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Making It Work: Three Case Study Narratives from a  
Secondary Science Professional Development Program

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## Introduction

This paper presents three cases from the evaluation of the National Science Foundation funded professional development program for high school teachers of the physical sciences, the Mississippi Academy for Science Teaching (Project MAST). Project MAST is currently recruiting its third cohort. Data for this study were collected from members of the first cohort in 2009-2010.

Project MAST's professional development program is intensive and content-driven. Teachers attend a three week summer institute consisting of day long workshops at the university where Project MAST is based. They return during the academic year for five Saturday workshops. Workshop sessions are guided by the state curriculum framework for the five physical sciences: physics, chemistry, physical science, earth science and astronomy. Numerous content and pedagogy experts from a variety of academic and scientific institutions conduct the workshops. In addition to workshop instruction, participants receive lab equipment worth approximately \$1000 and three classroom support visits during the academic year. One visit brings an inflatable planetarium to each participating school. Another provides students with a workshop on using iPods to access science related podcasts. The third visit provides each teacher with feedback on her/his implementation of a lesson plan introduced in the Project MAST workshops. The mixture of content, various instructors and workshop topics makes teacher implementation of program activities complex.

This study is a part of a larger evaluation of Project MAST. Desimone (2009) argues that core features of professional development such as content focus and collective participation lead to increases in teacher knowledge, changes in attitudes and finally to changes in teacher practice and student learning. The path from professional development to outcomes is mediated by various contextual factors including teacher and school characteristics and district policies. Other portions of the Project MAST evaluation capture quantitative changes in attitude, teacher efficacy and teacher and student content knowledge. However, the case studies are intended to provide description, analysis and interpretation of how the intense activities of the summer and fall workshops are translated into actual teaching practice and how the local context facilitates or impedes this translation (Wolcott, 1994). Given that there is some quantitative evidence indicating positive trends in teacher content knowledge, efficacy and attitudes towards science teaching, the case studies allow us to explore the complexities of implementing program activities. Through them we are attempting to learn how the particularities of a teacher's background and school environment shape her/his experience of the program and success in putting its content to use in her/his classroom.

## Design

### *Methodology*

These case studies examine individual teachers' experiences across multiple sites and institutions. They attempt to describe, explain and interpret how contextual conditions shape that experience. Yin (2003) argues that the case study method is appropriate when researchers hope to investigate "a contemporary phenomenon within its real-life context, especially when the boundaries between phenomenon and context are not clearly evident," (p. 13). In each of our cases, the phenomenon to be investigated is the teachers implementation of the Project MAST professional development program. The context in which the implementation occurs is dynamic. It is shaped by national, state and district level accountability concerns, administrator relationships with faculty, the composition of school science departments and the students

enrolled in the relevant courses. Furthermore, the teacher brings with her/him a particular background that includes her/his teacher preparation program, prior professional development experiences, relationships in the school and community and beliefs about science teaching. These lists are not exhaustive, but should begin to make clear the fact that the implementation of a professional development program in a school is a complex endeavor where the border between implementation and context is fluid. Thus, a case study of each teachers' implementation efforts will provide a compelling glimpse of the phenomena in question. We are aware that what the cases describe is not generalizable beyond its setting. However we agree with Noblit and Hare (1988) that:

Interpretive explanations are narratives through which the meanings of social phenomena are revealed. They enable us not to predict but to anticipate what might be involved in analogous situations; they help us to understand how things might connect and interact (p. 13).

### *Research Methods*

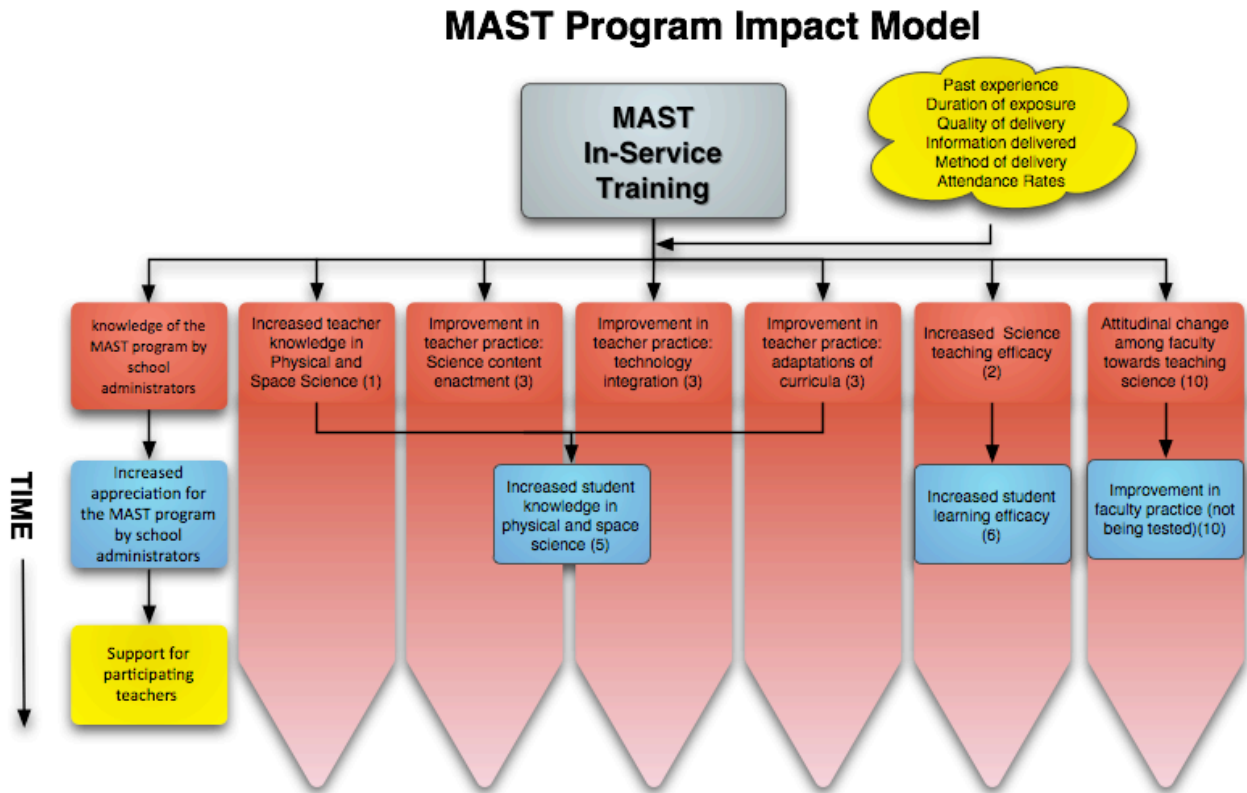
The three cases in this paper are part of a larger, ongoing evaluation of the National Science Foundation funded teacher professional development program described above. Each of the three individuals profiled in the cases were participants in 2009-2010. They were chosen to participate in case studies in the basis of their academic performance in the program and, in part, their unique school district contexts. Staff from the program's external evaluator, Rockman et al, attempted to choose teachers from a range of high and low achieving school districts in economically and socially diverse geographic regions of Mississippi.

The first author visited each participant's school twice during the spring semester of 2010. Visits consisted of interviews with each participant, school administrators or science department chairs and student focus groups, and classroom observations of the relevant physics, chemistry, earth or physical science courses taught by each participant. The first author used participant group specific interview guides that were modified for each interviewee based on information that was either taken from participant survey responses or publicly available district and school data. Observations were conducted using an evidence log and observation protocol created by Rockman et al. (Bass & Mushlin, 2010). Observation notes captured in the evidence log were entered into a summary report form. Interviews were transcribed and coded using HyperResearch coding software. Summary reports were translated into narrative descriptions of the observed lessons, with the reports' categories guiding the composition of the narrative. Each case was composed using a collaboratively created outline created by the authors. Cases describe the local school context, each observed lesson and data related to program implementation taken from the interviews.

### *Theoretical Framework*

Project MAST's evaluation is driven by a program impact model (Bass and Mushlin, 2010) (Figure 1). That model describes the expected outcomes resulting from participation in Project MAST's professional development program. Most of these outcomes focus on changes in the practice or dispositions of participating teachers. Secondary outcomes are related to changes in student skills and dispositions or improvement in administrative support for Project MAST and participating teachers. The model also represents our recognition that a number of factors moderate the expected teacher outcomes. In part, this study is designed to describe some of those moderating factors, particularly teachers' past experiences and the context in which they work.

Figure 1. MAST Theory of Change



### Participants

Rockman et al and Project MAST's Program Director, Dr. Mehri Fadavi, chose the four participants for this study. Three teach in rural districts. One teaches in a suburban district. Of the three rural teachers, two attended Project MAST workshops as a team. Each of the participants is profiled below. All case study participants teach some combination of Physics, Chemistry, Physical Science or Earth Science, courses which coincide with Project MAST's professional development areas. Several also taught life science courses such as Introduction to Biology, Biology or Human Anatomy and Physiology. Three are female. One is male. All are European American. None have taught more than ten years. Most have taught between five and ten. Participants were invited to join the study during the 2010 spring semester. In exchange for their participation, each teacher received a small stipend.

Each case begins with a description of the participant's background and her/his school context. This is followed by a summary of the lessons observed for the case. Each case study concludes with an analysis of the case and benefits the participant perceived from her/his involvement with MAST.

## Case Study Narratives

### *Case 1: Bruno Jones:*<sup>1</sup>

Bruno Jones' participation in the Project MAST professional development program equipped him to take chances with his teaching. Jones used the material resources and pedagogical strategies he received in MAST to teach familiar topics in new ways. He believes that his work as a teacher involves a constant reinvention of himself. He never wants his students to come to his classes knowing that they will be doing the same labs as last year's students. Bruno also believes that his background as a former elementary school teacher influences his teaching practice with high school students, making him more willing to use a variety of teaching methods to address the same content and more aware of the need to use strategies that will appeal to a variety of students. He was confident in his ability to teach his assigned courses. Project MAST provided him with additional resources and strategies which he used to make an already strong teaching repertoire even stronger.

Jones teaches Physical Science, Earth Science and Introduction to Biology at Marney Attendance Center (MAC) in Sanders, MS. After completing an undergraduate elementary education degree, Jones taught in the South Point School District, a school system in a town adjacent to his undergraduate *alma mater*. He was then hired at Marney Elementary as a Science teacher, but was reassigned to teach English just prior to the beginning of his first year. After three years "across the street," Jones moved to the high school where he has worked for the last three years. His high school colleagues are a close knit group.

"If I need something, I can go ask a person down the hall do you want to help me with this, they'd be quick to show me. If I have any questions about chemistry I ask the chemistry teacher who says yes this is the way you should teach it because when they get to me this is how I'm going to teach it. And if they need, like with my Department Chair, we're constantly bouncing test questions off of each other, 'So how do you think this would work on the test, do you think this would be a good test question, or you could write it this way,' So there's a lot of collaboration, a lot," Jones said.

Jones has completed three professional development workshops since he began teaching at the high school: one in Physics, one in general pedagogy, and one in the use of technology in the classroom. Each lasted between two and four days. Outside of school, he runs his own private business, a disc jockey service. He travels around the metropolitan area, playing music at wedding receptions, high school dances and other events.

Project MAST did not revolutionize Bruno's teaching. He exudes confidence both in his ability to know what to teach and in how to teach it. Instead of bolstering his confidence, Jones believes that MAST made it easier for him to do what he already does well. "I am one of these I teach 3 different ways when I am teaching. MAST showed me more efficient ways of doing what I have already been doing," he said. He feels that his elementary education background has prepared him to address the different needs and skills his students possess. "I was an Elementary Ed major so you have got all these different types of learning. You have tactile learning, visual learning and audio learning. You have got to cover the entire class. You can't just focus on one group of kids or you leave 2 other groups alone," Jones said. He implied that his elementary education background provided him with strong preparation for doing hands-on activities with his students as well.

