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ABSTRACT

A survey of participants in a model teacher education program examined instructor and student attitudes toward modeling of recommended instructional approaches. The Maryland Collaborative for Teacher Preparation (MCTP) has the goals of developing and implementing programs to prepare special middle grade level mathematics and science teachers at Maryland public institutions of higher education. This study involved semi-structured interviews of two groups of participants. The first group included instructors of MCTP mathematics and science content courses taught at six colleges/universities and three community colleges in Maryland during school years 1994-95 and 1995-96 (n=31, 102 interviews). The second group was comprised of MCTP teacher candidates enrolled in some of these courses (n=85, 146 interviews). Most MCTP content instructors indicated they accepted the dual role of modeling good instruction while teaching content. For many teachers, the role of exemplar was new and teachers made special efforts to offer models of good teaching while creating collaborative learning environments. Students' responses indicated they generally appreciated instructors' efforts to model good instruction. Both groups expressed concerns about using the same teaching approach for college students and middle grade students. (Contains 15 references.) (JLS)

University Faculty "Modeling" Good Instruction in Mathematics and Science Courses for Prospective Middle Grades Teachers: Voices from the MCTP

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Introduction

Learning to teach is a complex process, taking place over an extended period of time. There are a number of factors that influence this process. One of the most powerful influences frequently asserted is teachers' own experiences as students (for example, Britzman, 1986; Holt-Reynolds, 1992). The notion of "teachers teach in the manner they were taught" has been well documented and discussed. This idea is consistent with the basic assumption of social learning theory:

> Learning would be exceedingly laborious, not to mention hazardous, if people had to rely solely on the effects of their own actions to inform them what to do. Fortunately, most human behavior is learned observationally through modeling: from observing others one forms an idea of how new behaviors are performed, and on later occasions this coded information serves as a guide for action. (Bandura, 1977, p.22)

The impact of teachers' teachers is of special concern in time of systemic changes in mathematics and science education. Those of us who are involved in the process of preservice teacher education are engaged in helping teacher candidates develop a different style of teaching from those they themselves experienced and observed. One of the most crucial components of such an effort seems to be that preservice teachers to experience such teaching in their undergraduate and graduate courses. Many educators take on this challenge and attempt to teach their courses in the manner consistent with new visions of teaching (for example, Ball 1988, 1990).

However, this effort should also include not only the professional courses preservice teachers take but also content courses they experience in their teacher education processes. Recent mathematics and science reform documents by National Council of Teachers of Mathematics (1991), American Association for the Advancement of Science (1993), National

Science Foundation (1993), and National Research Council (1996) argue that mathematics and science courses for preservice teachers must also be taught in the manner consistent with the new visions of teaching. But, how do instructors of content courses, especially content area specialists such as mathematicians and scientists, perceive this notion of 'modeling' good instruction? Furthermore, what do college students, i.e., preservice teachers, see in those courses where good instruction is supposed to be modeled? This paper reports findings from a study conducted by the research group of the Maryland Collaborative for Teacher Preparation (MCTP). Specifically, the following four questions will be addressed in this paper.

1. What are the MCTP instructors' perceptions of modeling good instruction?
2. What and how are they modeling?
3. Do students see the instruction in these courses modeling the type of instruction for middle grades mathematics and science?
4. What impacts are these courses having on prospective teachers' pedagogical conceptions?

MCTP

The Maryland Collaborative for Teacher Preparation (MCTP) is funded by the National Science Foundation, and the project's goal is to develop and implement special teacher education programs on a number Maryland public institutions of higher education. These programs aim to prepare special middle grade level mathematics and science teachers who can: (1) teach mathematics and/or science emphasizing their connections, (2) utilize modern technologies in teaching mathematics and/or science, and (3) effectively implement alternative teaching and assessment strategies. Although each campus has developed its own program, there are certain common features to these programs, and those features are shown in the figure 1.

