argued that both math and science require similar reasoning skills in order to discover necessary patterns and relationships, as well as tap into similar scientific processes, such as inquiry based thinking and problem solving approaches (Pang & Good, 2000). However, both research and practice typically keep these content areas separate, rather than infuse or integrate them together to help students build their conceptual understanding of both math and science. Czerniak, Weber, Sandmann, and Ahem (1999) suggested that integrating math and science would enable students to develop a common core of knowledge, form deeper understandings, envision a larger picture, and find relevance in the curriculum. They believed that students would then be able to make connections among central concepts, and possibly even become more interested and motivated in their science and math classes.

Unfortunately, a problem arises when trying to define math integration or infusion, mainly due to a lack of consensus upon a definition for both terms. In a review of the math-science integration literature, Hurley (2001) found five forms of integration, and defined each type from the least to the greatest level of integration. The five forms of integration from least to most integrated are sequenced, parallel, partial, enhanced, and total integration. Sequenced integration takes place when science and mathematics are planned and taught sequentially, with one preceding the other. Parallel integration occurs when science and mathematics are planned and taught simultaneously through parallel concepts. Partial integration is found where science and mathematics are taught partially together and partially as separate disciplines in the same classes. Enhanced integration happens when either science or mathematics is the major discipline of instruction, with the other discipline apparent throughout the instruction. Lastly, total integration is where science and mathematics are taught together in intended equality.

For the purpose of this paper, the term 'math infusion' will be used here after. Math infusion is similar to what Hurley (2001) would call 'enhanced integration', and can be defined as mathematics content taught in science or technology classes, where the science or technology is the major discipline of instruction. This should be considered contextualized infusion, as math is delivered within connected science or technology lessons or activities. It is based upon the idea that as science and technology teachers infuse their lessons with math; their students will increase both their conceptual knowledge of and fluency in mathematics.

One of the existing Mathematics and Science Partnerships (MSP) that involves math infusion as well as other elements is *Mathematics Across the Middle School Math, Science, and Technology Curriculum* (The MSTP Project, 2003). MSTP is a five-year project targeted toward improving teaching and learning in middle schools. It is situated in 10 districts in New York where students have failed to meet state standards in mathematics and science. This project focuses on increasing student learning and performance through an extensive model of teacher professional development, aimed at increasing both teacher pedagogical and content area knowledge. This model has developed into the 'A/B model of professional development', which simply put, consists of two separate workshops, one where teachers create a lesson and another where the same lesson is reviewed and revised after implementation.

Currently in its fifth year, MSTP has done much to create and sustain a collaborative professional development program for school-based and higher education faculty, as well as establish many other distinctive components. In the following sections, a brief overview of the MSTP components will be discussed, as well as an in-depth description of the A/B professional development model, including evidence to support use of the model, and a math-infusion research project that was launched to determine the effectiveness of math infusion on student mathematical understanding.

Overview of MSTP

The five-year MSTP Project targeted at improving middle school mathematics teaching and learning, through both enhancing the mathematical content and pedagogical knowledge of mathematics teachers, and infusing math into science and technology classes, consists of five major components. These components include a curriculum revision and alignment process, a teacher recruitment initiative aimed at minority college students, a parent leadership institute, collaboration among school-based teachers and higher education faculty, and a professional development model for science, technology, engineering and mathematics (STEM) instructors.

The curriculum revision and alignment process has taken place throughout the five years of the project. Middle school faculty and administrators have worked on aligning mathematics curriculum with state standards and assessments, and determine which mathematical concepts connect to specific portions of the science and technology curricula. Curriculum revision and alignment supports district reform initiatives and involves participants as a component of the professional development.

A teacher recruitment initiative that works to inspire minority college students to enter careers in education and become role models for middle school students has been developed. More specifically, this initiative targets students who participate in the Collegiate Science and Technology Entry Programs (CSTEP), which supports the academic work of underrepresented and disadvantaged students engaged in science, technology and math studies. These students are provided with academic and personal support, such as faculty workshops on how to infuse math into science and technology. Moreover, these students are introduced to teaching through work as teaching assistants in middle school math, science, and technology classrooms, and as mentors in related after-school activities.

Additionally, a parent leadership institute to increase the level of parental involvement in the project schools has been established. Hundreds of parents of middle school students participate in math and science related activities and workshops before, during, and after school hours. The institute develops well informed parent leaders, who are aware of policies, practices, legislation, and school data that affect their children's education**.** The institute also works to enhance the ability of informed parent leaders to collaborate with school and district personnel to achieve mutually desirable goals.

Collaboration between higher education faculty and MST school-based teachers underpins the Project's approach. Higher Education faculty members work with middle school teachers to support math infusion in the classroom by discussing content and pedagogical concerns, as well as student needs and issues. In addition, Higher Education faculty members are involved with research related to how MSTP influences their own teaching and practice, as well as how MSTP impacts various educational elements at the middle school level.

Lastly, an intensive, sustained, collaborative professional development model for science, technology, engineering and mathematics (STEM) school-based teachers and STEM faculty, with a particularly strong focus on mathematics and science teachers, has been developed. Through this program, teachers have the opportunity to learn more about their own content area, as well as other disciplines, learn new pedagogy, and create inquiry based math or math infused science and technology lessons. The rationale behind this last component is that more instructional time devoted to mathematics (math taught within science and technology), and math taught using pedagogical practices that research has documented to be effective will lead to an increase in student mathematical learning.

Progression of Professional Development in MSTP

An important feature of MSTP is that each school district can shape how it provides professional development and how it builds an MSTP community. This characteristic was realized through the establishment of seven-person Collaborative School Support Teams (CSST) for each district. In actuality, the professional development began in the first year of the five year project through the development of the CSST teams in every district. Each CSST is responsive to the diverse needs of their specific district. CSST members included a teacher of mathematics, science, and technology, the middle school principal, and a guidance counselor or social worker. Two university disciplinary faculty members were also involved to support each team. Since the project worked with ten districts, ten unique CSST teams were developed during the first year.

In the second year, the CSST teams ran awareness workshops and, with district help, recruited school-based teachers for professional development. Two districts held professional development workshops during the academic year, while the rest chose to do so over the summer. Teacher feedback on the process indicated the professional development during the year, rather than the summer, was more successful because teachers learned mathematics contextualized in science and technology and then directly applied their new knowledge in their classes. In the third year, this success was noted, and the professional development was further refined to allow for teachers to develop lesson plans to implement in their classes.

In the third year, teachers developed lesson plans to implement in their own classrooms, in order to further break down disciplinary barriers between STEM teachers, and to allow for communication and mutual understanding. Teachers attended afternoon workshops, where they were introduced to current middle-school mathematics content and pedagogy. Mathematics teachers were introduced to new pedagogical approaches, and science and technology teachers were provided with ways to assist students in applying their mathematical knowledge to better understand a science concept or create a technological design.

After reviewing the lesson plans developed during the afternoon sessions and based on feedback from CSST members, a new format for professional development was implemented during the forth year of the project. This arose from need create more explicit opportunities for teachers to infuse mathematics into their classroom lessons, as well as reflect upon the process through lesson plan revision and critique. This approach became known as the 'A/B Professional Development Workshop Model'. The A/B model is essentially a two-step process for lesson development and revision. First, teachers develop a lesson during the 'A' component. During the next two weeks, the teachers implement the lesson in their own classroom, and then revise the lesson during the 'B' component. It should be noted that this lesson development process is guided and assisted by the CSST team, who received extensive training on the various workshop elements, and worked together as a team to plan both workshops. This training included an innovative mathematics infusion model that presented teachers with the unique opportunity to work with peers to optimize their efforts towards mathematics infusion into their science and technology lessons.

A/B Professional Development Workshop Model

Most often professional development involves teachers attending classes or workshops to learn about new content, pedagogy, and/or advancements in the field of education that they must then work to link to their own practice. The experience, however engaging, is often disconnected from what occurs in teachers' classrooms, with new practices being difficult to implement in their own classrooms (Martin-Kniep, 2004). The A/B workshop model sought to eliminate this disconnect, through its three unique elements. First, teachers created lessons on a template that was specially designed to guide their lesson plan design, as well as allow for math infusion and implementation strategies. Second, teachers designed a lesson collaboratively, and then immediately after designing the lessons, a teacher could then implement the planned lesson in their own classroom. Finally, after implementing their lesson, teachers met in learning communities to reflect and undergo peer review in order to revise and rework their lesson in a way that would optimize student learning. Refer to Appendix II, for a complete overview of the entire A/B process.

Lesson Template

The first element of this professional development model was the design of the template, for both math lessons and math infused science or technology lessons. All three templates (enhanced mathematics lesson template, math infused science template, math infused technology template) include the same components but are subject specific and can be found in Appendix I of this paper. Considerable development work went into the design of the template, including field testing, revisions, and re-testing. There are several important features of the template that support math infusion that are worth noting.

First, teachers must indicate what background knowledge is required for students to understand the lesson. This allows for teachers to reflect on the complexity of the lesson content, and what supports will be necessary for lower performing students. Second, the template requires teachers to identify one or two major math and science content topics, along with the related process and performance standards. Hence, teachers will then consider links in greater detail, and minimizes the need for investigative efforts into various standards and content areas at one time. Because the MSTP project focuses on mathematics, the teachers needed to explicitly find the math they would infuse that would enhance the lesson, rather than simply address a general but decontextualized need to teach math. This is challenging and a reason for learning community and peer support in lesson plan development.

A large focus of the lesson template is on the instructional planning of the lesson. In this section teachers are to indicate the lesson progression in detail. Teachers provide a complete sequence of all teaching processes and student activities fort implementing the lesson. All teacher explanations, including examples, questions and student activities should be described, as well as alterative instructional strategies for differentiating instruction for students with special needs. As math infusion into science is one of the features of the MSTP project, teachers must explicitly mention how they were able to infuse math in the teaching procedure section. This section provides documentation of the various inquiry based constructivist pedagogical techniques teachers used in order to infuse mathematics into their specific content areas.