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<sup>1</sup> All people and places named in this paper other than Project MAST and Jackson State University are pseudonyms.

### *School Context*

Marney Attendance Center serves approximately 600 students in grades 7-12. It is (racial breakdown of demographics from current snapshot sums to over 100%, needs to be found/verified online) with approximately 31% of students eligible for the Federal School Lunch Program in 2007-2008. 2009-2010 was the first year that Marney qualified for federal Title I funds. It is rated as a “Successful” school according to the state’s accountability model.

MAC is one of seven high schools in Flint County, a suburban county just outside the state’s largest city. The county is among the fastest growing in the state, currently possessing one of the state’s lowest unemployment rates and highest per capita family incomes. That wealth is most visible in the county’s north half where two of the largest high schools and the county’s most affluent residents live. The two schools in that part of the county have grown rapidly over the last two decades. Four of the other seven high schools are Title I schools as well. The Northern school system was created in the 1970s after the state developed a large reservoir on the Parnell River and subdivisions began to crop up around it. This area remains largely unincorporated, though some of its commercial areas have been annexed in the last decade. Northern High School was constructed in the early 1980s, but has been growing rapidly and is now the largest school in the county. There is a pervasive, but often subtly stated belief among many staff and students at MAC, that a disproportionate amount of the county school board’s attention and the county’s fiscal resources go to the two northern schools.

Wanda Ammons, the MAC Science Department Chair, describes it in terms of “the label students put on themselves.” She believes this is one of the biggest challenges facing the school. “We are MAC and they live in the shadow of Northern and Braden. Sometimes kids feel like they are a stepchild. You look around our facility and it is old. It was an old black school. The district has worked hard to improve things. They have lowered the ceilings. They have painted. They have done some electrical work but it is still an old building. So they feel slighted and sometimes that carries over into putting a label on things,” Ammons said.

Both Ammons and Jones spoke of additional challenges students face outside of school, but that the school deals with daily. “A lot of single parents. A bunch of apathy, like I was telling you earlier, I don’t know, I don’t really want to label my students but there’s a large population that are in really bad environments. Parents maybe do drugs, they may do drugs themselves, but you get that anywhere, you’ll get pockets of that in any school you’re in. I think pretty much blue collar. We don’t have a lot of professional parents out here, I think it’s just because what area it is.”

Principal Eric Dorman believes that the school is beginning to turn the corner in terms of parental involvement. “It’s my eighth year here and this is the first year that we really had a functioning PTO, which is a good thing for us. That’s basically because we just have been able to recruit a good group of parents who are interested in spending that kind of time to support the school. That’s good,” Dorman said.

MAC’s faculty and administration are trying to make the best of their situation. There are no plans for a new school building. However, the school’s new Title I funding will allow the improvement of the school’s technology infrastructure, adding wireless access and additional computers for teachers without desktops.

Dorman is emphatic that the biggest problem in the science department is not equipment, but lack of space. In order to be competitive with the other county schools, MAC has added multiple programs. Still, the school remains stuck with only two science labs. One of them is used full-time by a teacher. The other is available part-time. Eleven teachers are required to

“float,” meaning they have no classroom of their own but must move their materials and equipment from room-to-room to teach their courses. Title I will not alleviate the space issue.

Ammons chairs a department of six teachers, herself included, who are responsible for all science instruction in grades 7-12. The combination of a small faculty and small students means that science offerings vary year to year in the high school.

“Physics one year, the next AP Chem or Biology which will take some planning on the kid's part but because of our counselors they can plot it out with the kids for 4 years. This is what we are going to be teaching. There is a huge variety for a school to be so small of the different like...I teach Botany and Zoo and Human Anatomy, Biology II. I mean there is a lot of them and a lot of physical sciences too, Earth Science, Physical Science, Chem I, Chem II, the College Biology,” she said.

The consensus between Ammons and Jones is that regardless of the difficulties they face because of the school's small size and aging buildings, school administrators support the science department. This support is most apparent, they say, in terms of their willingness to purchase lab equipment and other technology as teachers indicate it is needed.

“They couldn't be more supportive. They've got your back pretty much. If you need something, they're there. And they don't beat around the bush to tell you there's something wrong. They come out and say, look, this is what needs to be fixed. They're real quick to tell you when you're doing a good job. And if you're not doing a good job, they tell you that you need to improve, but I've never been on that side. They're always like you guys are doing a great job, continue doing what you're doing, so we are,” Jones said.

Professional development at MAC is mostly school and district based. Subject specific professional development workshops are largely conducted by the district curriculum staff. School and departmental professional development focuses on the Understanding By Design planning framework and preparation for the state Subject Area Testing Program (SAT-P). Teachers feel constrained in their pursuit of professional development opportunities that support their own career growth.

“The problem with professional development here is time is so limited. They don't pay for subs anymore. You have to kind of catch it on your own time, so they expect you to go on holidays, summers and whatever,” Ammons said. “Well, the things we do have to be low cost or free because there is no money. So MAST is the only thing that has a lot of meat to it. Now you are getting a great product at an amazing value,” she added. Jones is one of three departmental faculty who have participated in the MAST program, and the first to participate in the NSF funded program.

### *Classroom Visits*

In the spring of 2010, the first author of this paper visited Mr. Jones's classes twice, observing a total of four lessons, two in earth science and two in physical science. On the first visit, both the Earth science and the physical science classes conducted labs. On the second visit, only the Earth science class did a lab. The physical science class was reviewing for its final exam.<sup>2</sup>

### *Earth Science Class I*

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<sup>2</sup> All lesson observation summaries were written from the perspective of the paper's first author who made all of the site visits for this study.

The first earth science class I observed consisted of 14 students: three female students, four African-American students and the rest white males. On the day I visited, the class was beginning a new chapter on erosion. Mr. Jones had written on the board that the class would be focused on Mississippi Earth science framework competency 4–d, erosion due to wind and deposition. The first 40 min. of the 90 min. class period took place in Mr. Jones’s classroom. He had set up a PowerPoint slideshow using his computer and the Promethean board. After spending the first 5 min. of class allowing late students to arrive and taking attendance, Mr. Jones began. “We’re going to be talking about wind erosion,” he said. As if on cue, a voice came over the school intercom and began to make some announcements. Mr. Jones wrote the words “wind erosion” on the board and the question “what is wind erosion?” Below it. Mr. Jones would then pose a question and respond to student answers. He was working from a handout that he had created for himself. Gently, he guided the class through incorrect responses to his questions and towards the information he wanted to impart to them.

Gradually, that information appeared on the whiteboard. Mr. Jones progressively created a list of the various sizes of soil particles: sand and dust. He divided dust into two subcategories: clay and silt. Jones then asked the class to describe how sand moves. Several students responded saying, “the wind pushes it.” However, Mr. Jones was looking for more. He put more scientific terms into play, adding to his list of terms: suspension, saltation and rolling (creep), and pointing out that each type of motion corresponded to a specific particle size. Frequently, Mr. Jones would introduce terms, then provide students with an anecdotal connection. For example, after introducing suspension, Jones said, “The suspension of dust particles from a volcano in South America, several years back caused a temperature drop in the United States.” “That’s awesome,” a student responded.

“It’s crazy,” Jones said.

The somewhat informal quality of this interchange is indicative of how Jones interacted with his students. He moved back and forth between the formal language of science as he introduced terms and concepts, and the informal language of his students, bridging the two with his anecdotes and other connections to students’ lives. The topic of erosion and deposition lent itself to talk of the dustbowl of the 1930s/Great Depression and the wind patterns within Jones’s own subdivision.

As Jones lectured and talked back and forth with individuals, I noticed that he engaged several students repeatedly. Not everyone in the class was taking notes, but students who were off task were not being openly disruptive. One put his head on his desk. A couple of others were listening, but not writing down terms or the examples that accompanied them.

Jones transitioned the lecture from a focus on the types of wind erosion to its effects. Again, he focused mainly on introducing a vocabulary term and providing a definition and examples. Rather than creating a table, each definition was accompanied by a photograph or two. A typical sequence with a single term sounded like this:

“Deflation. What does that mean?”

“It goes somewhere else?”

“Deflation occurs when the wind removes thin layers of soil, picking up small parts and leaving heavier ones behind. This results in deflation hollows. Can you guess what that means?”

“It has to do with erosion. It leaves some sort of hollow.”

“Deflation leaves a hole.”

This Earth science lesson was driven primarily by Jones’s introduction of terms related to two topics: the types and effects of wind erosion. Jones’s introduction and definition of terms

was interspersed with occasional anecdotes or asides, which were the main opportunities for students to participate. The effects of wind erosion included photographs of dramatic examples from around the world.

The final topic before moving to the lab was deposition. Again, Jones listed four types of deposition and projected photos of each using his Promethean board. Before moving to the lab, Gershon distributed a handout consisting of instructions on how to conduct the lab and questions to answer while completing it. The lab required the students construct a beach using sand and a box. Jones explained that each student would be responsible for completing and submitting responses to the questions but that they would work in lab groups. We walked down the hall to the lab.

It appeared that the school has one lab reserved for physical sciences and Earth science and another lab for biology. Jones shares the physical sciences lab with at least one other teacher who works from a desk at the back of the lab. The physical science lab is a long room with windows that are partially covered by blinds and paper. It was cluttered. A teacher workspace at the front of the room was covered with papers and the detritus of previous labs. student workstations consisted of hexagonal lab benches with a sink in the middle surrounded by smaller wooden tables that were connected to the lab benches like spokes on a wheel. Each table had at least four chairs facing one another, two per side. On each table was a drinking straw, a cup of sand and shoebox. Students were instructed to pour their sand into the shoebox to simulate a beach, use the straw to direct wind onto the beach and to record their observations.

As the students worked, Jones engaged me in conversation about his school, his class, and his own background. There was an implied quid pro quo which I would not make myself party to. Jones wanted feedback about his teaching from me in exchange for information about school and his background. This persisted across visits and interviews. He would occasionally drop the question, “what did you think?” or “did you think that was good?” I read this as a teacher seeking validation not because of a lack of confidence in his practice but because he was accustomed to evaluative observations of his teaching. A visit to observe and learn from him rather than have him learn from my feedback was not what he was used to.

Once the students had modeled simple wind erosion, they were then asked to design a wind barrier similar to those that are created on beaches to prevent wind erosion. They were given a set of materials and asked to configure them in any way they chose, then to simulate the wind and describe and draw the barrier’s effects on the pattern of wind erosion. This part of the activity moved the lab away from a confirmation type lab and into a more sophisticated form of inquiry. The students had little trouble coming up with creative and interesting designs. Jones flitted back and forth between groups, doling out praise and posing questions in the same breath. His enthusiasm was matched by his students’ level of engagement once all of the lab groups had transitioned into this part of the lab. It was a high point of the lesson, and continued until the bell rang.

### *Physical Science Class 1*

The second class that I observed on my first visit was Mr. Jones’s physical science class. This group of 15 students were also completing a lab activity on my first visit. However, Jones did not lecture the class prior to the lab. Instead he announced at the beginning of class that there would be no notes today that the entire class would focus on two labs. The physical science class is broken into two parts with a lunch break in the middle. Jones used the first 20 min. of class to explain the two labs.

“This is not going to be a boring lab, if you remember the pulley lab,” he said. I assumed that he meant that the pulley lab was a boring lab that all the students could remember. Jones went on to indicate that there would be no handout for these labs. Students would be responsible for recording any observations in their notes.