One of unique features of these programs is the new content courses that incorporate teaching strategies that are consistent with the visions presented in recent reform documents. Thus, this project included not only mathematics and science educators but also a number of mathematicians and scientists. The project participants developed new courses and modified existing courses so that they will reflect the spirit of MCTP. MCTP courses were first offered in Fall of 1994, and the program continues to grow.

The teaching of MCTP courses was informed by the constructivist principles (e.g.,Brooks and Brooks, 1993). Specifically, the project emphasized the following:

* highlighting connections between mathematics and science
* understanding and using students' prior conceptions
* emphasizing understanding as opposed to rote memorization and practice (and using appropriate assessment strategies to reflect this emphasis)
* encouraging students' to reflect
* using appropriate technologies

Methodology

Participants:

There are two groups of participants in this study. The participants in the first group are instructors of MCTP mathematics and science content courses, taught at 6 colleges/universities and 3 community colleges in the State of Maryland during school years 1994-95 and 1995-96 (TOTAL: n = 31, 102 interviews). The break-down of the faculty participants' specialities is shown in Table 1. The participants in the second group are MCTP teacher candidates from 6 colleges/universities enrolled in some of these courses (n = 85, 146 interviews).

Data Collection and Analysis

The data for this study were semi-structured interviews. Instructors were interviewed

twice during the semester they were teaching their MCTP courses, and once during the following semester. MCTP teacher candidates were also interviewed twice during the semester they were enrolled in MCTP courses. A subset of MCTP teacher candidates were selected to gather longitudinal data. The interview protocols are included in Appendix. All interviews were audio-recorded and later transcribed. The transcribed interviews were coded to identify patterns and themes (Alasuutari, 1995; Glaser & Strauss, 1967; Goetz & LeCompte, 1984; Lecompte, Millroy, & Preissle, 1992).

Findings

Extensive use of exemplar faculty and teacher candidate statements are used to support the themes which emerged from the data. The purposes for the use of the exemplars are varied. Fundamentally, they are intended to enhance the credibility of the researchers interpretation of a complex area of social science investigation. They do so by providing the reader with authentic instances of the faculty and teacher candidates perspective of their social world. The use of the exemplars also allow for the depiction of multiple perspectives within and between groups. Finally, they are essential to the development of a collaborative text, co-constructed by the interplay of the researchers, the reader, and the faculty and the teachers candidates representing the setting of the study (Atkinson, 1990).

Instructors' Voices

How did instructors perceive their role?

For most of the content area specialists, intentionally working with prospective teachers was a new experience. They might have had some prospective teachers in their courses, but their focus was on teaching content. However, most MCTP instructors interviewed accepted the idea of modeling good instruction for prospective middle grade

mathematics and science teachers as a part of their roles. For example,

> My role in teacher education, I see myself as a trying to model the kinds of teaching that I would hope they would be doing in their jobs as they get out. Secondly, perhaps getting them to think about the different ways in which, when they do get out, they might like to teach science and mathematics. (science instructor, institution #2, 3/96)

> Trying to get the students a good model to follow in the classroom for working with, you know, their own students and to develop for them an approach pattern that's probably different from the one that they were trained into where the work is more hands-on, more concrete, more doing in conjecture and so on. (math instructor, institution #3, 4/96)

Furthermore, not only have they accepted 'modeling' as an appropriate role, more than 10 MCTP instructors indicated that they felt good about their students using the teaching strategies they had used in their courses as the following quotes indicate:

> I would feel good about it if my students taught in a way which I think we went about it this semester. I would feel quite happy then. (math instructor, institution #5, 12/95)

> I think that was probably the strongest part of what we did. I feel very confident that the way that we did things was... basically the right way, and I think if they approach their students that way, they'll be successful.(science instructor, institution #4, 11/95)

The primary reason for these instructors' positive feeling appears to be their observation that their students were having more successful learning experiences. Furthermore, this observation impacted these instructors' teaching in general. For example,