Another necessary component of the lesson plan is embedded assessment. Each lesson should include some measure of student learning in mathematics and science or technology. A checklist of assessment methods is included in the template to help teachers consider which evaluative techniques would be most appropriate for their respective lesson designs.

Lastly, the template includes a reflection section where teachers contemplate the strengths and limitations of each lesson. This is particularly important in assisting teachers with the development and revision process, considering how to better address student learning with their respective populations, and supporting future teachers who might decide to implement the lesson design.

A Workshop

The first step of the A/B workshop model is the A workshop, or lesson development, which incorporates a two and a half hour meeting of the CSST team, and math, science and technology teachers from middle schools across the district (see Appendix III for examples of agendas for the A workshop). The focal point of the workshop is on lesson plan development, where teachers work in grade and/or discipline level teams to create and refine lessons using the MSTP templates. Collaboration with peers during the workshop is encouraged, both within content areas and across content areas, in order to ensure that math infusion is "optimized" throughout science and technology lessons.

Along with developing the lesson itself, teachers created student assessments to gauge student content knowledge before and after the lesson was taught. The core idea behind these assessments is to determine what students know about the lesson topic before (pre) it is taught and again after (post) it is taught. In other words, teachers were asked to create diagnostic or 'pre assessments' to use before teaching to plan instruction, connect new student knowledge with prior knowledge, and secure additional data about class functioning. Teachers also developed formative and summative, or 'post assessments', to be used directly after lesson implementation. These are to be employed to adjust instruction, monitor where individual students and the class are, and assess student learning. The pre and post assessments should cover the same content, and actually could be the same exact measure. These are much like assessments that are already used in teachers' classrooms (e.g. Do-Now's or exit questions). Lastly, teachers created a scoring rubric to assess student learning of lesson objectives. These rubrics were used in order to help teachers think about and create clear guidelines of what they expected from students, as well as to facilitate a more systematic and standardized means of assessing student work.

At the conclusion of the A workshop, each teacher should have produced a two-to-four day lesson plan in science, technology, or mathematics with a detailed teaching process section, scoring rubric, and pre and post assessments. Teacher were expected to spend the two weeks after the conclusion of workshop A implementing their lessons in their respective classrooms during the regular school day. Teachers recorded their reflections about their lessons and its degree of success immediately following the implementation. In addition, teachers scored all student work and selected three samples representing varied levels of student performance (good, passable, and poor) that would allow for a more in depth analysis of student understanding.

B Workshop

After lesson implementation, the second step of the professional development occurs, the B workshop, or lesson revision. Refer to Appendix IV for a sample agenda of a B workshop. The teachers meet with the same group as in the A workshop, for a two and a half hour B workshop. Each teacher is expected to come prepared to the workshop, with their lesson plans, reflections, and student work. During the B workshop, teachers review the success of their lesson implementation in small 'peer review' groups. Peer collaboration and review is the crux of the B workshop.

Peer review is a structured process, in which small groups of either same or mixed discipline teachers meet to discuss the strengths and pitfalls of implemented lessons. The process begins with teachers breaking into smaller groups of 3 or 4, and nominating a facilitator to keep track of the time and ensure the discussion runs smoothly. One teacher presents his/her lesson at a time. The first presenting teacher distributes copies of his/her lesson plan, student work, and student assessments to each member of the group. Each member individually reviews the lesson and its components for approximately a minute. After review, the presenting teacher gives a verbal overview of the lesson for 2 minutes, including a discussion of what the expectations of the lesson were, immediate reflection notes, assessments, collected student work, etc. After the explanation, each member of the group provides the teacher with 'warm' feedback, or what they liked about the lesson and/or what they felt was most beneficial to student conceptual understanding, in a round robin style until all warm comments are exhausted. For example, one teacher might say "this might allow your students to understand..." The presenting teacher is not supposed to respond to these comments at this point; rather he or she is to listen and/or write down what his or her peers are explaining. Next, each group member gives 'cool' feedback to the presenting teacher. These are suggestions for improving the lesson itself, how to enhance math or infuse more math and should focus on areas of question or confusion in the lesson. For example, a teacher could make the comment, "would you ever consider…" Lastly, the presenting teacher has a few minutes to discuss any of the feedback with the group, make comments, and/or have a mini-discussion on how to optimize the lesson. Each teacher goes through this process at every B workshop, so that every lesson that is written is also reviewed.

The entire peer review process should take no more than seven to ten minutes per lesson. Each teacher goes through this process at every B workshop, so that each lesson that is written is reviewed. Ideally, this peer review process should first be done in same discipline groups (i.e., all science teachers), and then mixed discipline groups (i.e., science, math, and technology teachers), to ensure expertise within and across disciplines is provided. However, many district teams felt the process was too time consuming to complete both same and mixed discipline review groups. Therefore, these districts adjusted the peer review process to fit their own individual needs. For example, one district broke into mixed discipline peer review groups that were slightly larger, with 5 or 6 members, to save time, but also ensure all elements of every lesson was thoroughly examined and extensive feedback provided.

The culminating activity during the B workshop is for each teacher to revise their lesson and/or student assessments and rubric. This revision is based on student accomplishments, the achievement of the lesson's goals, and peer input. At the end of the B workshop the lesson plan should be optimized to provide for the maximum amount of student understanding the next time the lesson is implemented.

CSST Planning Meeting

The final step of the A/B workshop cycle is a follow up B1 meeting for CSST members only. During this meeting the leadership members review the lessons that were developed in that month of workshops (including, initial and revised lessons, assessment measures, rubrics, and student work samples) and plan for the next A/B cycle. Every month, the process is repeated through much of the academic year, with a total of six A/B workshop cycles.

Teacher Feedback from the A/B Workshops

During the 2006 – 2007 school year, math, science and technology teachers in each district attended 36 hours of infusion related A/B professional development workshops. In order to gather further insight into the A/B process and how teachers, and facilitators responded to the process, all members were asked to fill out a feedback survey after each cycle of A/B workshops. Moreover, a survey was given to all teacher participants at the last B workshop of the academic year in order to further clarify the highlights and challenges of the process. For copies of these surveys, please refer to Appendix V.

In general, it was found that teachers experienced growth in both their understanding of the concept of math infusion into science at the middle school level and their valuing of math within the science classroom. Teachers were able to use the developed MSTP template to create enhanced math, or infused science/technology lessons. Additionally, the majority of teachers believed these lessons helped students develop a deeper understanding of math and/or science concepts.

When teachers were asked what they liked and disliked about the A/B workshop process, the majority stated they enjoyed and benefited from the collaboration with other teachers. Common responses mentioned the unique opportunities that the workshops provided for teachers to discuss lesson development with peers, as well as facilitate lesson development, implementation, and revision. Teachers appeared to appreciate and value the opportunity for collaboration and review. One teacher indicated, “As always the collaboration process helped to design a successful lesson that excited the students.” Teachers also mentioned that the template, peer collaboration across disciplines, and feedback allowed for easier math infusion, and perceived benefit from the students. A science teacher noted that, “I like the ideas I received from my colleagues about my lesson. I feel my students are benefiting from incorporating math in all subject areas.”

Across all months and districts, the preponderance of participants, over 95% of all teachers found the workshop to be very useful or useful and only 1.3% of teachers (for a total of 5 teachers, each from different districts) stated the workshops were not at all useful. These are highly impressive response rates, considering the number of teachers involved in the project over time (over 150) and the amount of engagement and work required from teachers who participated in the A/B professional development model.

What is equally striking, as Table 1 indicates, is that teachers were generally satisfied in the lesson development process of the A/B workshops. Over 82% of teachers indicated they were successful, or very successful in writing lessons that helped students develop a deeper understanding of the content. With over 93% noting that they were successful or very successful in collaborating with teachers in order to write lessons during the workshop. Teachers also strongly supported writing lessons based on the work during the A/B workshops, indicating the workshops were an important facilitator of the lesson writing process.

Table 1. Teacher ratings of lesson plan development based on last B survey results.

	Not at all Successful		**Moderately Successful**		**Very Successful**
	(1)	***(2)***	***(3)***	***(4)***	***(5)***
Writing lessons that help students develop a deeper understanding of math? (n=106)			17.9% (19)	50% (53)	32.1% (34)
Collaborating with teachers in order to write lessons? (n=105)	1% (1)	1% (1)	4.8% (5)	31.4% (33)	61.9% (65)
Writing lessons based upon work at A/B workshops? (n=106)		1.9% (2)	18.9% (20)	49.1% (52)	30.2% (32)

To add to this, teachers felt that the template was an integral part of the math infusion process. Across all workshops, 92.5% teachers stated ‘yes’, they were able to use the MSTP lesson template to create a successful lesson that included enhanced math and/or that infused math into science or technology. One teacher explained, “The form [template] allowed for the thought process in how to infuse the math concepts into science and technology.” Another teacher noted, “Yes, explaining the steps we took to create the lesson helped us to break down the topics and see connections in science and math.”

The impact of collaborative learning groups, as structured through the A/B workshop process, was reported by teachers to be an important component for their increased use and understanding of math content and pedagogy at the middle school level. As displayed in Table 2, survey results show that 90% of teachers agreed or strongly agreed that workshops met their needs for collaboration with other teachers. One teacher noted, "The more time I spent collaborating with my fellow teachers the better my lessons and the greater the impact on my students." Additionally, 86% of teachers agreed or strongly agreed that meeting collaboratively during the workshops helped them to develop new math, science, or technology teaching techniques. One science teacher noted, "By working with other teachers, I became more confident in teaching math to struggling students. I was actually able to make math fun".