The first lab was a demonstration of the change in volume of the balloon when the air inside of it is heated and cooled. Students attached a balloon to the neck of an Erlenmeyer flask partially filled with water. They placed the balloon and flask onto a hot plate, and recorded their observations. As Jones described this lab he drew a diagram of the apparatus on the board. After they had heated the balloon, students were to carefully remove it, allow to cool slightly and then place it into a water bath. Before the lab, Jones told the students, “you’ll see the changing density of the air inside the balloon.”

The second lab combined a comparison of the viscosity of several fluids with the measurement of the speed with which they flowed down a known distance. Again, as Jones explained the lab he drew a diagram on the board of how the students would construct the apparatus for the activity. Given a piece of card stock, students were asked to measure off a 15 cm distance and to mark that 15 cm with two lines, a beginning and an end. At the back of the room, they would find a materials station at which there were bottles of vinegar, shampoo, vegetable oil, molasses, and corn syrup. Half of the corn syrup would be heated in a hot water bath. Students were to place a single drop of each fluid at the beginning of the 15 m distance, then hold their card stock at an angle so that gravity would pull the drops down the distance. They were also told to use a stopwatch to time how long it took each drop to travel the distance. Jones wrote the formula for speed on the board and worked a sample problem to demonstrate how to calculate the speed of each drop. After each drop had traveled the distance and the students had calculated the speed, they were to write the speed beneath the end of the drops’ tracks. The class was somewhat anxious to get to lunch. Students were sighing and some were squirming in their seats. Jones very briefly asked the class if they knew the term “weight” in reference to motor oil. Some did. Jones explained that the weight of the motor oil was related to its viscosity. Before leaving for lunch, the class gathered its materials and moved to the lab. Jones explained that the viscosity lab was the first part of a two-part lab and that the second part would be completed in a few days as the class reviewed for a test.

After lunch, the class returned to the lab and separated into lab groups. Half of the groups worked on the balloon lab while the other half worked on the viscosity lab. Jones circulated to each group, checking on their progress and assisting as needed. Most of his interactions with the students consisted of praise or instructions on how to get a balloon around the neck of the flask. Jones also focused on heating some of the liquids for the viscosity lab. Students were told to place a small quantity of the liquids into separate test tubes and to put those into a hot water bath for no more than 10 seconds.

“We’re not going to do room temperature on these liquids. There’s a reason for that.”

He never gave the reason.

It quickly became apparent that the viscosity lab was not functioning properly. Instead of flowing down the card stock, several of the liquids simply soaked into it. Jones was unfazed.

“How viscous is it?” Gresham said.

“Viscous? I don’t even know what viscous is,” a student responded.

When Jones realized that some of the liquids were soaking into the card stock, he told the class need to time the drops going down the page. A student called Mr. Jones over and raised the question of possibly changing from card stock to another material. He responded that they could

not. The student then asked if Mr. Jones thought that the angle at which they held the card stock had anything to do with the speed of the drops. Jones asked the student what he thought. The student said he thought so.

Once the students had completed the required portion of the lab, there was still sufficient time to allow them to engage creatively with the materials. A group of students during the balloon experiment decided to see if they could lower the temperature of the cold water bath sufficiently to suck the balloon into the Erlenmeyer flask. They added more ice and noticed that the balloon continued to shrink. Then, Jones suggested that they add salt to the ice bath. One of the students immediately knew why and told the rest of the group that by adding salt to the ice bath they would be able to lower the temperature below freezing. Across the room another group of students heated a balloon until it exploded. Jones was calm and told the group, “it’s all good.” Midway through the lab, some students had placed a metal screen on a hot plate to separate their beaker from the heating element. The metal screen began to smoke and before Jones noticed this, the smoke alarm on the hallway went off. Everyone in the class thought this was funny particularly when Jones had to go out into the hallway to reassure other teachers on the hall that the class was not trying to burn the building down. Towards the end of the period, Jones approached a group that had completed the balloon lab, and the following interchange took place:

“You guys get an A on this. It’s great. Since you’re not adding air, what’s causing the balloons to inflate?” Jones asked.

“A change in the temperature of the air inside the balloon?” a student responded.

“When you increase the temperature of something, you increase its kinetic energy. What caused the balloon to pop? Heat or molecules?”

“Molecules.”

Jones moved on to another group, and began to encourage the class to begin to clean up the lab. The class concluded without any discussion of the lab other than that that occurred in the individual small groups. It was unclear to me what data had actually been collected in the drop experiment and how students were going to compare their results.

### *Earth Science Class II*

On my second visit, I again saw in earth science class perform a lab activity. The class began in the classroom, but as soon as Jones had taken roll, the class moved to the lab. After the students had again gotten into groups of three or four, Jones worked from the front of the room, writing on the whiteboard as he dictated instructions. Students were to gather from a materials station at the back of the room: a pan with sand, a beaker with sand, a marble and a golf ball. Jones quickly amended this saying that students could choose a golf ball or a ping-pong ball.

“Today you’re going to see how a meteorite impacts different surfaces in different environments. We’ve talked about how meteorites and meteors smack planets with and without atmospheres. You’re going to simulate both.”

Jones explained that students would fill their beaker with water and allow the sand to settle. The water was a “fake atmosphere,” and would demonstrate how a meteor changes medium as it enters an atmosphere from outer space.

The tray with sand would represent a surface like that of our moon, Jones indicated. Students would drop the marble and ping pong ball into the sand from different heights and measure how far the sand flies out of a the crater created by the falling object, how far they had dropped the object and how deep of a crater it created in the sand.

Very quickly a group of students noticed that it was impossible to drop a ping pong ball into the simulated water atmosphere. The ball floated on the surface.

“Like I said, you’ll make adjustments,” Jones responded.

Jones created a data table for the students to copy off of the board. That table is recreated below.

<i>Drop</i>	<i>Height</i>	<i>Crater Depth</i>	<i>Crater Width</i>	<i>Debris Field</i>
1-A				
1-B				
2-A				
2-B				

“Start at like 2cm, then go to 4cm and so on. Hopefully if we have time we’ll bring back our data and graph it. This is more math than anything else, but I also want you to see how much damage these things can do,” Jones said.

“Do you think it will matter which things we drop,” a student asked.

“Obviously a golf ball sized object will create a larger crater. We need to look at mass, too,” Jones said. He then wrote: Mass x gravity (weight) and completed a sample problem with a 3g object. “This is a little physics integration to make things more interesting.”

Jones told the students that they could experiment with different angles as well. He suggested that they might want to roll the objects off of a flat surface, and showed students that they could also create a track with two meter sticks formed in the shape of a “V.”

Once the students began to work in earnest, Jones shifted the requirements as students noticed that they were getting small craters from the suggested 2, 4 and 6cm distances. Jones quickly suggested that they increase the distances to 10, 20, 30 and so on until they reached 1m. He also told the students that it would be necessary to restore the sand surface’s smoothness after each drop.

“How will I know what the debris field looks like if all the sand is the same color?” a student asked.

“It’s not very visible from a low height, but if you look down from higher up, you can see the blowout,” Jones responded.

Jones began to move between groups as they progressed in their work. “This is not a zen garden,” he told a group who were raking their sand smoothly and admiring the lines that their raking created.

“Do we measure the height from the top or the bottom in the beaker with the water?” a student asked.

“The surface. The sand. But do the water last. It will be messy,” Jones responded.

Jones stopped at one group’s station and demonstrated how to measure the circumference of a golf ball. “If you think about that on a planetary scale, it’s going to cover a lot of territory,” Jones said.

For the next half hour, the students worked on their required measurements. They were creating their own data tables, as Mr. Jones’s initial suggestion proved to be inadequate once he

suggested the 10cm-1m drop heights. As student groups finished, their members would disperse to other groups. Sometimes they helped those groups. Other students started talking about unrelated topics. One student pulled out a mirror and started looking at her hair and adjusting her makeup. Mr. Jones shifted to asking groups how many more measurements they needed to take. After approximately forty five minutes, he addressed the entire class.

“We’re going to move to the next step, which is graphing the data. But we’re going to go back to the classroom to do that.”

Once the class had migrated down the hall, Jones moved to the front of the room and worked from the white board, where he explained how to set up the graph that he wanted students to submit.

“This should be easy. You can do it two different ways. The way I prefer is the way I’m going to show you,” he said.

Jones drew a graph on which the x axis was labeled “depth and debris field” and the y-axis was labeled “drop height.” No units were provided for depth and debris field. The drop height axis was broken into 10cm units that corresponded to what he had instructed students to do back in the lab. Jones wanted a line graph where students used different colors to represent the different objects. They were to plot the drop height and size of the crater for each trial. As an alternative for those who wanted to “do something really fancy,” students could create a dual bar graph that plotted the debris field size for each object’s drop height. Students were unclear on which graph they were supposed to submit. Jones said that he preferred the line graph, but would accept either.

Once the students began working on their graphs, there was a clear uptick in crosstalk between students, particularly crosstalk not related to the task at hand. Engagement dropped. Three students completed their graphs quickly and were asked to help others. Jones was seated at his computer and appeared to be checking email or completing some other typing task. Eventually, he began writing the objectives and agenda for his upcoming Physical Science class on the whiteboard. Once most of the class had finished and turned in their graphs, the period ended with Jones reading a list of students who were exempt from their final exam for the course, then distributing exam study guides to the remaining students and giving them the final ten minutes of the period to work on those and “hang loose” if they were finished.

### *Analysis of Case*

Bruno Jones is a capable science teacher who is unafraid to tinker with his practice. As he interacts with his students he straddles a line between the informality that many high school students crave as a sign of their acceptance in the adult world, and the formality necessary to manage a group of such students well. Jones’s experience with Project MAST was beneficial, he believes, because it built on his strengths in both pedagogy and content.

The most valuable outcome of Jones’s participation in MAST was his addition of a licensure endorsement in Physics. It appears that both he and Principal Dorman felt that the work in MAST could be used strategically to bolster his content knowledge sufficiently to accomplish this. Adding that endorsement will now allow MAC to offer Physics every other year, thus making it even more competitive with the county’s larger schools, and providing its students with access to a high-status science course often necessary for college admission.

Jones felt that the content knowledge he most needed to pass the Physics test was a review of electricity and magnetism. His content knowledge was already strong in Physical

science, but the opportunity to review electricity and magnetism concepts and to learn the mathematics that goes along with them was helpful.

“There is a lot of math that goes along with the magnetics and with what they showed us in MAST I was able to fill in the blanks of what I didn't know and know what to go look for so I could figure out what I didn't know, he said.

As described above, Jones valued the opportunity to learn how to use new technology such as the Vernier LabQuest. He was so enthusiastic about the LabQuest that he successfully petitioned his principal to purchase enough for a class set upon his return from the summer portion of the program. He did not use them while I was visiting, but indicated that he has used them in the past and will continue to do so in the future.

Instead of taking MAST materials and simply using them indiscriminately to plug holes in his planning, Jones says that he's worked to make them fit his needs. Unfortunately, some of the most useful MAST content came too late in the program for him to incorporate it this year.

“I took some of the stuff that they did and I expounded upon it and made it fit my needs. Some of the stuff that they had taught I would have loved to have incorporated this year but when we learned it that was after the fact so it gives me like a big bag of tricks to pull from for next year,” he said.