> ... there were two or three activities that I had scheduled the first time that we didn't get to, and it was very interesting that, even though that was the case, I was able to get through most of the major concepts to them. I mean, they were able to come up with those ideas from a smaller number of exercises, so, I think that was an eye-opener to me, that maybe it's better to do fewer things and give them more time to reflect on it than to try to do too many exercises and push them too hard. So I think that's my major change. I'm not so nervous about it now, and I am willing to let the class lead me rather than have me lead the class. (science instructor, institution # 4, 1/96)

> I'm convinced. I would not teach it differently. I could not go back and

> lecture to them the way that I did for years. That's a good summary. I could not do that. I would be doing them a disservice. (mathematics instructor, institution #2, 10/95)

However, these instructors' efforts to model good instruction were not without problems and difficulties. One issue raised was whether or not the same teaching strategies are appropriate for both college and middle grade students. For example, a mathematics instructor responded to the question, "How do you feel about your students teaching their students in the way that you taught this course?" by saying,

> Well, I hope they wouldn't because I'm trying to teach adults, and they're trying to teach children, and I don't think that that's necessarily exactly the same thing. (mathematics instructor, institution #6, 11/95)

Two other instructors expressed similar concern about the contrast of adult learners, that is, teacher candidates, and young middle grade learners. A variation of this concern was expressed by a science instructor who wondered whether similar equipment would be available in middle grade classrooms. However, this issue did not attract an attention from a wider audience.

How and what did instructors model?

Although MCTP content instructors were still grappling with different issues, most instructors reported that they were indeed attempting to model good instruction. Therefore, the next question was how and what MCTP instructors modeled. The ways MCTP instructor modeled fell into two categories: focusing on middle grade teaching and learning, and creating student-focused mathematics and science classrooms.

Focusing on middle grade teaching and learning

Some of MCTP instructors decided to model by connecting classroom discussions and activities directly to middle grade teaching and learning of mathematics and science. Two

strategies often mentioned were: (1) discussing about young learners, and (2) using activities and materials that can be used in middle grade classrooms.

Discussion about young learners usually meant MCTP instructors asking their students to think about how they might teach the specific mathematics and science concepts under consideration. For example,

> We tried to emphasize, "How would you explain this concept?" "How would you do this?" "What sort of activity would you do for a student like this?" And many of the activities we kept stressing were in fact things that, you know, they don't require a lot of knowledge, prior knowledge. (mathematics instructor, institution #3, 12/94)

> Some of the exams questions would be in the line of I would ask them, I would say, "You are a teacher of, let's say, a 4th-grade class, and as part of your science unit you're going to be trying to a section on Newton's Laws." And I would ask them then to design some... some hands-on activities in a similar fashion to the ones that they had experienced, that they would feel comfortable using in the 4th-grade setting. So they'd have to take the science knowledge they were learning, and they would have to then interpret it in terms of how they would do presentations and appropriate material at, let's say, the 4th-grade level, or the 3rd-grade level, or the 6th-grade level. (science instructor, institution #2, 10/95)

These instructors attempted to model by connecting mathematics and science content of their courses to middle grade teaching and learning situation.

Another strategy used by MCTP instructors was the use of activities and materials that are also appropriate in middle grade classrooms.

> What we've been showing whenever possible, relatively easy ways to demonstrates, you know, some scientific principles... the same thing with our outdoor activity with the... the solar system, stuff that could be done in the elementary or a middle school class without a lot of expensive stuff. (mathematics instructor, institution 3, 10/94)

> The activity sheets that they were given, for example, were formatted so that that kind of activity sheet could be used when they teach. As I said, we did... we did spend a lot of time talking what they were seeing here in this course and what they might apply later on in their own teaching. (science instructor,

institution #2, 10/95)

Thus, some MCTP instructors felt that they modeled the type of instruction appropriate for middle grade level because they used the activities that could be directly translated into the future classrooms of their students. Moreover, some of them made their intent known by discussing about it.