Table 2. Teacher ratings of A/B workshops last B workshop.

	Strongly Disagree	**Disagree**	**Somewhat Agree**	**Agree**	**Strongly Agree**
	(1)	***(2)***	***(3)***	***(4)***	***(5)***
The A/B workshops helped me to develop new teaching techniques. (n=103**)**	1% (1)	2.9% (3)	10.7% (11)	57.3% (59)	28.2% (29)
The A/B workshops have met my needs in terms of collaboration with other teachers. (n=102)		1% (1)	8.8% (9)	42.2% (43)	48% (49)

Furthermore, through the year long A/B workshops teachers reported great confidence in both their ability to teach their developed math infused lessons, as well as their ability to use these lessons to increase student understanding. For example, approximately 73% of teachers reported they were confident to highly confident in infusing math into science and technology, as per developed lesson in A/B workshops. As one teacher explained, "MSTP workshops exposed me to our schools math curriculum and allowed me to teach concepts in creative ways. Creative is the big word, I was able to use my creativity." Teachers also reported that the A/B workshops allowed them to improve on their own ability to teach math. 80% of teachers indicated that they were confident to very confident that the A/B workshops allowed them to develop their mathematics pedagogy. One teacher noted, "I improved my teaching and improvised my approach to infusion of math/science into the curriculum." Teachers also indicated that they were confident to very confident that they were able to provide students with real world solutions for using math (93%), as well as emphasize connections between math and science/technology (90%). For example, one teacher explained, “Their [students] understanding of math has improved and they are more aware of the connections between math and the rest of the world.”

As previously discussed, teachers were allotted time during each B workshop to revise their lesson based upon collected student work, their own reflections, and the comments they received from their peers and faculty to aid math infusion. Approximately 83% of teachers indicated they used their collected assessment data to revise their lesson, student activities, or assessment tools. One teacher explained, “Results of student work drove my decision to rewrite pre/post assessments and lab packets.” The majority of teachers explained that looking at the student work was helpful in deciphering what the students did not understand, and on which areas they needed to spend additional time. Those that did not report that they used student work to make revisions typically indicated that they used other methods to do so. One teacher noted that, “I revised my lesson based on insights from the other teachers and on my own reflections (after I did it, I noticed what would work better next time).”

Obviously, one important outcome of the A/B model is for students to develop a deeper conceptual understanding of the math concepts, in both math lessons and science/technology lessons. Across the months, teachers generally reported that over 95% of students developed a deeper understanding of the topics covered in the lessons. Several teachers based their response upon students improved performance on the post test measure. One teacher stated, “Through my post observations, I was able to immediately see students understanding and how their understanding grew before to after the lesson.” Other teachers explained that students developed the deeper understanding from making real life connections or applications that were included in their lesson. For instance, a teacher explained, "The lesson was inquiry based, so students developed a deeper understanding of the topic."

Teachers were also asked to indicate what percentage of their students scored at 'good', 'passable' and 'poor' on the teacher administered post assessment (preferably using their rubric). The greatest percentage of teachers reported that their students' scored at the good or passable range, indicating that students were benefiting from the developed lessons. On average across all the months, teachers rated that 53% of their students scored in the "good" range on their post assessment. One teacher noted, "I was able to see the growth from pre to post." Moreover, around 34% of teachers indicated students scored in the "passable" range, while only 13% of the teachers reported their students fell into the "poor" range. Please see Table 3 below for more information. However, because teachers rated the level of their own student understanding, there is no way to identify what criterion was used in their creating these judgments. Regardless, these results are promising, as 87% of total students were passing or above according to teacher administered post assessments.

Table 3. Teacher rating of the percentage of students who scored at 'good', 'passable', and 'poor', averaged across districts and months.

	Teacher Rating		
	Good	**Passable**	**Poor**
Mean	53.09%	32.56%	14.36%
SD	24.28	19.08	10.71
n	321	320	317

Moreover, teachers also anticipated that students should be able to score higher on the state assessments, because of their own participation in the A/B workshops and their increased ability to enhance or infuse math throughout the curriculum. For example, almost 80% of teachers were confident to very confident that their lessons would create change so students would score higher on math assessments. Many teachers indicated qualitatively that their lessons and involvement in the A/B workshops would help their students on state and in classroom math tests. As one teacher explained, “Better test scores and positive moral, as it is said ‘More effective educators produce more effective students’", while others simply indicated “better scores” or “improved state test scores.”

Results gathered from the last B workshop also showed that teachers reported improved student attitudes toward math and greater awareness of the value and use of math within different contexts. Approximately 85% of teachers surveyed after the professional development activities indicated they were confident or very confident in promoting positive attitudes about mathematics. As one teacher explained, “My students have recognized the connection between MST. When one subject is emphasized in another class they feel it is more valued.” Teachers also indicated that they were confident in their own teaching abilities to make math meaningful, as almost 80% of teachers reported that they were confident to very confident in their ability to help make mathematics more meaningful to students. One science teacher noted that the A/B workshops, “Helped them [students] with seeing how math is important to real life applications.”

Although the majority of teacher comments were positive, a few had critiques about the workshops. These teachers indicated that the A/B process was hurried, they desired additional opportunities to work with teachers from other disciplines, and they disliked the paperwork involved. For instance, one teacher explained, “The time to fully develop, plan and implement a lesson is rushed.” However, the majority of negative comments were given during the earliest months, or workshops, when the process was still in its developmental phase. In addition, some teachers thought the peer review process was too rigid and structured. One teacher explained, “Warm and cool feedback is useless. It is much more beneficial to discuss the lesson among peers without a set format.”

CSST Feedback Survey

Data was also collect each month from CSST members (Appendix VI), in order for them to reflect upon whether teachers understood the process and purpose of the A/B workshops. As was expected, the level of understanding improved over time. During the first set of A workshops, the majority of district teams indicated they had somewhat or mostly understood the agenda of the A workshops, while only two indicated that they completely understood. However, as time progressed, almost all of the CSST teams noted that teachers completely understood the process and purpose. This was consistent across the B workshops.

Additionally, CSST members were asked to indicate if teachers had "bought in" to the A/B process and the MSTP project. Across all months and districts, responses consistently indicated that teachers were enthusiastic about MSTP and engaged in the A/B workshop process. Furthermore, CSST members explained that teachers had enjoyed their participation in the process, and the benefits were seen in their lessons and during the school day. For example, one districts CSST members noted, "Yes, we have full participation. Teachers are working together in a collegial way to design math infused lessons." Moreover, another team responded, "Yes, again it is evident in the conversations the teachers have throughout the school day regarding pedagogy, content, lessons and assessment. Collegial sharing is common place at the middle school between Math teachers/science teachers. This is directly related to the A/B workshops."

Lastly, CSST team members were asked to collectively rate the overall success of both the A workshop and the B workshop. The majority of CSST district teams indicated the success of A and B workshops was either 'Very Good' or 'Excellent', as indicated in Table 4. Overall these responses indicate that teachers not only enjoyed the A/B process, but also felt both they and their students benefited from the workshops.

Table 4. District CSST team overall success rating of the A and B workshop, across all months and districts.

	N	*Poor*	*Fair*	*Good*	*Very Good*	*Excellent*
A Workshop	*33*			3% (1)	64% (21)	33% (11)
B Workshop	*33*			9% (3)	66% (22)	24% (8)

Lesson Study

Over 150 teachers were able to develop and implement math enhanced and math infused science or technology lessons. After the completion of these workshops, there were over 373 math lessons, 266 science lessons, and 62 technology lessons, for a total of 701 lessons developed. In order to assess teacher growth, a rubric was used to quantify teacher development in understanding of the model through the lesson plans created during the yearlong initiative.

Although separate rubrics were developed for use with math and for science/technology lessons, the general content of both is similar. Each is used to examine if the lesson included all essential components of the template as well as the degree of math infusion, expected student understanding, and extent of real world applications. Each area is assessed on a 0 to 5 point scale, with 0 indicating the element was not present to 5 indicating the element was met.

Common areas for both the math and science/technology rubrics include; if the lesson conforms to the required format, if instructional planning procedures are explicit enough to allow for replication and if the math/science content accurate. There were also areas assessed that were directly related to math infusion, such as, if students are provided with opportunities to apply important mathematical concepts, if math and science concepts applied in an inquiry-based way, and if the lesson improves conceptual understanding of math and mathematical procedural fluency. A full version of these rubrics can be found in Appendix VII of this paper

Currently, these rubrics are being used to first run an analysis on all of the submitted unique lessons, in order to quantify both teacher growth throughout the year of A/B workshops, as well as estimate the overall quality of the lessons developed. Preliminary examination of the math infused teacher developed lessons showed that over time and with adequate professional development the lessons became more inquiry based, and indicated increased teacher understanding of the model.

Pilot study

Based on initial findings from the A/B workshop and examination of lessons in the lesson study, six science and three technology teachers were selected to undergo further training to study the benefits of math infusion through the A/B model. It was hypothesized that if teachers received highly specialized and specific professional development to create high quality math infused science or technology lessons, their students would show increased mathematical skills and increased positive attitudes toward math.

To describe the process briefly, selected teachers met for a week of professional development workshops, similar to the A/B workshops. Present at these workshops were science teachers, technology teachers, higher education faculty (specializing in math science and technology), and middle school administrators. The goals of this week long training were for each teacher to develop 20 days of math infused science or technology lessons, and for him/her to increase in conceptual and pedagogical understanding of math. In order to meet these goals, the principal investigators, with input from science and math teachers, chose three math topics (measurement, graphing, and ratio/proportions) to infuse in their lessons. Each teacher decided on the science unit that he or she believed would enable them to infuse mathematics in a way that would also facilitate the learning of the science material.