Adapting MAST activities to fit his needs was not without complications. The fluid viscosity activity from the first visit was not completely successful. Jones said that he was attempting to modify something he had seen at MAST to work in his classroom. He said that this activity was a modification of the Velocity Tubes which all MAST participants receive. Those tubes contain fluids of various types and a bubble which travels the distance of the tubes at a consistent velocity that varies depending upon the type of fluid contained in the tube. Jones was hoping to construct a lab on his own in which students could observe a moving fluid, measure its speed and define the relationship between a fluid's viscosity, temperature and the speed with which it flowed. This was an ambitious activity that fell somewhat short of the mark. The lesson was not a loss. Students still had the opportunity to learn about fluid viscosity and speed. However, midway through the lesson Jones did away with the requirement that students time the drops as they travel down the card stock. The lab became a simple observation of the phenomenon of fluids flowing.

Jones's implementation of MAST activities was also moderated by the fact that he felt some of the activities were too risky for his classroom. A chemistry instructor demonstrated to a MAST workshop how zinc and hydrochloric acid produce Hydrogen, which then causes a barking noise when it ignites smoldering wooden splint. Jones said he would not do that as a lab, but would demonstrate it to his students because he was concerned about the fire hazard.

Finally, Jones feels that he cannot implement MAST lab activities as well as he would like because of class size. His largest classes consist of nearly 30 students, which he believes is too large a group to take into the lab. Fifteen would be ideal. Large classes increase his own desire to control the group because they seem unwieldy, and Jones knows that part of successfully implementing MAST activities is that he must give up some of that control in the classroom and allow students to work independently.

“I'm supposed to be the leader of the classroom and I understand that in order for them to learn I'm going to have to let go. But class size would be my biggest issue,” he said.

Jones's department chair, Ms. Ammons, believes that another variable working against MAST implementation at MAC is time. She pointed to this when talking about the portable planetarium visit, saying, “The kids have always wanted to spend more time. Time has always

been limited, time has always been, I think, frustrating. Both for the students and for the teachers.” She feels that it might be useful to have the students come to Jackson State’s campus for the planetarium visit or for a science field trip.

Mr. Jones believes that MAST has helped him to be a better teacher because it has increased the number of tools he has at his disposal when teaching particular topics. MAST bolstered his background in the Physical Sciences and has given him “more meat.”

“I think it’s made me a stronger teacher in the classes that I teach,” he said.

His colleagues agree. His department chair says, “He is taking a situation where there is not a lot of home encouragement, where the kids are not traditionally highly motivated, especially in science. He has low level learners and he has taken the concept and pushed it. He has made science fun again. The kids don’t miss his class, the kids don’t misbehave. The kids are on task and their grades have improved. They are learning the content because of MAST. So he has really used it well.”

“It’s made him a better teacher. It’s made him more aware of what he does in the classroom. He’s become a more reflective practitioner. His lessons are better. His planning is better. It has just made him a better classroom teacher all around,” his principal adds. His lessons are more targeted on student outcomes and objectives, and less about what he’s doing but more about what he wants the students to be able to do, Dorman said.

### *Case 2: Gina Smith*

Gina Smith’s case is the first of two that illustrate the ways in which participation in Project MAST mitigates against teacher isolation. Smith is the only Chemistry and Physics teacher at her school, the only female science teacher and the only teacher who is not also a coach. Her position is one which the school’s principal describes as typically being occupied by a younger woman who teaches for a few years, then moves on to other career aspirations. Smith’s participation in Project MAST helped her to place her teaching practice in a broader context. By connecting with other teachers in the program, she realized that many of the struggles she has are shared by other teachers and many of the strategies she uses with her own students are successfully used by other teachers around Mississippi. MAST’s material benefits were minimal for Smith because her school has well supplied science labs. Like Bruno Jones, she learned new, sometimes more efficient ways to teach lessons she had been using for years.

Smith teaches Chemistry, Physics and Biology II at Ardmore High School. She is in her fifth year of teaching overall and her third year at Ardmore. After earning an undergraduate degree in Biology from a Mississippi university, she took a position that was advertised as an English and Chemistry teacher at Newtown High School, a town approximately forty miles west of Ardmore. Gina was pressed into service teaching Physics, a subject for which she had no teacher education background, in her first year at Newton. “The first year I taught it (physics), I wasn’t in this school (Ardmore), and the first year I taught it I was told that’s the room you’ll be in, the books, we’re not really sure where they are. They’re probably in a storage room somewhere. So initially, we found the books and then we went from there,” she said. She moved from Newton to Ardmore when the outgoing Newton superintendent recommended her to his colleague at Ardmore as “a good chemistry teacher.” Administrators and students consistently describe Ms. Smith in similar terms. “Of course, Gina is amazing. She just never stops,” one administrator said. Yet, much of her work is done in isolation.

### *School Context*

Ardmore is a small town of approximately five hundred people, twenty miles south of East Mississippi's major metropolitan center, Marbury. It's a separate municipal district from both Clarke county where it is located and another nearby town with a separate municipal district, Quitman. The town is a rural bedroom community for Marbury. Housing turnover is infrequent, so most faculty and staff live elsewhere. However, as Principal John Davies describes it, the school has a strong reputation. "We had a couple folks come in at Christmas saying I did some research and this is where I want my children to go to school and that's good to hear. We're real proud of that," Davies says. That reputation is largely a function of the school's Star accreditation status granted by the Mississippi Department of Education. Ardmore High School is one of a small number of Star schools across the state. What makes Ardmore unique is that it has managed to garner and retain Star standing despite being a rural district. There are several similar districts scattered around the state, but the lion's share of Star Schools in Mississippi are schools in either large urban or suburban districts such as Rankin County outside of Jackson, DeSoto County which borders Memphis and the cluster of schools along the Mississippi gulf coast.

According to the most recent publicly available state profile of Ardmore, the district enrolled 872 students in 2008-2009. 54% of the district's students received free or reduced lunch, though an administrator pointed out that more would be eligible, but do not submit the paperwork because of the negative connotation of accepting the program's benefits. Almost 88% of Ardmore's students were White while 11% were African American. The other 1.25% was split between Hispanic (1.03%), Native American (0.23%) and Asian (0.11%) students. The district's graduation rate was 96%, 25% higher than the statewide rate. The school's demographics are not representative of the county's, as it is 64% White, 35% African American with a similar split between the three other racial/ethnic groups listed above.

The Ardmore High School campus is a composite of the original, old school, a long brick building with twin entrances on either side of a sign that announces its name and several generations of additions and new buildings. Wood floors creak underfoot as soon as you enter the building to sign in at the office. The long hallway of the original building is marked on both sides by senior class composite portraits dating back to the 1950s which are hung high on the walls. Close attention to them reveals significant changes in the size of Ardmore's student body and changes student demographic makeup. It's possible to walk the hall's length and trace the desegregation of Mississippi's public schools in the late 1960s and early 1970s, and then the gradual resegregation of Ardmore during the 1980s and 1990s. At some point I was informally told that there was a court fight during the 1980s that resulted in the school district lines in Clarke County being redrawn.

Gina Smith's classroom is on the same hall as the main office in the original school building. It's tucked between the entrance hallway and a computer lab. In addition to the classroom where she lectures and keeps her main work desk and computer, Gina also has a dedicated chemistry and physics lab that she does not have to share, as well as a storage and work space for staging lab activities and keeping equipment and chemicals. In addition, she has access to the dedicated science department computer lab next door to her classroom and across the hall from her lab space. The computers in that classroom have been equipped with a variety of science education appropriate programs including probe ware.

Hired at Ardmore knowing that she would teach Biology, Anatomy and Physiology and Physics as well as Chemistry, Gina continued to teach Physics with very little support. In

essence, she was teaching herself Physics content and instructional strategies. “The first year or two, probably the first year or two, a lot of it was, ‘please let this work, please let this make sense because I’m not sure I fully understand myself,’” she said. Planning Physics lessons without colleagues who could help added to her already copious instructional planning. “When I first was told that I had to teach Physics, the lessons were so time consuming to prepare with two other preps at the time. The first year I taught, I had four other preps other than Physics, so that Physics class really didn’t get the knowledge it needed, and I think that it has definitely gotten better over the years.” Her move to Ardmore coincided with a recent renovation of the school science labs, and sufficient funding to order additional equipment. Her year of experience teaching Physics at Newton helped with this process. “Having taught it the previous year, I did know a little bit about what we were looking for, and I was able to order some of the stuff that I had found at Newton, the K-Nex rollercoaster, and things like that, things that I knew would be helpful and more than content. Something fun.”

Professional development takes a variety of forms at Ardmore. Most school based professional development is focused on preparation for the Mississippi Subject Area Testing Program (SATP) or the state special education referral framework, Response to Intervention (RTI). Principal John Davies leads the SATP related professional development while guidance counselor Gloria Romain leads faculty learning related to RTI. Each week, Davies or Romain leads an extended faculty workday that lasts until 4:30pm. “We’re writing timelines and we’re writing pretests, posttests and looking at Tier I, Tier II, Tier III things...That’s our main focus is to stay on your feet, move, be a good classroom instructor by looking over the shoulder and not sit behind your desk,” Davies says. Other school wide professional development takes place at the beginning of the academic year. In previous years, faculty have completed the P.E.T. program which emphasizes monitoring teachers’ actions in the classroom. They’ve also learned about the planning and management frameworks of author Harry Wong. Davies, Romain and Smith all recalled a joint professional development day with another Level Five accredited school from the same region of the state. On that day, the teachers broke into content area groups, discussing and trading activities and lesson plans. This was the only example given of content-specific professional development.

Gina’s participation in Project MAST is similar to a number of other teachers’ individual, content-specific professional development. Principal Davies says, “our teachers are always trying to better themselves and better our school.” He reels off a list of teachers’ individual professional development activities: three are pursuing masters degrees online; several have taken computer courses; three other teachers spent time last summer getting certified to teach Advanced Placement courses this year. In the past several have attempted the National Board of Professional Teaching Standards certification process for their subject areas.

### *Classroom Visits*

#### *Physics Lessons*

I observed Gina teaching two Physics lessons. Her only Physics class had four students, two male, two female. Three of the students were White, one was African American. The first Physics lesson I observed was a lesson on wave motion and types of waves. According to Gina it was the second lesson of the wave unit. It was a set of activities she had learned at MAST and supplemented with her own equipment.

On the previous day, Gina said that preparation for the lab was minimal. “To be honest, we didn’t do very much because I knew that this needed to be the introductory activity. We

looked at the first part of the chapter, discussed where they knew waves from. We worked a set of problems that dealt with frequency and period, and we left it kind of at that because I didn't want to go way too in depth before the activity." In the focus group discussion with the Physics students, the students said that Gina used the textbook frequently, and that a lot of their class time was spent in ways that sounded much like the first lesson of the wave unit.

The 90 minute class began in Gina's main classroom where she took attendance and introduced me to the class. We then walked across the hall to the lab where her students took their seats. The lab that Gina used for her physics and chemistry lessons is a modern, well equipped high school science lab. Students sit on stools at hexagonal lab stations. At the center of each lab station is a sink with water, gas and air jets. Gina directs student work from her station, a longer table that allows her to face the students and provides her with easy access to the storage and work space where materials are neatly arranged on shelves and in a closet, though for the first Physics lab I observed, Gina's space was taken up by a large K'Nex model roller coaster, clearly a work in progress as K'Nex pieces littered the table. Standing at Gina's workspace and moving clockwise, the side of the classroom closest to the hallway is lined with cabinets, shelves and sinks. At the end of the classroom opposite the teacher work station is a whiteboard with cork boards to either side of it. The side of the classroom opposite the entrance looks out on a grassy space between the original Ardmore High School building and one of the more modern additions.

The wave lab consisted of several activities. Students used a handout that Gina distributed at the beginning of class. The handout contained both the instructions necessary to complete the lab and questions to which the students were to respond in writing as they completed it. The four students split into pairs, boys in one lab group, girls in the other. Gina had put out the rudiments of the lab: Slinkies, a length of rubber hosing, and moved back and forth between the lab space and the storage area. The students worked through the steps listed in the lab handout, creating compression and transverse waves in the different media, recording their responses to the questions listed in the handout.