It appears that these instructors were attempting to keep the visions of middle grade classrooms and learners in teacher candidates' vision through these activities and discussions. The main emphasis is to make the connection between college level mathematics and science courses and middle grade mathematics and science courses more direct and obvious by focusing on middle grade teaching and learning situation.

Creating student-focused mathematics and science classrooms

Another way MCTP instructors attempted to model good instruction was by creating different types of mathematics and science classroom environments. Instead of explicitly discussing pedagogical issues, instructors focused on creating the type of learning experience that enhanced teacher candidates' learning of mathematics and science. Their main emphasis is to model *good instruction* appropriate for their students, that is MCTP teacher candidates. To achieve this goal, MCTP instructors attempted to engage their students more actively in their courses and emphasized students' own understanding.

MCTP instructors used a number of strategies to have students actively participate in their courses. One strategy MCTP instructors employed was through the use of cooperative group activities:

> Essentially what we did was to let them... you know, as you'd expect, let them develop the ideas, and...and begin by finding out where they are, encouraging them to do a lot of talking with each other, trying to encourage

> them that this was not a competitive situation, but rather a situation where they're trying to help each other to understand things ... (science instructor, institution # 4, 11/95)

> Well, very much more running class sessions with students actively involved in something in collaborative groups themselves, much less of the sort of read something and then come to class and talk about it kind of style of operating. Much more emphasis on strategies for using collaborative learning. (mathematics instructor, institution # 5, 11/95)

Another strategy often used by the instructors to actively engage students was by using activities that required the students to handle equipment and manipulatives:

> I tried to have as much hands-on kind of experience as I could ... I did very little in the way of... lecturing. (science instructor, 12/94)

> ... every single day they have... they are handling, something where they are creating the math... the math reality. ... any of the math facts that we are exploring from that curriculum we're going at from a discovery point of view and I think that this is really what needs to be happening in the classroom as well, and getting at things from a visualized point of view rather than from just manipulation of abstract symbols. (math instructor, 3/95)

Others have tried to encourage students to share their ideas. Moreover, some of them not only had students share their ideas, but also tried to accept students ideas and allowed students' idea to drive their courses. Yet others focused their attention on their questioning. They encouraged students to participate by asking questions that challenged their prior knowledge, and asking them to reflect on their new ideas. In essence, these instructors were trying to create different patterns of classroom interactions, different from what they have done in the past.

As these instructors attempted to create different classroom interaction patterns, many of them were also shifting the focus of the classroom from themselves, that is, the instructors, to the students. Instead of them working out examples and lecturing how to solve problems, many MCTP instructions mentioned that they had their students find and

verify solutions to problems:

> I mean, clearly, this business of, you know, having the students figure things out. ...We do a lot of things we won't answer questions. We have a lot of activities where we.... They're doing one of the glob experiments right now and the globe wasn't marked off quite right, and we said, "Well, work it out." ... You know, we won't... we won't answer questions. Let them figure it out. And they sit down in a group of two or three and they make their best guess, and they start collecting data, and they start doing it, and they start figuring out. And that approach will work anyway, so a constructivist approach we're trying to illustrate. (mathematics instructor, institution # 3, 10/94)

> I didn't interpret the answers for them. When they would come up with an answer, or a concept, or an idea, I would either have each group come up with an idea and write it on the board, and then the other groups would critique it, the individuals would come up with an idea, and rather than say, "Yes, that's right," or "No, that's wrong," I would ask the rest of the class to either defend it or... or disagree with it. I think that when... when things were really working well and I had... had good lab experiences for them and they were really involved with the course, which I think was most of the course, you know, that that is exactly the kind of thing that I would... I would like to see them doing in the lower grades. (science instructor #4, 12/94)

In summary, by engaging their students more actively and encouraging them to find and verify their own solutions, these MCTP instructors attempted to create more student-centered mathematics and science classrooms. As the last quotation by a science instructor indicates, some MCTP instructors envisioned that middle grade level mathematics and science classrooms should be about student engaged in mathematics and science. Therefore, what they tried to model was to create similar experiences for prospective teachers.