In order to infuse the math properly, teachers received math content knowledge and various teaching strategy instruction throughout the workshop. This instruction allowed the teachers to increase their own knowledge of the math topics, as well as inform them about various methods they could use to infuse these topics into their own disciplines. Furthermore, higher education faculty members were present throughout the workshops to support the teachers in developing math infused discipline specific lessons.

One essential element of this training session was peer collaboration and feedback, similar to the A/B workshop model of lesson development. Teachers were encouraged to work together on lessons to develop inquiry based lessons. Teachers left this workshop with the beginnings of lessons, pre-post assessments, and rubrics. Teachers spent the remainder of the summer finalizing their lessons, and met again in the fall at the beginning of the academic year for further development and clarification of the research processes.

In order to determine if students were actually able to learn math when taught with the created math infused lessons, a pre and post math concept knowledge assessment was developed. This assessment contained 19 questions (both multiple choice and open-ended) based upon questions taken from various years of the 6^{th}, 7^{th}, and 8^{th} grade New York State Education Department (NYSED) standardized Math tests. These questions covered the three math topics that were infused into the lessons, and were consistent with the content taught in the teacher developed science and technology lessons. Student attitudes and beliefs about math, science and technology were also a focus of the assessment. A student opinionnaire was administered both before and after the math infused lessons were implemented to collect these attitudinal data. Each of the science and technology teachers who infused math into their lessons also had a comparison teacher from the same school and grade level collect data from a class that was not exposed to math infusion.

Quantitative analysis of this data is still underway; however teacher feedback was generated during a follow up meeting with the science and technology infusion teachers involved in the study. Overall, this feedback suggests that teachers found the A/B Professional Development Model particularly helpful in creating well planned lessons that supported student learning, and the majority were pleased with the results of their math infusion lesson.

One science teacher spoke about how the A/B workshops influenced her and her colleagues. She said, "It's [A/B workshops] more of an awakening for teachers than students. It provided us with an opportunity to plan together as a group. It was nice because the teachers who participated wanted to do it. It was a great opportunity to see what was going on with my colleagues." Another had a similar viewpoint as she explained, "It [A/B workshops}broadened the scope of what students got out of the lesson by making you [the teacher] really analyze the students' work. Before, we might have looked at the math, but not necessarily given feedback. You go back where you wouldn't have before and it leads to personal reflection. It's the B part of the A/B workshop." Teachers indicated that this professional developed helped shape them, in order to properly plan lessons and infuse mathematics. One teacher even noted, "Yes. Professional development is the key."

Teachers also indicated that they enjoyed the summer planning sessions, and the collaboration and instruction that was provided during that time to develop high-quality inquiry based lessons. As one teacher explained, "Why haven't we done this together from day 1, plan? We have similar things, the planning together was wonderful. It gave us more time for skill building then we would have had. It was great." Another teacher agreed and added "Yes, but even the structure was detailed in the lesson plan, like what questions to ask. So, everything was done. Every unit should be planned like that."

Teachers also explained that the math infusion model was very practical, and added to student learning of both math and science. As one teacher reported, “The beginning unit skills [science unit skills] you do math because science skills blend with math skills, for example, measuring objects. Later, however, for example with proportion, if students do this skill wrong, they could use different math to get the answer.” Another teacher noted, “Before I was uncomfortable teaching the single lessons. But now, I feel more comfortable because the math was more consistently integrated.” Teachers indicated that through more time spent on teaching the math, students not only conceptually understood the math, but it also added to their science abilities. As one teacher eloquently put it, “They [students] understand more science because they have a deeper mathematical understanding.”

A few teachers mentioned that the model of math infusion into science was helpful for reasons that even surprised them, for example for students with special needs. One teacher explained, “I had low end kids. But at the culminating lesson “Bouncing Balls” they all worked together… I was so impressed how even the inclusion kids took a lead role. They had a thought process and were following it through with very little help from me… Before I spent more time on things like, “here’s a ruler.” But now they were more comfortable with their [math] skills and competence that I didn’t have to do that. Without the basic skills, it would have been a nightmare.”

Overall, teachers were enthusiastic about professional developments ability to assist them in developing high quality lessons for use in their classroom. They also consistently reported that they were able to infuse the math into their lessons, and through this infusion their students gained confidence in their abilities, and were able to understand both math and science at a deeper level.

Conclusion

A ‘math infusion’ approach, or mathematics content taught in science or technology classes, was the vision of the MSTP Project. Through a well developed model of professional development, this project was able to increase both teacher pedagogical and content area knowledge and enable teachers to create lessons that infused math. In turn, these lessons were able to increase student learning and performance. This is consistent with Czerniak et al. (1999), where it was suggested that meaningful student learning occurs when new knowledge and skills are embedded in context and students make connections among ideas. This model of professional development, as evidence by teacher feedback, the lesson study, and pilot study, was able to accomplish the goals of connecting math and science skills, in order to increase student conceptual understanding.

References

Czerniak, C.M., Weber Jr., W.B., Sandmann, A., & Ahem, J. (1999). A literature review of science and mathematics integration. *School Science & Mathematics, 99*(8), 421-430.

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Martin-Kniep, G. O. (2004) *Developing learning communities through teacher expertise*. Thousand Oaks, CA, Corwin Press

MSTP Project. (2003). Retrieved from http://hofstra.edu/MSTP August 13, 2005.

Pang, J.S. & Good, R. (2000). A review of the integration of science and mathematics: Implications for further research. *School Science & Mathematics, 100*(2), 73-83.

Appendix I

Teacher(s):		Date:
Subject: Math	Grade(s):	Time to complete (in periods):
Unit:	Lesson Topic/Title:	
Student population: ☐ Special Education ☐ LEP ☐ LD ☐ G&T ☐ Academically Average ☐ Low achieving		

OBJECTIVES of the lesson: [State the SPECIFIC goals of this lesson. What will students know or be able to do by the completion of the lesson? Start each statement with "Students will be able to…".]

BACKGROUND KNOWLEDGE necessary for students before engaging in this lesson:

PRECONCEPTIONS that may need to be addressed:

List 1 or 2 of the overarching NEW YORK STATE MATHEMATICS STANDARDS to be addressed in this lesson:	**Write out CODES and PERFORMANCE INDICATORS for RELATED MATHEMATICAL CONTENT & PROCESSES addressed in this lesson:**

MAJOR CONCEPTS addressed:	**MAJOR SKILLS addressed:**
APPLICATIONS to Science and/or Technology: [Include 1 or 2]	

MSTP MATH Lesson Plan Template

<table>
<tr><th colspan="2">How does this lesson represent <u>BEST PRACTICE</u>?</th></tr>
<tr><td>
☐ Focuses on important (standards-based) ideas & skills and promotes conceptual understanding
☐ Uses a variety of instructional approaches to maintain student engagement (e.g., ◻ lecture ◻ group work and team work ◻ demonstration ◻ field trips ◻ role play ◻ skits ◻ dramatization).
(others) ◻__________ ◻ __________ Please check.
☐ Encourages guided discovery, inquiry, and design
☐ Engages students in peer and self assessment
☐ Includes key questions to elicit responses that reflect understanding of important content
☐ Promotes procedural fluency
☐ Addresses naïve conceptions
☐ Prompts discourse among students and with teacher
</td><td>
☐ Builds on prior student knowledge
☐ Aligns curriculum, instruction, and assessment
☐ Establishes cross-disciplinary connections
☐ Establishes real-world connections for students so that they generalize lesson concepts to MST applications
☐ Prompts higher order thinking (students analyze, compare and contrast, classify…)
☐ Prompts students to generate alternative ideas and strategies
☐ Adjusts instructional methods according to student population and understanding
☐ Procedure includes summary focused on key ideas
☐ Motivates learning during and beyond the lesson
</td></tr>
<tr><th colspan="2"><u>MATERIALS AND RESOURCES</u> needed (including IT resources and other materials)</th></tr>
<tr><td colspan="2"></td></tr>
<tr><th colspan="2"><u>INSTRUCTIONAL PLANNING</u>: PROVIDE A <u>COMPLETE SEQUENCE</u> OF <u>ALL</u> TEACHING PROCESSESS AND STUDENT ACTIVITIES INVOLVED IN IMPLEMENTING THE LESSON.
This should include <u>ALL</u> teacher explanations, examples, questions, and student activities associated with the delivery of the lesson. Nothing should be left to the imagination. Other teachers should be able to reproduce this exact lesson using this lesson plan. Indicate (with an asterisk) where embedded formative assessments will occur during the implementation of the lesson. Indicate instructional alternatives that may be employed for differentiating instruction for students with special needs.</th></tr>
<tr><td colspan="2"></td></tr>
</table>

<u>ASSESSMENT Methodologies</u> [Embedded Diagnostic, Formative and Summative] planned to demonstrate the degree to which students have mastered the listed NYS Performance Indicators indicated on the prior page. *Attach COMPLETE EXAMPLES of all methods checked below*
☐ Selected Response: (Circle type(s): Paper/pencil tests; multiple choice; true/false; matching; short answer fill-ins) ☐ Essay: (Circle type(s): Extended written answers; Graphic organizers - KWL or TWK) (*indicate guiding questions, scoring criteria, and sample student responses*) ☐ Constructed Response: (Circle type(s): Multi-steps; Document-based questions) (*indicate guiding questions, scoring criteria, and sample student responses*) ☐ Performance Assessment: (Circle type(s): Individual; group; product-based; performance-based; artistic; authentic. (I*ndicate guiding questions, scoring criteria, and sample student responses.*) ☐ Classroom observation (Circle type: Formal; Informal) (*if formal, indicate guiding questions, scoring criteria, and sample student responses*) ☐ Whole class discussion (*indicate guiding questions, scoring criteria, and sample student responses*) ☐ Small group discussions (*indicate guiding question, scoring criteria, and sample student responses*) ☐ Individual student interviews (*indicate interview questions, scoring criteria and student responses*) ☐ Process or Reflective measures: (Circle type: Journals; Logs) (*indicate scoring method; explain development and use of rubrics; provide an example of a finished journal*) ☐ Portfolios (*indicate scoring method; explain development and use of rubrics; provide an example of a finished portfolio*) ☐ In-class worksheet/written assignment (*explain assignment and/or provide example of student work*) ☐ Quiz/Test/Exam (*indicate scoring method; provide an example*) ☐ Others (*describe*) ____