The goals of the lesson were never explicitly discussed. Rather, Gina told the students at the outset, "Today, we'll continue working on waves, and we'll be in the lab." The two student groups progressed at different speeds, largely because of different levels of engagement. The pair of young women required more encouragement to engage in the activity and by the end of the lab time, were surprised that they had been expected to complete significantly more work than they had. At one point Gina remarked that the instructions on the handout "seemed written for middle schoolers," something that her students picked up on and repeated several times. However, the lab activities never appeared to be so simple that the students were not engaged. The handouts required them to answer comprehension questions and to tie what they were observing when they produced waves to the scientific vocabulary associated with them: amplitude, compression, wavelength.

It was clear on both visits that Gina's relationships with her Physics students are close. They speak to one another easily. On my second visit, a student had turned 18 the previous weekend and had gone to get her first tattoo. The beginning of class was taken up with a discussion of the tattoo itself, the experience of getting it drawn and the other activities that had marked the student's birthday weekend. Much of the instruction-related talk between Gina and her Physics students regarded procedures and the construction or use of the apparatus necessary to complete the lab. When Gina was working with a particular pair of students, it often involved figuring out how to put something together, such as the standing wave generator that she had

assembled for the students to use during the lab. Her feedback was cursory, telling students that what they were doing was correct or admonishing them for not working at a sufficiently brisk pace. Both groups of students were working from steps provided them on the handout, with very little room for improvisation or creation of their own procedures. Both of the Physics labs I observed concluded with cleanup and ended just as the dismissal bell was about to ring. Discussions of the lab and the opportunity to connect what was observed and recorded were put off until the next class meeting.

The second Physics class I observed occurred approximately a month and a half after the first. The lesson was a part of an electricity unit. Students constructed parallel and series electrical circuits. We had discussed the particular MAST workshop session where Gina had first encountered this lesson on my first visit to Ardmore. She spoke of how the activity's use of copper tape would make teaching and learning circuits much easier, saying "I can do circuits before but it took me quite a bit longer than it does now. It was a lot harder to teach before MAST and I haven't taught it yet but I feel more comfortable with it. I have a better idea of how to give instruction." On the day of the circuits lab, one of the male students was absent because the band had returned in the wee hours of the morning from a performance trip to Texas. Instead of working at the student lab stations, Gina had the three students seated at stools around her teacher lab table. She passed out sheets made of card stock on which a circuit diagram had been printed. As she explained the procedures for the lab, Gina stripped the rubber from the copper wires on colored Christmas lights. She took a moment to demonstrate to the students how to properly fold the copper tape when the circuit diagram came to a right angled corner. For the next half hour, the students worked on constructing their own series circuits, placing the copper tape on top of the printed circuit diagram and connecting the light wires to the tape so that once the circuit was completed, the light glowed. While the students worked, Gina continued to stripe wires from lights in preparation for the next circuit type. Periodically, a student would express her/his frustration with a sigh or a word. Gina quickly put down her work and walked around to the student to find out if the student needed help or to repeat something she had said earlier. The construction of the circuits was interrupted by the arrival of the absent student. The class took a few minutes to discuss the band trip before going back to their work on the circuits. Again, there was no time taken at the end of the period to discuss the activity or to connect it to any concepts from previous lessons. Instead, the students put their work away and waited patiently for the dismissal bell.

### *Chemistry Lessons*

While she only taught four Physics students, Gina's chemistry workload was larger. She had two sections, one that met in the morning right after her Physics class, another which met at the end of the day. Her morning Physics class consisted of approximately 20 students, a mixture of boys and girls. Her afternoon Physics class was entirely female and a bit smaller, between 12 and 15 students. I observed the morning class on my first visit to Ardmore, and the afternoon class on my second visit.

The first Chemistry lesson I observed was a mid-unit lesson on stoichiometry, an activity Gina had learned about at a Project MAST workshop. Students had been learning about balancing chemical equations and calculating the theoretical yield of a chemical reaction. The stoichiometry lab activity began with a review of both procedures and a series of sample problems in the main classroom. The class packed into the lab where students situated themselves in groups of three or four at all of the available lab stations. There, they worked

together to calculate the theoretical yield of carbon dioxide and water from a mixture of specific quantities of baking soda and vinegar. Then, each group measured out the various materials using pan balances and graduate cylinders. They then combined the materials in a plastic bag, took the mass of the bag and its liquid and gas contents, then measured the mass of the liquid alone.

Gina had prepared the lab stations in advance, requiring that the students send one runner to a single station to obtain an unmeasured quantity of the baking soda and vinegar. Students worked on their own calculators at each station. For a group as large as this in such a cramped space, there was remarkably little noise. Gina moved from group to group as they worked, and though I could not hear the exact words of conversations, it was clear that she was checking students' progress on the lab procedures and providing guidance on how to complete calculations or how to properly use the measurement devices. Almost all of the students were continuously engaged in the activity for the duration of the class period.

Similar to both of the Physics activities, this MAST activity required students to follow a predetermined procedure to complete the lab. There was no leeway or improvisation. The lab required students to compare actual yields of products in a chemical reaction to their pre-calculated theoretical yields, then answer questions in writing.

The second Chemistry lesson I observed was on my second visit to Ardmore. This lesson took place entirely in the traditional classroom setting. Students had been studying radioactive decay and the applications of element half lives in radiometric dating. The class period was entirely taken up with completion of an activity in which students modeled half life by shaking a container filled with M&M candies, then removing those that landed on the side on which the M&M logo was printed, recording the number of M&Ms removed, then repeating the procedure. At the conclusion of the lab, students were required to graph the data they had collected and to respond in writing to a set of questions about half life and their data. This lab was among the more amusing to observe, as two student groups scattered their M&Ms all over the classroom floor while completing the lab.

On both visits, I never observed a lesson that consisted of more time spent under teacher direction, either lecture and student note taking or reading from the textbook, than time spent doing a lab activity. In both focus groups, a typical day in Physics and Chemistry class was described as consisting of either note taking, the teacher reading from the text, then talking about what had just been read, or student completion of packets of handouts related to content from the textbook or working problems in a workbook. Almost to a person, students described themselves as learning best when this was the way content was presented. Students in the Physics class spoke as if they spent more time in the laboratory than did Chemistry students. Both classes agreed that Ms. Smith's classes were harder than their other science classes, that the content required them to use more math, which in turn meant that they liked the subjects less. As one student put it, "It doesn't really have anything to do with the human body like every other type (of science) I've taken."

### *Analysis of Case*

The distinction between content knowledge and instructional practices is not one that is unfamiliar to Gina Smith. It is uncertain whether she thinks of her MAST professional development in terms of those two categories. In conversations about Project MAST, it became clear that MAST provided her with a few instructional practices that she was able to carry across disciplines. Most of the instructional practices she took from MAST were embedded in the

content specific lessons that were taught to her as a MAST participant. She took those lessons back to her classroom and used them to replace or to supplement activities she had already found on her own. Gina talks about Project MAST's impact on her instruction in terms of affirmation of her instructional repertoire, enhancement of her content knowledge in areas where she was weak, improvement of her access to material resources and connection to other teachers.'

Gina is confident in her content knowledge and ability to teach Chemistry. Thus, MAST's Chemistry workshops were those from which she learned the least content. However, the workshop context helped mitigate her workplace isolation and reaffirmed that what she is doing in her classroom is good practice. "The main reason for the content knowledge part is because I came in with so much more, a lot of things have been self taught. And so getting to MAST and actually seeing it, I could look at the answer key and see that I'm doing it correctly but to see the same method, the same way that I'm teaching my kids being taught that way in MAST made me feel better. That is for sure," she said.

For her entire career, Gina has been asked to teach Physics without ever having been taught how to do so. However, her content knowledge growth in Physics was less significant to her than the affirmation that what she had taught herself to do and the content she did not know were not unusual. "I was sitting in a room with teachers who are in the same situation I am, or worse, most of them worse. Teachers who are teaching Physics, what activities they use, what websites they're pulling information from, what textbooks. And if I had a question about something Physics related, I could ask and I didn't have to feel....and not just to those teachers but to the instructors that were there as well. I didn't have to feel incompetent because we were all asking the same questions, we all had the same concerns, we were all teaching things and go am I teaching this right, especially that first year or two really heavily relying on that teacher's edition. And I've grown to realize that a lot of us do that, at least for the first couple of years." MAST validated what she was doing by allowing her to hear that other teachers were having the same struggles that she was, that they had similar questions and in some cases that there were people who were working in more difficult situations than she was.

Gina reinforced this point when asked to describe the materials from MAST that have been most beneficial to her teaching. She says, "Actually, the most beneficial material has not been the actual physical material. It's been the interaction with other teachers, being able to learn new activities. I guess if I had to pick a material, it would be the activities, not the \$2,000 worth of equipment of the however much, but simply the activities and the interaction with other teachers." The materials were a third thing that mediated the very important interactions that Gina was able to have with other teachers at Project MAST workshops.

Unfortunately, Gina indicated that the content areas in which she felt she grew the most are likely the least useful. She had the least prior knowledge of Earth Science, Geology and Astronomy. Another teacher at Ardmore teaches Physical Science and in that course touches on Earth Science and Geology. She has shared her MAST materials with him. She says "We touch on Astronomy here in Physics but we don't spend that much time. That's the only downside. For a school this size, the subject areas that I learned the most about are probably least used."

Changes in instructional practice are difficult to come by according to Gina. Both MAST and her undergraduate teacher education coursework emphasized inquiry based science teaching. However, she has been reluctant to implement inquiry into her teaching. "I've never been comfortable with inquiry activities because there's less guidance. I'm working on that. I do feel more comfortable than I ever felt before with it. Even in college, I graduated from USM and we were taught how to teach inquiry. But when you're in college, you're not in with a group of

students. I've had the knowledge but never how to implement it, I guess is the best way to say it.” Translating professional learning about inquiry into practice is difficult for her because she has not had a place in which to practice new skills with students. Perhaps this is compounded by her workplace isolation.

A similar issue frames Gina’s implementation of the technology she received at Project MAST workshops. Ardmore has wisely used funding to provide its science teachers with well equipped labs. Gina has attended training for using Pasco science teaching kits. Her interest in MAST was initially piqued because former colleagues who were MAST-5 participants and middle school teachers mentioned that MAST-5 was providing them with training on how to use Pasco measurement devices. She felt that she needed additional training on how to use such devices. However, she has been reluctant to apply her training and to use the Vernier LabQuest devices she received at Project MAST for two reasons. First, she only received one LabQuest and cannot use that with either of her classes. Second, similar to her training in inquiry based science teaching, she feels that she does not yet have the expertise to manage a classroom of teenaged students as they learn how to use a new piece of equipment. “I think though it is not really been at a point where I've been able to apply at this point, and I'm still very hesitant admittedly, still very hesitant to pull out the equipment,” she said. This fear is a product of “not doing it before with a group of kids.” She is emphatic that she has confidence in her students’ ability to learn how to use the device, but is worried that she is ill equipped to manage them in doing so. Here, it is unclear if her hesitance is because she is still uncomfortable using the devices herself or if she is concerned that she will lose control of the class.

The only non-content/non-lesson specific instruction strategy she recalls learning at Project MAST and using in her classroom is a management tool for choosing student volunteers. “There was a couple of ideas about just in general management that were suggested. The use of they're not popsicle sticks, tongue depressors, where everybody had their name on one and it was a random draw so you could be asked the same question three or four times, we did a very similar thing last semester, and it worked super well for the classes that I was teaching at the time,” she said.