Students' Voices

Did teacher candidates feel MCTP instruction was appropriate for middle grades?

Seventy-five interviews with MCTP teacher candidates included that question whether or not the instruction they experienced in their MCTP courses modeled the type of instruction that should be used in grades 4 through 9. During those 75 interviews, there

were 69 affirmative responses and 9 negative response. [Note, because some of the participants were taking more than one MCTP course at the time and chose to respond separately for each course. There were also four cases the response could not be classified as affirmative or negative. Therefore, the total number of responses do not match the number of interviews.] Of the 9 negative responses, four came from the participants who were enrolled in a large lecture science course in which only one of the laboratory sections was designated as an MCTP course. In fact, one of the four responded positively toward the laboratory section while responding negatively to the lecture. The remaining 5 negative responses came from four different MCTP courses at 3 different institutions. For 3 of the four courses, there was at least one positive response from other teacher candidates in the same course. The only exception is the case where only one MCTP student was interviewed from Institution 6.

Thus, in general, MCTP teacher candidates felt their MCTP instructors modeled good instruction. But what were the reasons they felt the instruction they experienced in MCTP courses was good? One reason frequently mentioned was that they "learned more" in MCTP courses. For instance,

> ... in the classes that I'm doing now because they're being taught differently than my other ones, and I've learned so much more in the past four weeks than I did, like, in my years in high school just because I've had to do it on my own and not had someone tell me, "Do it this way. This is why it is." (institution #4, 3/95)

> ... I think I have learned 20 times better with my math class now than I probably did in all the other math classes. (institution #5, 12/94)

Thus, as MCTP teacher candidates reflected upon the quality of instruction, they observed that the result, that is, their own learning, was positive. This self assessment then led to the

conclusion that the teaching they experienced modeled good instruction that should also be used in middle grade mathematics and science courses.

What did MCTP teacher candidates observe?

What are specific ideas that these MCTP teacher candidates gained from their experiences as students in these courses? In other words, what did they see as a good 'model'? Features MCTP teacher candidates identified include more interactive classes, connections to 'real-life, paying attention to the learners, and letting students find and verify solutions on their own.

Just as the instructors have noted, many MCTP teacher candidates stated that MCTP courses were much more interactive. One of the reasons MCTP teacher candidates felt that there was more interaction in MCTP courses was the use of manipulatives and equipments:

> ... and she [mathematics instructor at institution #3] was always using manipulatives. You know, it's just some kind of plastic things, especially with geometry, and I think that was the best to show, like, 3-D figures and stuff like that. (10/95)

> ... we use a lot of hands-on type stuff. (institution #5, 10/94)

Another factor that influenced teacher candidates' perceptions of the nature of interaction in MCTP courses was the use of small group activities:

> We had a lot of cooperative learning groups, and the project made it more fun than just, you know, doing problems out of the book. So, yeah, I would think it did ... (institution # 2, 12/95)

> ...the similarities [among MCTP courses] are the discussions, the groupings, that we students are grouped and in our groups we discuss, analyze and evaluate whatever lesson we're assigned to... (institution # 1, 4/96)

> I guess the similarities you, not only you learn from the teacher, you learn from other students. You learn from the questions asked and you sort of answer, they encourage the students to answer the questions that other students ask ... (institution # 5, 5/96)

Other students mentioned about MCTP instructors' emphasis on questioning, discussing alternative solutions, and listening to students' ideas as contributing to more active participation by students.

Another factor MCTP teacher candidates indicated was that many of them felt classroom activities and discussions were connected to 'real-life' experiences.