<u>DESCRIPTION OF SUMMATIVE ASSESSMENT</u>: Indicate how students' learning of lesson objectives (stated earlier) was comprehensively assessed. ("Post" assessment.) Include description of assignment and sample items. *Attach scoring criteria (checklist or rubrics) used to evaluate the work, and three samples of student work (high, medium, and low).*

***<u>AFTER LESSON IMPLEMENTATION,</u>* <u>PROVIDE YOUR REFLECTIONS</u>: Tell the story of what happened in the classroom. Indicate what worked, what you would change for the next implementation, and students' reactions to the lesson. Use additional pages if needed.**

***Attach to this lesson template: any and all WORKSHEETS and HANDOUTS, examples of ALL indicated ASSESSMENTS (embedded formative and summative), and SAMPLE STUDENT WORK.**

MSTP SCIENCE Lesson Plan Template

Teacher(s):		**Date:**
Subject: Science	**Grade(s):**	**Time to complete (in periods):**
Unit:	**Lesson Topic/Title:**	
Student population: ☐ Special Education ☐ LEP ☐ LD ☐ G&T ☐ Academically Average ☐ Low achieving		

OBJECTIVES of the lesson:
[State the SPECIFIC Science and Math goals of this lesson. What will students know or be able to do by the completion of the lesson? Start each statement with "Students will understand…" or "Students will be able to…".]

BACKGROUND KNOWLEDGE necessary for students before engaging in this lesson:

PRECONCEPTIONS that may need to be addressed:

List 1 or 2 of the overarching NEW YORK STATE SCIENCE STANDARDS to be addressed in this lesson:	**Write out CODES and PERFORMANCE INDICATORS for RELATED SCIENTIFIC CONTENT & PROCESSES addressed in this lesson:**

List 1 or 2 of the overarching NEW YORK STATE MATHEMATICS STANDARDS to be addressed in this lesson:	**Write out CODES and PERFORMANCE INDICATORS for RELATED MATHEMATICAL CONTENT & PROCESSES addressed in this lesson:**
MAJOR CONCEPTS addressed:	**MAJOR SKILLS addressed:**
Science: **Math:**	**Science:** **Math:**

MSTP SCIENCE Lesson Plan Template

How does understanding the listed math concepts INFORM Science knowledge? (Not just math that is simply *related* to the science, but math that helps students better *understand the science ideas*)

How does this lesson represent <u>BEST PRACTICE</u>?	
☐ Focuses on important (standards-based) ideas & skills and promotes conceptual understanding ☐ Uses a *variety* of instructional approaches to maintain student engagement (e.g., ◻ lecture ◻ group work and team work ◻ demonstration ◻ field trips ◻ role play ◻ skits ◻ dramatization). (others) ◻__________ ◻ __________ *Please check.* ☐ Encourages guided discovery, inquiry, and design ☐ Engages students in peer and self assessment ☐ Includes key questions to elicit responses that reflect understanding of important content ☐ Promotes procedural fluency ☐ Addresses naïve conceptions ☐ Prompts discourse among students and with teacher	☐ Builds on prior student knowledge ☐ Aligns curriculum, instruction, and assessment ☐ Establishes cross-disciplinary connections ☐ Establishes real-world connections for students so that they generalize lesson concepts to MST applications ☐ Prompts higher order thinking (students analyze, compare and contrast, classify…) ☐ Prompts students to generate alternative ideas and strategies ☐ Adjusts instructional methods according to student population and understanding ☐ Procedure includes summary focused on key ideas ☐ Motivates learning during and beyond the lesson

<u>MATERIALS AND RESOURCES</u> needed (including IT resources and other materials)

MSTP SCIENCE Lesson Plan Template

<u>INSTRUCTIONAL PLANNING</u>: PROVIDE A <u>COMPLETE SEQUENCE</u> OF *<u>ALL</u>* TEACHING PROCESSESS AND STUDENT ACTIVITIES INVOLVED IN IMPLEMENTING THE LESSON. **This should include *<u>ALL</u>* teacher explanations, examples, questions, and student activities associated with the delivery of the lesson. Nothing should be left to the imagination. *Other teachers should be able to reproduce this exact lesson using this lesson plan.* Indicate (with an asterisk) where embedded formative assessments will occur during the implementation of the lesson. Indicate instructional alternatives that may be employed for differentiating instruction for students with special needs. **BE SPECIFIC ABOUT HOW MATHEMATICAL CONCEPTS ARE INFUSED INTO THIS SCIENCE LESSON* Use additional pages if needed.***

<u>ASSESSMENT Methodologies</u> [Embedded Diagnostic, Formative and Summative] planned to demonstrate the degree to which students have mastered the listed NYS Performance Indicators indicated on the prior page. *Attach COMPLETE EXAMPLES of all methods checked below*
☐ Selected Response: (Circle type(s): Paper/pencil tests; multiple choice; true/false; matching; short answer fill-ins) ☐ Essay: (Circle type(s): Extended written answers; Graphic organizers - KWL or TWK) (*indicate guiding questions, scoring criteria, and sample student responses*) ☐ Constructed Response: (Circle type(s): Multi-steps; Document-based questions) (*indicate guiding questions, scoring criteria, and sample student responses*) ☐ Performance Assessment: (Circle type(s): Individual; group; product-based; performance-based; artistic; authentic. (I*ndicate guiding questions, scoring criteria, and sample student responses.*) ☐ Classroom observation (Circle type: Formal; Informal) (*if formal, indicate guiding questions, scoring criteria, and sample student responses*) ☐ Whole class discussion (*indicate guiding questions, scoring criteria, and sample student responses*) ☐ Small group discussions (*indicate guiding question, scoring criteria, and sample student responses*) ☐ Individual student interviews (*indicate interview questions, scoring criteria and student responses*) ☐ Process or Reflective measures: (Circle type: Journals; Logs) (*indicate scoring method; explain development and use of rubrics; provide an example of a finished journal*) ☐ Portfolios (*indicate scoring method; explain development and use of rubrics; provide an example of a finished portfolio*) ☐ In-class worksheet/written assignment (*explain assignment and/or provide example of student work*) ☐ Quiz/Test/Exam (*indicate scoring method; provide an example*) ☐ Others (*describe*)

MSTP SCIENCE Lesson Plan Template

<u>DESCRIPTION OF SUMMATIVE ASSESSMENT</u>: Indicate how students' learning of lesson objectives (stated earlier) was comprehensively assessed. ("Post" assessment.) Include description of assignment and sample items. *Attach scoring criteria (checklist or rubrics) used to evaluate the work, and three samples of student work (high, medium, and low).*

<u>AFTER LESSON IMPLEMENTATION,</u> **<u>PROVIDE YOUR REFLECTIONS</u>: Tell the story of what happened in the classroom. Indicate what worked, what you would change for the next implementation, and students' reactions to the lesson. Use additional pages if needed.**

Attach to this lesson template: any and all WORKSHEETS and HANDOUTS, examples of ALL indicated ASSESSMENTS (embedded formative and summative), and SAMPLE STUDENT WORK.

MSTP Technology Lesson Plan Template

Teacher(s):		Date:
Subject: Technology	Grade(s):	Time to complete (in periods):
Unit:	Lesson Topic/Title:	
Student population: ☐ Special Education ☐ LEP ☐ LD ☐ G&T ☐ Academically Average ☐ Low achieving		

OBJECTIVES of the lesson: [STATE YOUR SPECIFIC TECHNOLOGY AND MATH GOALS OF THIS LESSON. WHAT WILL STUDENTS KNOW OR BE ABLE TO DO BY THE COMPLETION OF THE LESSON? START EACH STATEMENT WITH "STUDENTS WILL UNDERSTAND…" OR "STUDENTS WILL BE ABLE TO…".