Principal Davies spoke glowingly of the changes he’s seen in Gina’s teaching since she participated in MAST workshops. He says that he’s seen two types of changes: increased confidence in her teaching and an improved ability to track down resources to enhance lessons. “I observed the labs and she's done some stuff out of there and I observed her in the classroom teaching. It was prefixes for the chemical things like that and she said she had picked that up in some little trying to write the equations or writing the names with the things. Her physics and I would say she's just getting a whole lot more confident. She knows where to go to find stuff. That's the main, a good point of this. She's figured out it's all out there if you just know where to find it. I think she's come back with a lot of good resources that have helped her strengthen her lessons.”

As described above, Gina also believes that MAST has improved her confidence in teaching Physics with no formal training and in her Chemistry teaching repertoire. She said that she was most likely to apply the Physics and Chemistry lessons she’s learned at Project MAST immediately. She speaks as if she is applying Chemistry lessons now and in a greater quantity than physics lessons. Again, she is limited in her ability to apply Earth Science and Astronomy lessons because they are outside of her assigned teaching areas.

Students describe Gina’s class as being more project-oriented than their other science classes. Whether this is attributable to MAST is unclear. They also say that she takes their

learning more personally than other teachers, that she responds emotionally to students' failure in her courses rather than just saying, "if you fail, you fail."

Like many of her colleagues around the country, most of Gina's work is done apart from other teachers. She is expected to plan the content of the courses she teaches. She alone directs the classes day-to-day. Unique to her work at Ardmore is the fact that Gina is the only teacher of the advanced physical sciences offered there: Chemistry and Physics. She is also the only full time and the only female science teacher on the faculty. Ardmore is a small and close knit school community. Gina speaks frequently with her colleagues and principal. She knows her students well. Socially, she is no wallflower. Despite abundant evidence that her work is respected by her supervisors, colleagues and students, she is the only person in her building who knows anything about the instructional practices and content knowledge related to the two MAST related subjects she teaches. Her professional isolation as a science teacher is profound. At the same time, her knowledge of physics content and pedagogy is nascent. Project MAST was the first formal professional development she received in either area. Her school's professional development capacity is dedicated to preparing the entire faculty to implement statewide mandates such as testing and special education referral.

Gina is unable to implement inquiry based teaching strategies and some of the technology she received at Project MAST because she has no space in which to develop the confidence necessary to do so. In both cases, she describes apprehension about how well she can translate what she has learned in a room full of undergraduate or adults into a teaching practice in a room full of students. The MAST implementation visit provided her with positive feedback, but was insufficient to change her teaching practice. Her principal is a former science teacher with whom she often speaks informally and asks for advice, but he is no expert on implementing technology and was trained in science teaching before the current inquiry based reform efforts began in the mid to late 1990s.

Project MAST has succeeded in providing Gina Smith with a respite from her isolation. Contact with other teachers affirms that she is doing her work well, in a way that no praise from an administrator or parent is able. She is also able to place her work at Ardmore in the larger context of Mississippi's public schools, where some teachers face significantly more daunting material and social challenges than she does. Moreover, MAST has expanded Gina's teaching repertoire, providing her with new ways to teach content with which she is familiar and better ways to teach the content that she's still learning. The challenge that Gina's case poses to Project MAST is how to better improve the confidence of teachers like her in implementing innovative teaching strategies and new technologies. Gina felt constrained by the fact that she learned new practices and was exposed to new materials yet never had a scaffolded opportunity to implement either with students. In her school context, it is clear that such opportunities are unlikely to occur with adequate support. Too much energy is devoted to other science subjects and there are simply too few people in the small, but warm community that is Ardmore High School.

### *Case 3: Amy Davis and Chloe Peters*

The cases of Amy Davis and Chloe Peters raise some issues similar to Gina Smith's case. Davis and Peters are two thirds of their school's science department. Their third colleague is a two decade veteran who is congenial, but who has a firmly established teaching practice. Davis and Peters' shared participation in Project MAST benefitted them both. They encouraged one another to participate fully, processed what they had learned in sessions on the long drive home from MAST events and had greater strength in numbers when lobbying school administrators to

purchase additional equipment for their school's science labs. Their school has fewer material resources in its science labs than do Jones' or Smith's. Thus, participating in Project MAST was a cost effective way for their school to improve the equipment on hand to teach the physical sciences.

Davis and Peters are both teachers at South Hampton High School in Littletown, MS. They attended Project MAST together, one of only two such teams of teachers from the same school in the 2009-2010 Project MAST cohort.

Amy is in her fourth year as a science teacher. She earned an undergraduate degree in Biology with a Chemistry minor, and has since obtained a Masters degree in Science Education. She teaches a combination of Chemistry and Biology courses, sponsors the school's environmental club and coordinates recycling on campus. In the three years prior to her participation in Project MAST, Amy participated in several other science education related professional development programs related to chemistry, biology and general science teaching methods.

Chloe is in her third year as a science teacher and her second year at South Hampton. She earned an undergraduate degree in Biology and Health Sciences with a Kinesiology minor. She holds an alternate route license. Chloe teaches Biology and Physical Science. During her three year tenure, Chloe has attended a number of professional development programs related to Biology, Chemistry, Physical Science, general science teaching methods and the use of technology.

Both teachers agree that Project MAST fits with their professional development needs and those of their school. However, they both express a belief that their administrators do not necessarily do all that they can to support them in learning about and in being able to attend professional development programs. In particular, when it might be necessary to obtain a substitute teacher so that they can attend a professional development event, it's almost certainly not even worth asking. Also, both teachers felt that South Hampton Principal Walter Dellinger is not a particularly hands-on manager. Both teachers feel that he does not visit their classrooms enough, and does not do enough to provide opportunities for them and other teachers to share what they have learned in their professional development with other teachers.

#### *School Context*

Hampton County is approximately two hours south of the state's capital city. It sits between two major south Mississippi cities: Hattiesburg and McComb. Littletown, the town where South Hampton High is located, is just on the other side of the Pearl River from Columbia, the Hampton county seat. A quick exit off of the U.S. highway takes you through downtown's single stoplight and cluster of stores, locally owned restaurants and the elementary school. The high school is nestled in a residential neighborhood where mobile homes bump up against worn houses. The school's gravel parking lot surrounds two sides of the high school, with the back facing a spot of woods and another side facing the football field.

Upon entering the school building, a single woman sits at the desk in the main office, answering the telephone, directing tardy students to class, checking students out and relaying messages on the school intercom system. It is clear from the first moment in the building that South Hampton students feel as though they are part of a family when they're at school. Several students hugged the office receptionist or recounted details of a recent sports event to her. All of the classes I observed began promptly when the bell rang, but did so only after their teacher cut off a conversation with several students who had gathered at the front of the room or were

talking from their desks, telling their teacher about what happened at lunch or last period, or asking about how an ongoing fundraiser had gone.

The Hampton county schools are one of two school districts in a county of 25,000 residents. The town of Columbia has its own, separate school system, apart from the county. Both South Hampton and its sister school, East Hampton, were rated “At Risk of Failing” under the 2009 Mississippi school accountability model. South Hampton is relatively small, having approximately 420 students in grades 9-12, of whom 70% are white and 29% are African American. 73% of South Hampton’s students are eligible for the National School Lunch Program. The school’s demographic makeup is fairly reflective of the county’s, where 66% of the population is white, 33% are African American and 1% are Latino. Per capita income for the county is \$12,301. Approximately a quarter of the county’s residents are below the federal poverty line.

Both Amy and Chloe spoke of the challenges many of their students face outside of school and how successful teachers understand and negotiate those issues. “I absolutely love my children here. But they have very, very, difficult home lives, and that makes it very difficult to teach them because you're dealing with so much more than Biology or Chemistry,” Amy said. Some students work jobs after school to help their families, or they have to take care of younger siblings so that parents can work multiple jobs. As a result, Amy feels that her students do not reach their full academic potential. “And I feel like my students are just dealing with so much more, and when you compare academic ability I don't think it's a socioeconomic thing as much as it is a parental involvement. A lot of my students, they're capable of doing what some of the higher level schools are, it's just they don't have the support or they're having to work an almost full-time job to be able to eat, she said. However, she says that’s not a deterrent to her work as a teacher. Instead, it makes her feel as if she’s needed.

Most South Hampton students enter the workforce upon graduation. Some attend a community college. Few go on to four-year schools. Many follow their parents’ career tracks, particularly young men whose father’s help them gain employment working in the Gulf on offshore oil rigs.

South Hampton is a school district in transition. First, in 2005, Hurricane Katrina struck south Mississippi, and the school sustained damage from the storm. Principal describes this as an opportunity. The storm damaged forced a cleanup of the school’s science labs and much of the outdated equipment and materials were removed. (quote re: chemicals from 1960s.) Then, two years ago, there was a mass change in school administration, which brought the current leadership to South Hampton. It is unclear what precipitated this change, but it came up across interviews that the changes are a mixed bag. The school’s culture became more familial, less adversarial. Faculty and administrators were again on the same page. However, the new principal is widely viewed as a less engaged administrator. As one teacher put it, “We went from a principal who before was in the hallway between classes constantly talking to all of the students, knew them all by name, and he's more of a delegator. He does what he's supposed to do and he delegates everything else.”

Amy and Chloe are two thirds of the South Hampton High science department. Their third colleague has been teaching for twenty years. Both teach Biology, thus they work together closely and complement one another. As Chloe puts it, “Brandy and I are good friends anyway working together in the science department. I'm not going to lie, some Saturdays I'm not looking forward to coming. We've had a long week and we encourage each other. That's been really, really nice just to have the motivation from each other and to be able to discuss things when I

don't really understand some of the stuff in chemistry she's able too kind of help me understand it, implement it and it's the same way with her with the physical science part.”

At one point in 2009-2010, they tried to team teach biology, dividing the class into groups based on their achievement level, and differentiating their lab instruction. “...We would separate our kids into lower and higher groups, and we had lab activities going on, some that were more advanced for the more advanced group and then Chloe or I would take the other group and work with them on skills they were lacking. So it did work really well,” Amy said.

The Science department’s material resources are kept in a single lab closet in Chloe’s classroom. Science teachers from the elementary through middle grades and the high school can sign out anything they need from it. All of the equipment and materials that Chloe and Amy received from Project MAST are in that closet, available for any other teacher to use as needed. The third, most experienced science teacher, who teaches Earth science, has not participated in Project MAST. She also has the accumulated materials of two decades in the classroom, and tends to use those rather than the departmental closet.

Administrator support is an area where there is no consensus. Amy and Chloe both learned about the program through the district’s instructional coach, who pressed them to apply. Their principal mentions that he uses professional development support strategically to motivate teachers. However, with a difficult state fiscal situation forcing cuts in state support for public education and creating the specter of teacher salary decreases or layoffs, hiring substitute teachers so that teachers can attend professional development is not always an option. However, the school’s principal has made equipping the biology and chemistry labs a priority. “It’s hard to teach chemistry without chemicals when you don’t even have certain things such as a, I’m not saying there’s not a triple beam balance but you know you actually need to be able to make certain types of measurements. So what we’ve actually done, you’re not allocated but x number of dollars a year to buy certain equipment and materials. This year I spent a large bit of my supply money, material money for the chemistry and biology and getting them the equipment they needed and what it would take, the supplies it would take, the lab supplies to get through at least the next couple of years,” Principal said.