> Dr. (mathematics instructor at institution # 3) is very good about.... She takes.... Before she starts on an equation, or a new theory or principle, she puts it into real life so you can understand it ... (5/95)

> ... they [MCTP courses] all stress how things are used in real life more than just memorization of facts. (institution # 5, 4/95)

For these teacher candidates, the connection to real-life is an important ingredient in middle grade mathematics and science courses. For example, one teacher candidates said,

> I think that a good science teacher would be one that would explain where science is all over the place and get... get the children comfortable with science by ... when you do different kinds of lessons, use things that they're familiar with. (institution #5, 4/95)

It is interesting to note that few MCTP instructors mentioned this connection to 'real-life' as something they stressed. However, many mathematics instructors tried to use science as contexts to doing mathematics problems (Watanabe, McGinnis & Graeber, 1996). This emphasis along with the efforts by some of MCTP science instructors to utilize materials that are easily accessible by middle school teachers may have contributed to this real-life connection perceived by MCTP teacher candidates.

Another idea MCTP teacher candidates felt as modeling good middle grade teaching was that they felt MCTP instructors paid close attention to students' understanding. For example,

> You take what they know and you build upon it, and I think that's kind of

> what MCTP does. You know, the philosophy is just a scaffolding process. (institution #3, 12/95)
>
> And he asks a lot of questions and wants to know our thinking. (institution #5, 10/94)

MCTP teacher candidates felt that good mathematics and science teachers of middle grade levels would be able to present their materials in the manner appropriate for their students and anticipate potential difficulties their students might encounter. This kind of attention, for these MCTP teacher candidates, was an essential quality of good teachers.

Finally, many MCTP teacher candidates pointed out that one unique feature of MCTP courses that would also be appropriate in middle grades was their emphasis on students finding and verifying their own solutions.

> ... in science class a lot of times the questions they try to make us think and come up with good questions. They don't just give us the answer, you know. They come up with an idea and we have to kick it around and play with it, you know. They don't just tell us the answer, we kind of have to come up with it. They help us work our way through it. (institution #3)
>
> In the beginning it was a little frustrating because, you know, you thought, well I think this is it, and when they wouldn't tell you the answer, well I'd hit the library and go find out so I could satisfy myself. But I think that was the purpose is to make us want to go and discover and to realize that it is the process that is more important than the answer a lot of times. (institution #3)
>
> ... the MCTP was more about us finding out the answers... (institution #5)

In general, what teacher candidates constructed as visions of instructors' practices matched what the instructors believed they modeled. MCTP teacher candidates felt that the nature of classroom interactions was different in MCTP courses from mathematics and science courses they had experienced previously. They also noticed that they were expected to solve problems on their own instead of instructors telling them what the answers were. MCTP teacher candidates generally considered these features of MCTP courses as positive

and many expressed desire of learning how to teach "this way."

Discussion

Overall, most MCTP content instructors have accepted the dual role of modeling good instruction at the same time teaching content. The following statement by a mathematics instructor from Institution 3 succinctly express the content instructors' feelings:

> One is to be a role model of how to teach some of this material, although more importantly, my role is to help the students learn how to use the constructive supports themselves to learn material. So, in a sense I'm doing two things, I'm teaching them how to teach this approach as well as getting them to learn it. (3/96)

However, this dual responsibility raised an issue of balance between content and pedagogical foci in mathematics and science courses. As much as these instructors have accepted the role of modeling good instruction and felt good about what they were doing, "at times we really needed to remind them in the course that this wasn't a methods course, that this is a science course" (science instructor, institution #3, 5/95). Two other instructors stated that pedagogical foci belonged to mathematics and science methods courses.

One possible source of this concern might be the interpretation of modeling as explicit discussion of pedagogical issues. As we have discussed above, one way some MCTP instructors modeled was by discussing about teaching and learning of young learners. This explicit discussion of pedagogy appears to raise two issues. First, there is an issue of competence. For example, a science instructor said,

> ... we tried to in many cases talk about what these kids might do with an elementary classroom. I guess I shouldn't say many times, but from time-to-time we'd start talking about, "Well, you know, on this subject, how would you present information on radioactivity or something of that sort to a group of fourth-graders, or fifth-graders, or seventh-graders?" just to get them thinking in terms of that although we didn't try to make this any kind of methods course or anything like that, that was.... That's outside our bailiwick.