BACKGROUND KNOWLEDGE necessary for students before engaging in this lesson:

PRECONCEPTIONS that may need to be addressed:

List 1 or 2 of the overarching NEW YORK STATE STANDARDS in technology to be addressed in this lesson:	Write out CODES and PERFORMANCE INDICATORS for your RELATED SUBJECT CONTENT & PROCESSES addressed in this lesson:

List 1 or 2 of the overarching NEW YORK STATE MATHEMATICS STANDARDS to be addressed in this lesson:	Write out CODES and PERFORMANCE INDICATORS for RELATED MATHEMATICAL CONTENT & PROCESSES addressed in this lesson:
MAJOR CONCEPTS addressed:	**MAJOR SKILLS addressed:**
Technology **Math**	**Technology** **Math**

MSTP Technology Lesson Plan Template

How does understanding the listed math concepts INFORM knowledge in technology? (Not just math that is simply *related* to the your subject area, but math that helps students better *understand the your subject's ideas*)

How does this lesson represent <u>BEST PRACTICE</u>?	
☐ Focuses on important (standards-based) ideas & skills and promotes conceptual understanding ☐ Uses a *variety* of instructional approaches to maintain student engagement (e.g., □ lecture, □ group work and team work □ demonstration □ field trips □ role play □ skits □ dramatization). (others) □__________ □ __________ *Please check.* ☐ Encourages guided discovery, inquiry, and design ☐ Engages students in peer and self assessment ☐ Includes key questions to elicit responses that reflect understanding of important content ☐ Promotes procedural fluency ☐ Addresses naïve conceptions ☐ Prompts discourse among students and with teacher	☐ Builds on prior student knowledge ☐ Aligns curriculum, instruction, and assessment Establishes cross-disciplinary connections ☐ Establishes real-world connections for students so that they generalize lesson concepts to MST applications ☐ Prompts higher order thinking (students analyze, compare and contrast, classify…) ☐ Prompts students to generate alternative ideas and strategies ☐ Adjusts instructional methods according to student population and understanding ☐ Procedure includes summary focused on key ideas ☐ Motivates learning during and beyond the lesson

<u>MATERIALS AND RESOURCES</u> Needed (List IT resources and other materials)

MSTP Technology Lesson Plan Template

<u>ASSESSMENT Methodologies</u> [Embedded Diagnostic, Formative and Summative] planned to demonstrate the degree to which students have mastered the listed NYS Performance Indicators indicated on the prior page. *Attach COMPLETE EXAMPLES of all methods checked below*
☐ Selected Response: (Circle type(s): Paper/pencil tests; multiple choice; true/false; matching; short answer fill-ins) ☐ Essay: (Circle type(s): Extended written answers; Graphic organizers - KWL or TWK) (*indicate guiding questions, scoring criteria, and sample student responses*) ☐ Constructed Response: (Circle type(s): Multi-steps; Document-based questions) (*indicate guiding questions, scoring criteria, and sample student responses*) ☐ Performance Assessment: (Circle type(s): Individual; group; product-based; performance-based; artistic; authentic. (I*ndicate guiding questions, scoring criteria, and sample student responses.*) ☐ Classroom observation (Circle type: Formal; Informal) (*if formal, indicate guiding questions, scoring criteria, and sample student responses*) ☐ Whole class discussion (*indicate guiding questions, scoring criteria, and sample student responses*) ☐ Small group discussions (*indicate guiding question, scoring criteria, and sample student responses*) ☐ Individual student interviews (*indicate interview questions, scoring criteria and student responses*) ☐ Process or Reflective measures: (Circle type: Journals; Logs) (*indicate scoring method; explain development and use of rubrics; provide an example of a finished journal*) ☐ Portfolios (*indicate scoring method; explain development and use of rubrics; provide an example of a finished portfolio*) ☐ In-class worksheet/written assignment (*explain assignment and/or provide example of student work*) ☐ Quiz/Test/Exam (*indicate scoring method; provide an example*) ☐ Others (*describe*)

<u>INSTRUCTIONAL PLANNING</u>: PROVIDE A <u>COMPLETE SEQUENCE</u> OF ALL TEACHING PROCESSESS AND STUDENT ACTIVITIES FOR IMPLEMENTING THE LESSON. **This should include ALL teacher explanations, examples, questions, and student activities associated with the delivery of the lesson. Nothing should be left to the imagination. *Other teachers should be able to reproduce this exact lesson using this lesson plan.* Indicate (with an asterisk) where embedded formative assessments will occur during the implementation of the lesson. Indicate instructional alternatives that may be employed for differentiating instruction for students with special needs. **BE SPECIFIC ABOUT HOW MATHEMATICAL CONCEPTS ARE INFUSED INTO THIS LESSON IN TECHNOLOGY* Use additional pages if needed.***

<u>DESCRIPTION OF SUMMATIVE ASSESSMENT</u>: Indicate how students' learning of lesson objectives (stated earlier) was comprehensively assessed. ("Post" assessment.) Include description of assignment and sample items. Attach scoring criteria (checklist or rubrics) used to evaluate the work, and three samples of student work (high, medium, and low).

***<u>AFTER LESSON IMPLEMENTATION</u>*, <u>PROVIDE YOUR REFLECTIONS</u>: Tell the story of what happened in the classroom. Indicate what worked, what you would change for the next implementation, and students' reactions to the lesson. Use additional pages if needed.**

Attach to this lesson template: any and all WORKSHEETS and HANDOUTS, examples of ALL indicated ASSESSMENTS (embedded formative and summative), and SAMPLE STUDENT WORK.

Appendix II

SUMMARY OF PROCEDURES

Guidelines for MSTP (2006-07) A/B Workshops

- At Planning **Meeting (A1)**, CSST members will gather to plan Workshop (A). They will write an Agenda for Workshop (A) and coordinate any necessary photocopying of forms to run the workshop. (See sample Agenda for Workshop (A) in Appendix.)

- *Prior to Workshop (A),* all teachers will develop drafts of initial lesson plans to bring to the workshop and discuss with colleagues. These lesson plans should aim to enhance a lesson usually taught rather than to plan an entirely new lesson. *(For the October 2006 Workshop (A), these will be drafted on teachers' own forms. Subsequently, for all other months, these initial plans will be drafted on MSTP project-created lesson plan templates, provided in the Appendix of this guide.)*

- At **Workshop (A)**, teachers will further develop their draft lesson plans, fitting them to MSTP templates, while collaborating with peers. Collaboration will occur both within content areas and across content areas (so that Math infusion is "optimized"). Teachers will also develop drafts of pre- and post- assessment measures and a scoring rubric to assess student learning of lesson objectives.

- *Throughout the next 2 weeks*, teachers will implement the lessons and assessments they drafted and collect student work. Immediately following lesson implementation, teachers will take notes in the last section of the template to record reflections on lesson success. They will refer to the *Immediate Reflection Prompts* (included in the Appendix to this guide) to help direct reflection notes. Teachers will score all student work and select 3 samples (good, passable, and poor) to bring to Workshop (B).

- At **Workshop (B)**, teachers will review the success of their lesson implementation. In small groups, teachers will examine student work samples collected for evidence of student understanding. They will revise lessons, assessments, and rubrics as necessary, based on evidence collected and peer reviews. Teachers will complete the *Teacher A/B Feedback Form* to document reactions to the workshops, to the process, and insights regarding impact. This feedback form is provided in the Appendix.

At the end of Workshop (B), CSST members will collect *Packets* from each teacher consisting of:

- draft lesson plans, assessments (pre/post) and rubrics (A);
- 3 samples of student work (good, passable, poor); and,
- revised lesson plans, assessments (pre/post) and rubrics (B).

Feedback forms will be collected separately and anonymously.

- At Follow-up **Meeting (B1),** CSST members will review and discuss the month's work. They will review all *Teacher Packets* (including initial and revised lessons, assessment measures, and rubrics; and student work samples) and *Teacher A/B Feedback Forms* submitted by teachers. CSST members will complete the CSST *A/B Synthesis and Summary Form*, with a University Faculty member as the recorder, about the A/B Workshop proceedings and teacher progress.

A/B WORKSHOP PLANNING CHART

Workshop	**Participants** *(Who attends?)*	**Preparation** *(What do I do or bring?)*	**Actions** *(What happen?)*	**Deliverables** *(What are the expected material outcomes?)*
Meeting (A1)	CSST only	---	▪ Plan Workshops (A) and (B) (write agendas) ▪ Coordinate prep tasks (copying, etc)	▪ Agenda for Workshop (A) ▪ Agenda for Workshop (B)
Before Workshop (A)	All teachers	▪ Find existing lesson plan to enhance/ infuse	▪ Draft a lesson plan using MSTP template (enhancing pre-existing lesson)	▪ Rough draft of lesson plan on MSTP template
Workshop (A) ***Week 1***	CSST & All Teachers	*For October 2006 only, CSST brings to Workshop:* ▪ *model lesson plans, assessments, rubrics* ▪ *blank templates*	▪ *For October 2006 only, presentation of process, model materials, and forms* ▪ Peer collaboration and review ▪ Complete drafts of lesson plans on templates ▪ Draft assessments measures ▪ Draft scoring rubric	▪ Drafted lesson plans on MSTP templates ▪ Drafted assessments measures ▪ Drafted scoring rubrics
Before Workshop (B)	All Teachers	----	▪ Implement lessons ▪ Administer assessments to students ▪ Collect and score student work ▪ Select 3 samples of student work (good, passable, poor) ▪ Write reflections and notes on template using *Immediate Reflection Prompts*	▪ Reflections on lesson template ▪ 3 samples of student work (good, passable, poor)
Workshop (B) ***Week 4***	CSST & All Teachers	Teachers bring to workshop: ▪ Lesson plans (with reflections) ▪ Assessments ▪ Rubrics for scoring assessments ▪ Sample student work ▪ Blank template	▪ Examine sample student work ▪ Peer collaboration and review ▪ Revise lesson plans ▪ Revise assessment measures ▪ Revise rubrics ▪ Administer feedback forms to teachers	▪ *Teacher Packets* including: ○ draft lesson plans, assessments (pre/post) and rubrics (A); ○ 3 samples of student work; ○ revised lesson plans, assessments (pre/post) and rubrics (B). ▪ Completed *Teacher A/B Feedback* forms
Meeting (B1)	CSST only	CSST gathers: ▪ *Teacher Packets* ▪ Completed *Teacher A/B Feedback* forms ▪ *CSST A/B Synthesis & Summary Form (blank)*	▪ Review *Teacher Packets* ▪ Review *Teacher A/B Feedback* forms ▪ Complete *CSST A/B Synthesis and Summary* form	▪ Completed *CSST A/B Synthesis and Summary* form ▪ **Send package of all materials to MSTP Management**

Appendix III

WORKSHOP (A) – SAMPLE Agenda

District/School: XXX District - Main St Middle School

Date/Time: November 1, 2006 (3:30pm – 6:00pm)

Workshop Objectives:

Teachers will draft lesson plans on MSTP templates for an enhanced Math or math-infused Science lesson to be implemented in the next 2 weeks.

Teachers will draft a pre- and post- assessment measure for this lesson to assess student understanding of lesson objectives.