And when Chloe and Amy returned from the summer sessions at Jackson State, they asked if the school could afford to purchase additional Vernier LabQuest devices. Principal agreed and purchased three additional sets of LabQuests and sensors, bringing the school’s grand total to five LabQuests, all of which are available for all of the science faculty to use. Chloe brought up the added benefit of having two teachers from the same school participate in MAST. “I mean it cut down a lot on their (the district technology department) cost because we were able to supply at least two of everything between the two of us.”

Professional development at South Hampton High School is focused almost exclusively on test preparation. Everyone spoke of departmental meetings in which teachers were required to practice writing test items based on the state science framework. This is coupled with the school’s traditional consultant-based professional development at the beginning of the year. Anything other than that is likely the result of teacher initiative, or as in the case of the two MAST teachers, an administrator realizing that a program might be useful to motivated teachers.

One of the ways Amy feels constrained in implementing MAST activities is that her 47 minute class period is not conducive to doing a full MAST lab. On the second day of my visit, her Chemistry class did a MAST stoichiometry activity. She prefaced the activity the day before saying, “The 47 minutes makes it difficult. Now, the Biology 1 classes, our labs aren’t that complicated. And so usually I don’t have too many problems with that. But with the Chemistry,

it does because a lot of times as soon as they get in class we've got to start just to try and finish. And if you don't finish or if someone's lacking behind, a lot of times these things can't wait to the next day. So it really makes things a lot more complicated.” Her school alternates block periods and shorter periods, and Chemistry, a full year course, gets a standard 47 minute period. Some schools allow science teachers a double lab period one day a week. South Hampton does not.

Some of the MAST teachers discussed having to scale down their lab activities in order for their students to be able to complete them. Amy did not. Most of her adaptations for the lab I observed had to do with making the activity more efficient. She changed to wording on some instructions because she felt it might be confusing. She adjusted the formatting of the data table. Finally, instead of measuring the materials for the lab in advance, she had her students measure them, because she felt that measurement is a perpetually weak skill and that her students would need more practice.

### *Classroom Visits Chemistry Lesson I<sup>3</sup>*

I visited Ms. Davis's class on consecutive days. Both 45 minute lessons were related to the chemistry concept of stoichiometry. The first day included a review of balancing chemical equations and an introduction to the topic as well as practice working stoichiometric calculations for expected yield from a chemical reaction. The second day, the entire class period was devoted to a stoichiometry lab that Ms. Davis had learned about at project mast. Ms. Davis's classroom is perpetually in motion when students are present. From the time she dismisses one class until she begins a second, students are coming in and out the classrooms single door where Ms. Davis stands as a kind of gatekeeper. From the hallway it is sometimes impossible to see her because of her short stature. However if a group of students is gathered anywhere near her classroom door, she is probably at the center of the group. Ms. Davis voluntarily directs the student recycling group. Interested students have set up receptacles all around the school. Once a week, they collect the recycling from those receptacles and bring it to Ms. Davis who then takes it to a local recycling depot.

Both South Hampton administrators and students speak highly of Ms. Davis. To administrators she is one part of the school's dynamic science department in which all three teachers are known both for their high student test scores and their willingness to pursue professional development opportunities above and beyond what is required. To her students, Ms. Davis is a patient teacher who will stick with the topic until she knows for certain that all of her students understand it. Though not required, Ms. Davis has weekly tutoring sessions after school for chemistry and biology students.

Ms. Davis opened both classes with the work posted on the board. The class of 11 students was mostly seated and on task when the late bell rang. After approximately 7 min., Ms. Davis asked a single student to go to the board to work the Bell work problem, demonstrating how to balance the chemical equation for a double displacement reaction. The student used a method in which she first recorded the number of molecules of each element in the reactants,

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<sup>3</sup> There are no lesson summaries for Chloe Peters. South Hampton High School was the pilot site for the instruments used in this study. Rockman, et al. staff visited in February 2010, and completed the administrator interview and one observation of Peters' teaching. Their visit was cut short by an approaching winter storm. The paper's first author visited in April and conducted the remaining observations and interviews. However, Peters' classes were reviewing for a test and taking a test of the two days of the second visit.

then attempted to match that number in each element of the products by manipulating the number of molecules of each of the compounds. This was not a difficult task for the student to complete. She did so without assistance from the teacher.

After the bell work had been taken up, Ms. Davis told the class to take out their notes. She then introduced the topic of stoichiometry by telling the class if they were actually working in an industry that required chemicals ability to balance equations would be vital. One student asked, "what if I want to be a radiologist technician? Will I use any of this there?" Miss Davis responded that it would be important in the courses required to become such a technician. At this point, Ms. Davis turned on a projector for PowerPoint slide labeled stoichiometry. Beneath it, were several steps for how to calculate the amount of substances that would need to be involved in a particular chemical reaction. The focus of the slide was the formula, "grams of given/grams per mole of given x (mol of unknown/ mol of given) x g/mol of unknown." students were to balance whatever chemical equation they were given and then simply plug into this formula what they knew in order to find out what they did not know. "You don't just throw a bunch of chemicals together. You need to know how much you're going to make in order to do that you need to know how much will be needed," Ms. Davis said.

Ms. Davis then guided the class through an example problem from their Chemistry textbook. She wrote the problem on the board, then had the class watch her as she worked the problem step-by-step, relating each of her steps back to the original powerpoint slide that began the lesson. Each necessary calculation was completed by a student using a calculator. Formula masses were calculated using the students' textbooks. Once she had completed this problem, a student asked if future problems on tests would be similar, i.e. would such problems require the students to balance the equation in advance of completing the stoichiometric calculations. Ms. Davis responded to this question, then seeing that there were no others, she had the students individually attempt a problem from the same problem set in their textbook. As students worked the problem, Ms. Davis circulated throughout the classroom, checking on the work that each student had written down and dispatching students who completed the problem to assist their classmates. After approximately five minutes, Ms. O'Neil sent a student, Alicia, to the board to show her work. As this student worked the problem, other students were silent, checking their own work.

At least twice, Ms. Davis and students joked about or otherwise discussed the volume of math required to solve a single problem and show all of one's work. Early in the lesson, Ms. Davis joked that this new topic, stoichiometry, was going to involve "the dreaded Big M!" Students laughed about it, but outside of class several made clear that the biggest difference between the chemistry they learned in Physical science and the chemistry done in Chemistry class was the larger amount and greater difficulty of the math required for the latter. Once Alicia had finished showing her work, on the individual practice problem, another student, referring to all of the work Alicia had shown on the board to solve the single problem, remarked, "That's a lot." Ms. Davis agreed, "It's a lot, but it's not that hard of math. I want to show you how the units cancel out and that the final unit left here is grams," she said, indicating that there was a purpose behind the volume of ink expended to solve this one problem.

As the class ended, Ms. Davis remarked that the next period would be a lab using stoichiometry with actual chemicals. Students were clearly excited to finish the week with a lab rather than more notes and problem. Several remarked that they were sad to be missing the lab because of a tennis tournament which was scheduled for the next day.

*Chemistry Lesson II*

On the second day of my visit to Ms. Davis's class, the class carried out an adapted version of a project mast laboratory on stoichiometry. The second is class began again as the first did, with students completing a bell work problem. Again, the problem was practice on balancing chemical equations. Surprisingly, the students who have lamented the fact that they would miss the lab because of a tennis tournament had returned to school in time for the lab and were excited to be there.

After 5 min. time, Ms. Davis began the class by asking the students what they had talked about yesterday. No one was able to answer. Ms. Davis began to review the bell work problem. Step-by-step she again modeled how she would approach and think about the problem if she were trying to solve it. Her first step was to have students name the correct products for the reaction. She then demonstrated how to quantify the number of atoms of each element on each side of the equation. Finally with student assistance she bounced both sides of the equation and was ready to move on.

Knowing that she had to complete a lab In the short time period of 47 min., Ms. Davis's pace was more brisk. Very quickly, she distributed a two-page lab handout to the 10 students in the class that day. Briefly, she was interrupted by a student who had a lingering question about the bell work. She took a moment to rework the confusing portion of the problem on the board before proceeding with the lab. The lab handout listed an objective which Ms. Davis had a student read aloud. The lab's objective was to experimentally and theoretically determine the amount of product produced in a chemical reaction. Ms. Davis explained that theoretically meant doing the reaction on paper using math.

Ms. Davis then summarized the seven steps listed in the procedure section of the handout explaining that acetic acid is the same thing as vinegar and that sodium bicarbonate is the same thing as baking soda. She also suggested that students use a cup when measuring the mass of a plastic bag and its contents. These two steps make clear the fact that Ms. Davis was aware of some of the difficulties that might crop up in the process of doing the lab. She was attempting to anticipate these difficulties, combining both the knowledge of the lab and her students' skills.

Briefly, the stoichiometry lab required students to measure and record a given mass of baking soda and a given volume of vinegar and the mass of the vinegar and a cup. The students then combined the quantities of baking soda and vinegar in a plastic bag, allowing the carbon dioxide that was produced to escape. After 5 min. of agitating the solution, students took the mass of the products remaining in the plastic bag. Then, using the law of the conservation of mass students calculated the mass of carbon dioxide which was formed during the reaction but escaped the bag. Using their stoichiometry skills, students also calculated the expected yield of carbon dioxide from the given quantity of sodium bicarbonate. Then, using the values of actual carbon dioxide released and the expected yield of carbon dioxide they calculated, students determined the percent yield of carbon dioxide for the experiment. Finally, a single question required students to speculate on any possible sources of error in this experiment.

For the remainder of the period students worked in pairs, save for one group of three. Ms. Davis rotated from group to group assisting with any questions or checking on their progress. She was sometimes called to a group or noticed a group having problems. One student asked, "does vinegar have acetic acid in it?" Ms. Davis responded, "vinegar is acetic acid. I bought it at the store. It is diluted." Another student added, "will it explode if we put lots of baking soda in the bag?" Ms. Davis smiled and responded, "well, the pressure will cause the bag to pop. So, no sir, no explosion."

As the students' work progressed, several other students asked if it would be possible to increase the amount of baking soda or vinegar. Ms. Davis connected this lab activity to the well-known baking soda volcano. A student then said that she had seen the Mentos dropped into a 2 L bottle of coke YouTube video and asked if this was like that video. Ms. Davis said this was not the same reaction, then brought the class back to their focus on their group's work on this lab. After 25 min. time, students had moved into the calculation hand written questions on the lab handouts. The class was interrupted by announcements on the school intercom system shortly thereafter. After the announcements concluded, with about five minutes left in the period, Ms. Davis announced that the class would complete the calculations on Monday and that the lab needed to be cleaned up before the dismissal bell.

### *Analysis of Case*

South Hampton is unique among the schools profiled in these three case studies because it is the only school from which two teachers participated in the program at the same time. Moreover, these two teachers are relatively close to one another in terms of teaching experience, and were also teaching different sections of the same, albeit non-MAST related, subject.

All of our teachers mentioned that attending MAST during the academic year was sometimes challenging. After a long week of teaching, the last thing some teachers want to do is drive two hours, stay in a hotel and spend ten hours in classes. However, a team of two teachers has built-in motivation. Amy and Chloe encouraged each other to attend the program and to participate. Moreover, because each MAST teacher receives a full set of the equipment and resources distributed at MAST, if teachers share materials when they return, this is a more cost effective way for a school to bolster its science classroom technology. South Hampton's science department encompasses grades 7-12, with three teachers responsible for all high school science courses. The 7th and 8th grade science teachers also have access to the MAST resources and are being recruited by their high school peers. In addition, because Amy and Chloe already had two Vernier Labquests and probe kits because MAST distributes them for free, once the school ordered three additional LabQuests and kits, the school then had five, enough for a class of 20 students to work in groups of four using a single Vernier. The additional free Vernier saved the school more than \$400.