Teachers will draft a scoring rubric to score pre- and post- assessment measures.

Agenda: **(3:30pm – 4:15pm) - Peer Collaboration**

- Participants collaborate with peers, discussing lesson ideas with same- and cross-discipline teachers.

(3:30pm – 3:50pm): Within discipline

Math teachers work with Math teachers, Science teachers work with Science teachers

(3:50pm – 4:15pm): Cross discipline

Math teachers and Science teachers pair off and work together

(4:15pm – 5:15pm) – Drafting Lesson Plans

- Participants complete drafts of lessons on MSTP templates.

(5:15pm – 6:00pm) - Drafting Assessment Measures and Scoring Rubrics

- Participants develop draft pre- and post- assessment measures and a draft scoring rubric.

To All Participating Teachers:

During the next 2 weeks, you are to implement the lesson plan that you drafted here today. Assessment measures should be administered to students. Student work should be collected and scored and 3 samples should be brought to Workshop (B) (good, passable, poor). Immediately, following lesson implementation, please note immediate reflections in the space provided at the end of the MSTP lesson plan template, using the Immediate Reflection Prompts as a guide.

Please note that our next meeting (Workshop (B)) will be on Tuesday, November 28, 2006. Please make sure to bring a copy of each of the following, to facilitate the next phase of our work:

- *Your implemented lesson plan (on the MSTP template) with immediate reflections noted*
- *Each of your assessment measures (pre- and post-)*
- *Scoring rubrics*
- *Copies of sample student work*

Appendix IV

WORKSHOP (B) – *SAMPLE* Agenda

District/School: XXX District - Main St Middle School

Date/Time: month day, 2006 (3:30pm – 6:00pm)

Workshop Objectives:
Teachers will revise lesson plans, assessments and rubrics, based upon evidence available, from lesson implementation, reflections notes, student work collected and scored, and peer collaboration.
Teachers will complete a brief feedback form on the process and outcomes of the A/B workshops.

Agenda:

(3:30pm – 4:15pm) - Peer Collaboration

- Participants collaborate with peers, discussing lesson implementation and examining sample student work, with same- and cross-discipline teachers.

(3:30pm – 3:50pm): Within discipline
Math teachers work with Math teachers, Science teachers work with Science teachers

(3:50pm – 4:15pm):Cross discipline
Math teachers and Science teachers pair off and work together

(4:15pm – 5:00pm) – Revising Lesson Plans

- Participants complete revisions of lessons on MSTP templates, using all collected evidence as support for revisions (including, notes on implementation, student work, peer reviews, etc.).

(5:00pm – 5:45pm) - Revising Assessment Measures and Scoring Rubrics

- Participants revise pre- and post- assessment measures and scoring rubrics, again using all collected evidence as support for revisions (including, notes on implementation, student work, peer reviews, etc.).

(5:45pm – 6:00pm) – Feedback Forms

- Participants complete a brief *Teacher A/B Workshop Feedback* form to document insights about the A/B workshop process and its outcomes and impacts.

To All Participating Teachers:
Please note that our next meeting (Workshop (A) will be on (date), 2006.
Please make sure to bring with you an existing lesson plan that you would like to develop for the next month's A/B workshops. This should be either a Math lesson you would like to enhance, or a Science lesson that you would like to infuse with more Math.

Appendix V

MSTP Teacher A/B Feedback Form

Please consider your experience this month in both the (A) and (B) workshops, as well as in developing, implementing, and revising your lesson plans, assessments, and rubrics.
Please keep all responses anonymous.

District: ___________________

Which subject(s) do you teach? __________________________________

What did you like and dislike about the A/B Workshop process this month?

How helpful was the peer collaboration/review? Did it help you to choose a topic for your lesson? to plan appropriate pedagogy?

Did spend enough time working with teachers from your own discipline?

	☐ **Yes**	☐ **No**

…with teachers from other disciplines?

Please explain.	☐ **Yes**	☐ **No**

Did you create a new lesson or adapt one you've used in the past?

	☐ **Created a new lesson**	☐ **Adapted an existing lesson**

Were you able to use the lesson template to create a successful lesson that included enhanced Math and/or that infused Math into Science/Technology?

Please explain.	☐ **Yes**	☐ **No**

Did you implement this lesson in whole?

	☐ **Yes**	☐ **No**

Based on your experiences implementing the lesson, did students develop deeper understanding of the concepts covered?

Please explain.	☐ **Yes**	☐ **No**

Based on the rubric you developed, what proportion of your students scored at each of the following levels?

"Good" ______%   "Passable" ______%   "Poor" _______%

Did you use assessment data (i.e., collected student work) to revise your lesson plan?

☐ **Yes**	☐ **No**

What revisions did you make? based on what evidence (student work, insights/reflections, etc.)?

How likely are you to use this lesson (as adapted for MSTP) again?

☐ **Definitely Not**	☐ **Probably Not**	☐ **Maybe**	☐ **Probably**	☐ **Definitely**

Overall, how useful were the A/B workshops?

☐ **Not at all Useful**	☐ **Somewhat Useful**	☐ **Very Useful**

Please feel free to add any additional comments below.

MSTP A/B Workshop Survey

To Be Completed After Final B Workshop

Please check your current position:

☐ **Middle School MATH Teacher**	☐ **School Administrator**
☐ **Middle School SCIENCE Teacher**	☐ **University Faculty**
☐ **Middle School TECHNOLOGY Teacher**	☐ **Other**________________________________

Are you a member of the CSST Team?

☐ **Yes**	☐ **No**

Overall, how useful were the A/B workshops?

Not at all Useful ←				→ ***Very Useful***
(1)	***(2)***	***(3)***	***(4)***	***(5)***

Across all of the A/B workshops you have attended, please rate your overall success at each of the following on a scale from 1 (*Not at all Successful*), **to 3** *(Moderately Successful),* **to 5** (*Very Successful)*:

How Successful Have You Been At:	**Not at all Successful** →		**Moderately Successful** →		**Very Successful**
	(1)	***(2)***	***(3)***	***(4)***	***(5)***
Using the MSTP lesson template to design enhanced math lessons or math-infused science/tech lessons?					
Writing lessons based upon work at A/B workshops?					
Collaborating with teachers in order to write lessons?					
Writing lessons that help students develop a deeper understanding of math?					
Designing pre and post assessments of student learning?					
Embedding meaningful formative assessments into lessons?					
Creating assessments that measure students' deeper understanding of math?					
Developing or adapting a scoring rubric to support and evaluate student learning?					
Participating in a peer review of lessons?					
Using assessment data or student work to revise lesson plans?					

Please rate how confident you are in the following areas on a 10 point scale, from 10 *(very confident)***, to 1** *(not at all confident):*

	Not at all Confident	←——							——→	*Very Confident*
	(1)	***(2)***	***(3)***	***(4)***	***(5)***	***(6)***	***(7)***	***(8)***	***(9)***	***(10)***
Infuse math into science and technology										
Improve mathematics pedagogy										
Create change so students score higher on math assessments										
Help make mathematics more meaningful to students										
Involve parents in mathematics										
Provide students with opportunities to use math, science & tech further										
Use state test data to make improvements in math										
solve all problems in the NYS 8th grade Math assessment										
Emphasize connections between math and science/technology										
provide students with real world solutions for using										
Help students to develop their own understanding of math										
Use MSTP exemplary math materials										
Share what I have learned in the workshops with others										
Help new teachers implement MSTP										
Continue to recruit new teachers to participate in MSTP										
Create lesson plans using the project template										
Implement lesson plans created using the project template										
Promote positive attitudes about mathematics										

→

Please rate the following statements about A/B workshops on a scale from 5 *(Strongly Agree)* **to 1** *(Strongly disagree)*, **and then explain your response:**

	Strongly Disagree	**Disagree**	**Somewhat Agree**	**Agree**	**Strongly Agree**
	(1)	***(2)***	***(3)***	***(4)***	***(5)***
The A/B workshops were worth the time they took.					

Please explain your response:

	Strongly Disagree	**Disagree**	**Somewhat Agree**	**Agree**	**Strongly Agree**
	(1)	***(2)***	***(3)***	***(4)***	***(5)***
The A/B workshops helped me to develop new teaching techniques.					

Please explain your response:

	Strongly Disagree	**Disagree**	**Somewhat Agree**	**Agree**	**Strongly Agree**
	(1)	***(2)***	***(3)***	***(4)***	***(5)***
I have been enriched by the A/B workshops I have attended.					

Please explain your response:

	Strongly Disagree	**Disagree**	**Somewhat Agree**	**Agree**	**Strongly Agree**
	(1)	***(2)***	***(3)***	***(4)***	***(5)***
The A/B workshops have met my needs in terms of collaboration with other teachers.					

Please explain your response:

→

Please report what additional impacts participating in the A/B workshop has had on:

	Impact
You	
Your Teaching	
Your Students	
Your School	

Appendix VI

MSTP CSST A/B Synthesis & Summary

Please complete this summary form as a team (CSST) at your (B1) end-of-month meeting, using observations, teacher packets, and Teacher A/B feedback forms as evidence.

Today's Date: _____/_____/_____ **District: ______________**

Workshop Feedback

Re: WORKSHOP (A)

When was Workshop (A) held? Date: ______/______/______

How many teachers attended Workshop (A)? Math __ Science __ Technology __ Other ___

In your collective estimation (as a leadership team), did it seem that teachers understood the "process and purpose" of the (A) Workshop?