The third science department teacher is a twenty year veteran, and is not likely to participate in MAST. Listening closely to Amy and Chloe speaking about her, both teachers clearly respect her, but are reluctant to press her to participate. She also seemed unwilling to take them up on their offer to share the resources they had received from Project MAST. It is possible that she is reluctant to change her teaching practice this late in her career, and thus is uninterested in learning about MAST's potential benefits. It is also possible that despite their cordial personal relationship with her, Amy and Chloe are reluctant to push harder in recruiting their colleague to enroll in the MAST program.

The school's new principal has made the improvement of science labs a priority. This dovetails neatly with MAST's distribution of science equipment and other resources. However, as two of the other three cases, the principal is not a science content specialist, and is not as engaged with the changes in their teaching that have resulted from their MAST participation. His response when asked about changes in their instruction is rudimentary, "Their lesson plans are in depth and they use them. As far as the equipment, the technology, the resources they use, there so much has changed at the high school level and they're actually getting curriculum that I didn't get until I was in college in Biology." This seems to indicate that he's capable of grasping their

lesson planning, but is somewhat in awe or intimidated by the content they're teaching to students.

Both of the teachers in this case described project mast as the program that increased their content knowledge, their pedagogical skill and their confidence in their ability to teach science. Brandy describes her growth in confidence as a shift towards guided inquiry. She is more willing to, "let them think through the process, make the decisions, let them come up with a hypothesis, but then decide what to test, let them go through the whole process without having a step-by-step this is what they do, so that way they demonstrate to me not only do they understand the concepts but they can apply the concepts and the understand the scientific process."

She also felt that Project MAST is a great place for teachers to share their knowledge. She expressed the hope that project mast would someday allow teachers full session to either share an activity that works in their classes or to share teaching strategies. It is clear that in her school's small science department there is a culture of collaboration. She seems to believe that mast could benefit from a similar culture.

Both teachers felt that the activities and science knowledge that they brought back from project mast benefits their students. However, their ability to implement some of that knowledge is constrained by their school's small size and limited course offerings. For example, project mast devotes a good deal of time to astronomy, even sending out a portable planetarium to participating schools. South Hampton does not offer an astronomy course. Astronomy is only a half credit elective course in the Mississippi science curriculum. Brandy said that despite the large amount of time spent in the program studying astronomy, she would likely be unable to use that knowledge at any point. Conversely, Chloe has found that project mast has improved her knowledge and confidence teaching physics as a part of her physical science course. Whereas she formally emphasized chemistry because of her strong academic background in that subject, she now feels more comfortable teaching physics and doing physics lab activities.

In the case of South Hampton high school, teachers are not working in isolation, as in the other rural case in this set. However, they are more constrained because of the small size of their department of only three teachers, in terms of course offerings. Their principal is regarded as hands-off, perhaps even uninvolved to a fault, and thus it seems they are reluctant to approach him in order to make changes to broaden the school's course offerings. Thus, the school's small size is an asset in terms of the collegial nature of the science faculty, but is a challenge in terms of providing the maximum breadth of science coursework available to Mississippi public school students.

### *Summary of Findings*

Teachers' <sup>4</sup> participation in Project MAST resulted in increased confidence. Participants felt that Project MAST allowed them to review science content knowledge they had last encountered in high school or college, but were expected to teach now. This made them more confident in their content knowledge, which had a range of consequences. Teaching courses with which they had taught in years past, all of the teachers were more willing to trust students to guide classroom discussions and more willing to use hands on activities. Teachers were also comfortable enough with MAST activities that they were adapting them based on their students' needs or creating new activities inspired by MAST lessons. Bruno Smith's fluid viscosity lab,

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<sup>4</sup> The distinction between perceived content knowledge gain and content knowledge gain as measured on our assessments is important. One thing we might examine in the future are the kinds of content knowledge that teachers feel they gain from Project MAST.

despite being a failure, was an excellent example of the confident adaptation of a MAST activity. Smith did not have a class set of the constant velocity tubes MAST distributes, but attempted to replicate the principle of velocity in a fluid using common materials. In previous years, Chloe Peters felt that she had neglected to teach the Physics objectives in the Mississippi Curriculum Framework for Physical Science, and had instead focused on Chemistry, her undergraduate major. However, after participating in Project MAST, she said that she felt much more capable of teaching those Physics related objectives because of her increased content knowledge. Gina Smith describes her willingness to allow students to direct their own activity during lab activities. She says this would not be possible if her confidence in her own Chemistry and Physics content knowledge had not increased. Finally, Bruno Smith has said and Amy Davis has intimated that Project MAST's focus on Physics has been sufficient to equip him/her to take the Praxis II in Physics, thus adding a Physics endorsement to his/her teaching license. In general, the practices resulting from this theme may result in improved student learning opportunities, access to more of the knowledge required by the state curriculum and an increase in rural schools' capacity to offer Physics.

Teachers' participation in Project MAST also connected them with other teachers, thereby mitigating the isolation they experience as a result of their unique circumstances. All four participants agreed that meeting other teachers from around Mississippi helped them to realize that their struggles were not unique, but that other people faced similar challenges. This is related to the increase in confidence outlined above. Teachers not only learned more science, but also learned more about how and under what circumstances others teach it. They also agreed that other teachers were useful resource for ideas on how to teach particular topics or to remember the specifics of a MAST activity. Also, in the case of Amy Davis and Chloe Peters, participating in Project MAST strengthened an already existing relationship. These two teachers pooled their MAST resources, approached administrators together with suggestions for additional science equipment purchases and even attempted to team teach the same non-MAST related course. While they were participating in the program, these two teachers also felt that they helped each other stay engaged with the program and attend on days when they might not have otherwise done so by themselves. This cross-cutting theme reveals that the MAST network of teachers is a valuable asset. Teachers' confidence increases as their sense of isolation decreases. Knowing that other teachers have similar struggles and having supportive colleagues in the same building encouraged each of the case study teachers to teach with confidence and to approach school administrators with suggestions, concerns and assessments of their students' needs.

Administrators are not an impediment to the implementation of MAST activities and strategies in the classroom, but they are not doing all that teachers believe they can to support MAST in schools. They view Project MAST favorably because they see the increased confidence in their teachers and are glad to receive the additional lab equipment and instructional resources. Administrators are willing to support MAST teachers by improving material conditions in science classrooms: purchasing new chemicals, purchasing a classroom set of Vernier LabQuests, funding a new computer lab. However, they are not providing instructional leadership to change science pedagogy. Two seemed intimidated by the science instruction they saw, one saying that his teachers were doing work that he had not done until he was an undergraduate. Another, a former biology teacher, remarked that he could not provide his MAST participant teacher with much feedback on her teaching because it was so different from the way he had taught it two decades prior. Knowledge of and appreciation for MAST are resulting in some kinds of support, but not others.

In all three cases, school level professional development is focused on implementation of state and district mandates such as testing, positive behavioral interventions and frameworks for addressing students with special needs. Project MAST thus represents a unique professional development opportunity: one focused on the state mandated Science curriculum and how to improve teaching rather than how to improve test scores. Teachers recognized this and did not view it as a program liability. Instead, they welcomed the opportunity to participate in content specific professional development designed to improve their pedagogical practice and better equip their classrooms.

## **Discussion**

### *Strengths and Limitations of the Methodology*

One of the purposes of program evaluation is to equip program staff with data and insights that are potentially useful for changing the program to better serve its participants and to better meet its goals. Most of the qualitative data collected from program participants in the Project MAST evaluation is written feedback on individual workshop sessions and at various key points during the program (e.g. the end of the summer institute, completion of the program.) This data is most immediately useful for making decisions related to the program's structure. The qualitative case studies presented here are helpful because of their depth. That depth is made possible by extended site visits and long conversations with participating teachers, their administrators and students, and the chance to observe multiple lessons. In the day-to-day commotion that is the management of an NSF grant funded program, there is little opportunity for program staff to step back and consider participants' experiences and the program's effects in depth. These cases make that possible.

As we pointed out in the introduction, these cases have no predictive power. There is no algorithm that allows Project MAST staff to take the information in these cases, make changes and know with certainty what consequences will follow. We cannot be sure that recruiting teams of teachers from underresourced schools will result in strong participation and the cost effective improvement of a school science department's lab equipment. Nor can we be sure that isolated teachers will forge strong connections with their peers in the context of Project MAST. Instead, we can use these cases to improve our ability to anticipate what will occur in the context of the program. We can say that it is likely that school administrators will provide little more than material support to their science teachers and that many of them will be intimidated by anything bearing the name science. We can anticipate that teachers with increased confidence in their science content knowledge will consider how they might alter lessons they have taught in the past. Indeed, we can use that insight to provide a structured space within our program for them to be guided in such practices. Our cases are limited by their specificity, but gifted in their depth.

### *Implications for Project MAST's Design and Evaluation*

True to their intention, the cases have informed the design and evaluation of Project MAST in a number of ways. When the cases are treated as formative evaluations of the program, they highlight needs that should be addressed for teachers to maximize the classroom impact of their professional development experiences. For instance, the cases have suggested that administrators could play a stronger role in facilitating professional development. Project MAST staff have therefore created an annual day-long seminar to acquaint administrators with the program and give them suggestions for supporting their teachers. The hope for these seminars is to better acquaint administrators from participating MAST schools with the MAST program and

to increase their capacity for instructional leadership. Findings from end-of-seminar surveys suggest that the seminars are meeting these goals well (Yumol, 2011).

The cases have also indicated that teachers benefit from being part of a larger community of practice. How can this community be maintained between Project MAST sessions and long after the professional development has ended? Project MAST staff are investigating the most feasible and effective ways of helping teachers keep in touch with one another. They've tried one online community, OpenVES, which teachers rarely used. They plan to present a new system in the upcoming summer program.

When the cases are used as summative evaluations, they serve to reinforce and expand the theory of change. First, the cases reinforce the theory of change model, providing initial evidence from the first cohort that Project MAST is meeting its goals. Teachers report increased confidence, and varying degrees of increase in their content knowledge and skills. They demonstrate this confidence and skill in their classroom teaching and conversations with peers and administrators. This data corresponds to findings in the quantitative survey data (Rockman et al, 2010). At the same time, the cases highlight factors that appear to mediate teacher growth, such as intrinsic motivation and within-school collaboration.

Second, the cases expand the theory of change by identifying long-term outcomes for future study. While the original theory of change model focused on benefits to individual teachers and their students, Bruno Jones' case demonstrates how a single teacher can expand the capacity of an entire school. Future evaluation work will pay closer attention to short and long-term benefits at this larger school level.

With the four cases presented in this paper, and the ones that will follow in the subsequent years of Project MAST, evaluators will continue to refine the program's theory of change, gradually replacing theoretical constructs and pathways with empirical evidence of program implementation and effectiveness.

### *Implications for Research on Teacher Education*

Our case study approach enhances and expands the literature on professional development in several ways. The research to date has focused primarily on using large-scale studies to identify the features of professional development that have the greatest influence on teacher outcomes (Desimone, 2009; Holland, 2005). From these studies it has become apparent that coherence, or alignment with teachers' prior knowledge and school, district or state standards and policies is essential to the design of effective professional development programs (Desimone, 2009). Our work offers individualized, qualitative narratives of the ways in which teachers' past and present experiences mediate their ability to make professional development meaningful and feasible in their classrooms. Ultimately, all professional development – like politics – is local; large-scale, statewide professional development initiatives must be cognizant of school and teacher-specific contexts and challenges if their programs are to be truly successful. This study and the discussions we hope it fosters have implications for making large-scale professional development sensitive to local contexts, and for establishing school or district policies and practices that optimize professional development implementation in classrooms.

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