☐ Not at all	☐ A little	☐ Somewhat	☐ Mostly	☐ Completely

Questions to consider:
- Did teachers come in to (A) with draft lesson plans, etc. prepared? ☐ Yes ☐ No
- Did Science/Technology and Math teachers work together to develop their lessons? ☐ Yes ☐ No
- Did Math teachers assist Science/Tech teachers with planning appropriate content and pedagogy? ☐ Yes ☐ No
- Did teachers revise their lessons based on peer reviews and collaboration? ☐ Yes ☐ No
- Did teachers leave (A) with a lesson they could teach? ☐ Yes ☐ No

Please Explain.

Was there enough time in Workshop (A) to get everything done? What was left out?

Is there anything *NOT* working? What? Why? How can it be fixed?

Overall, how successful was Workshop (A)? *(from a CSST consensus)*

☐ Poor	☐ Fair	☐ Good	☐ Very good	☐ Excellent

Please attach your agenda for Workshop (A)*
Be sure that time spent on each activity is clearly indicated

Re: WORKSHOP (B)

When was Workshop (B) held? **Date: ______/______/______**

How many teachers attended Workshop (B)? Math __ Science __ Technology __ Other __

In your collective estimation (as a leadership team), did it seem that teachers understood the "process and purpose" of the (B) Workshop?

☐ **Not at all**	☐ **A little**	☐ **Somewhat**	☐ **Mostly**	☐ **Completely**

Questions to consider:

Did teachers come in to (B) with meaningful samples of student work? ☐ Yes ☐ No

Did teachers revise their lessons based on implementation successes/challenges and via peer review?

☐ Yes ☐ No

Did teachers offer each other rich feedback? ☐ Yes ☐ No

Please Explain.

Was there enough time in Workshop (B) to get everything done? What was left out?

Is there anything *NOT* working? What? Why? How can it be fixed?

Overall, how successful was Workshop (B)? *(from a CSST consensus)*

☐ **Poor**	☐ **Fair**	☐ **Good**	☐ **Very good**	☐ **Excellent**

In general, does it seem teachers have "bought in" to the A/B process and the MSTP project? Explain.

****Please attach your agenda for Workshop (B).****
Be sure that time spent on each activity is clearly indicated.

Appendix VII

MSTP SCIENCE LESSON RATING RUBRIC

District: ___________________________________ **Month/Year: ____ / 200_______**

Name of Teacher: ___________________________ **Title of Lesson: ____**

	(0)	(1)	(2)	(3)	(4)	(5)	*Score*
1. To what extent does the lesson plan conform to the required format?	*Not completed*	*Lesson plan does not conform to the required format*	→	*Lesson plan somewhat conforms to the required format*	→	*Lesson plan conforms to the required format*	
2. To what extent does the *Math* content indicated in the lesson plan have potential to lead to *greater understanding of the Science/Technology* content?	*Not completed*	*Math concepts are not essential for understanding Science/Tech topic.*	→	*Math concepts are helpful but not essential for understanding Science/Tech topic.*	→	*Math concepts are essential for understanding Science/Tech topic.*	
3. To what extent does the lesson plan provide students with opportunities to apply *important mathematical concepts* that are typically difficult for students at this level?	*Not completed*	*Math concepts are not typically difficult for students.*	→	*Math concepts are important but not difficult for all students.*	→	*Math concepts are important and difficult for students.*	
4. To what extent is the Math concept applied in an *inquiry-based* way?	*Not completed*	*Planned pedagogy doesn't suggest students will be engaged in any inquiry-based activities.*	→	*While planned Math pedagogy is somewhat inquiry-based, it needs improvement.*	→	*Planned pedagogy is inquiry-based.*	
5. To what extent is the Science/Technology concept taught in an *inquiry-based* way?	*Not completed*	*Planned pedagogy doesn't suggest students will be engaged in any inquiry-based activities.*	→	*While planned pedagogy is somewhat inquiry-based, it needs improvement.*	→	*Planned pedagogy is inquiry-based.*	

	(0)	(1)	(2)	(3)	(4)	(5)	*Score*
6. To what extent does the lesson plan provide students with opportunities to improve *conceptual understanding of math*?	*Not completed*	*Lesson plan doesn't suggest that students will have opportunities to improve conceptual understanding.*	→	*Lesson plan suggests that students will only limited opportunities to improve conceptual understanding.*	→	*Lesson plan suggests that students will have opportunities to improve conceptual understanding.*	
7. To what extent does the lesson plan provide students with opportunities to improve *mathematical procedural fluency?*	*Not completed*	*Lesson plan doesn't suggest that students will have opportunities to improve procedural fluency.*	→	*Lesson plan suggests that students will only limited opportunities to improve procedural fluency.*	→	*Lesson plan suggests that students will have opportunities to improve procedural fluency.*	
8. To what extent are the Instructional Planning *procedures explicit* enough to allow for replication?	*Not completed*	*Procedures are unclear and/or incomplete. Cannot be replicated without more detail.*	→	*Procedures are fairly specified but further detail would enhance replication.*	→	*Any teacher could pick up this lesson and implement it exactly as intended.*	
9. To what extent are the Instructional Planning *procedures appropriate* for the math objectives of the lesson?	*Not completed*	*Procedures are not appropriate given the objectives of the lesson.*	→	*Procedures are somewhat appropriate given the objectives of the lesson.*	→	*Procedures are appropriate given the objectives of the lesson.*	
10. Is the Math content accurate?	*Not completed*	*Math content is not accurate*	→	*Math content is somewhat accurate*	→	*Math content is accurate*	
11. To what extent does the lesson plan seem realistic for the *time* allotted?	*Not completed*	*Poor estimation of time needed to accomplish stated objectives.*	→	*Approximately half of the stated objectives could be feasibly met in this period.*	→	*Class time allotted is realistic. Stated objectives can be feasibly met in this period.*	
12. To what extent are *math assessments* appropriate to the content taught?	*Not completed*	*Assessments are not at all relevant to content taught.*	→	*Assessments are only partially relevant to content taught.*	→	*Assessments are relevant to content taught.*	

	(0)	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	***Score***
13. Did the teacher make *relevant revisions* to the lesson plan based upon *student work* and documented immediate *reflections*?	*Not completed*	*Teacher did not appear to make any revisions.*	→	*Teacher made some revisions, but not all are relevant or more are indicated.*	→	*Teacher made sufficient revisions based upon the evidence.*	
14. To what extent is the amount of time spent on math adequate for the students to master the concept?	*Not completed*	*Not enough time spent on math for student to master concept,*	→	*Some time spent on math, but not likely to master concept.*	→	*Adequate time spent on math for students to master concept.*	
TOTAL SCORE →							

MSTP Math LESSON RATING RUBRIC

District: ___________________________________ **Month/Year: ____ / 200_______**

Name of Teacher: ___________________________ **Title of Lesson: ____**

	(0)	(1)	(2)	(3)	(4)	(5)	*Score*
1. To what extent does the lesson plan conform to the required format?	*Not completed*	*Lesson plan does not conform to the required format*	→	*Lesson plan somewhat conforms to the required format*	→	*Lesson plan conforms to the required format*	
2. To what extent does the lesson plan provide students with opportunities to learn *important mathematical concepts* that are typically difficult for students at that level?	*Not completed*	*Math concepts are not typically difficult for students.*	→	*Math concepts are important but not difficult for all students.*	→	*Math concepts are important and difficult for students.*	
3. To what extent is the Math concept taught in an *inquiry-based* way?	*Not completed*	*Planned pedagogy doesn't suggest students will be engaged in any inquiry-based activities.*	→	*While planned Math pedagogy is somewhat inquiry-based, it needs improvement.*	→	*Planned pedagogy is inquiry-based.*	
4. To what extent does the lesson plan provide students with opportunities to improve *conceptual understanding in math*?	*Not completed*	*Lesson plan doesn't suggest that students will have opportunities to improve conceptual understanding.*	→	*Lesson plan suggests that students will only limited opportunities to improve conceptual understanding.*	→	*Lesson plan suggests that students will have opportunities to improve conceptual understanding.*	
5. To what extent does the lesson plan provide students with opportunities to improve *mathematical procedural fluency?*	*Not completed*	*Lesson plan doesn't suggest that students will have opportunities to improve procedural fluency.*	→	*Lesson plan suggests that students will only limited opportunities to improve procedural fluency.*	→	*Lesson plan suggests that students will have opportunities to improve procedural fluency.*	

6. To what extent are the Instructional Planning *procedures explicit* enough to allow for replication?	*Not completed*	*Procedures are unclear and/or incomplete. Cannot be replicated without more detail.*	→	*Procedures are fairly specified but further detail would enhance replication.*	→	*Any teacher could pick up this lesson and implement it exactly as intended.*	
7. To what extent are the Instructional Planning *procedures appropriate* for the math objectives of the lesson?	*Not completed*	*Procedures are not appropriate given the objectives of the lesson*	→	*Procedures are somewhat appropriate given the objectives of the lesson.*	→	*Procedures are appropriate given the objectives of the lesson.*	
8. Is the Science content accurate?	*Not completed*	*Science content is not accurate*	→	*Science content is somewhat accurate*	→	*Science content is accurate*	
9. To what extent does the lesson plan seem realistic for the *time* allotted?	*Not completed*	*Poor estimation of time needed to accomplish stated objectives.*	→	*Approximately half of the stated objectives could be feasibly met in this period.*	→	*Class time allotted is realistic. Stated objectives can be feasibly met in this period.*	
10. To what extent are *math assessments* appropriate to the content taught?	*Not completed*	*Assessments are not at all relevant to content taught.*	→	*Assessments are only partially relevant to content taught.*	→	*Assessments are relevant to content taught.*	
11. Did the teacher make *relevant revisions* to the lesson plan based upon *student work* and documented immediate *reflections*?	*Not completed*	*Teacher did not appear to make any revisions.*	→	*Teacher made some revisions, but not all are relevant or more are indicated.*	→	*Teacher made sufficient revisions based upon the evidence.*	
TOTAL SCORE →							