> ... But at least I think we got them thinking about it. (science instructor, institution #4, 5/95)

Thus, although she did explicitly discuss teaching and learning of young learners, she only wanted to "get them thinking." Anything beyond that would be "outside our bailiwick." The second issue is more fundamental. Some instructors questioned whether or not it is appropriate to explicitly discuss pedagogical issues in content courses. (see Roth-McDuffie & McGinnis (1996) for a case study of a mathematics instructor who felt discussion of pedagogical issues in his content course inappropriate) Of course, this brings us back to the question of what it means to model good instruction. The question is not whether or not modeling good instruction is appropriate in content courses, but, rather, whether or not explicitly discussing pedagogical issues is an appropriate way to model in content courses.

Interestingly, teacher candidates also raised a similar concern. Just as some instructors questioned the appropriateness of using the same teaching strategies for both college students and middle grade students, some teacher candidates also raised the same concern. For instance,

> It might [be] appropriate for middle school, but I don't think it's appropriate for college.... Because I think we're going.... I think maybe it's just me personally, but I think we're going way too slow, and we're staying on one topic for a bit too long, and doing labs on the same idea over and over again. And I know some people still probably aren't getting it, but for the people who are getting it, it's... it's getting frustrating.(institution #5, 4/95)

> Some of the instructors that I have had have taken on the model approach, as far as they model what they want us to be doing when we are in the classroom and that is really good as long as its not taken to an extreme that we're treated as children in a classroom. I had one instructor that did that and it was quite irritating. (institution #2, 4/96)

These comments parallel the instructors' concern discussed above. MCTP teacher candidates in general appreciated and enjoyed MCTP instructors' efforts to model good instruction.

However, they, too, were questioning how this modeling should be done.

One of the underlying theme that was common to both the instructors' and the teacher candidates' voices is the notion that learning is the responsibility of students. Both instructors and teacher candidates recognized that one of the main features of MCTP content courses was that students were expected to find their own solutions. Furthermore, both instructors and teacher candidates, at least eventually, came to view this as a positive aspect of MCTP content courses. The primary reason for this conclusion was the quality of learning by the teacher candidates. Both instructors and teacher candidates reported that learning that took place in MCTP courses was much better than what they had observed or experienced previously.

This realization has led to some of MCTP teacher candidates to view their MCTP content courses as a new, alternative image of mathematics and science teaching. For example,

> I never...never thought that math could be taught other than follow these examples and fill in this formula. I always thought that, you know, that that's the way it should be taught, and that's that you can learn it, but I saw, watching Dr. (mathematics instructor at institution #5) and how he taught, that in seeing how I didn't have to cram the next four tests, I knew what I was doing, and I could remember a lot of things that we did in that case. Whereas, I mean, from any high school math class, I can't.... I can tell you, you know, the big titles, but I don't know what any of that means, or how they relate to each other.
>
> Like, until these courses, I wouldn't think science could have been taught similar to the way it was. (institution #4)

The realization that their students were learning better led some of MCTP instructors to teach their 'other' courses in "MCTP style". The following statements by a science instructor illustrates this point:

> Ten years ago, eleven years ago, I guess, is when I came to (institution #4) and started this career as a teacher, and at that time I never questioned the fact that you just prepared the very best lecture that you can, and you go in there and you go in there, and you use whatever visual aids you have available to you, and you just give the very best presentation you can, and you expect the students to go home and read all about it, and understand your every word and do well on exams. And through MCTP and the reading that I have done in association with the work with MCTP, I realized that a lot of people just simply don't learn that way, that trying to just simply force information down people's throats in that fashion can be counter-productive. I mean, it depends on the level of the course and so on, but students learn much better and retain ideas much better if they're able to come to them on their own. And, that's been a major change in my philosophy of teaching, and one that I'm trying to apply, as I said, not just in MCTP courses, but at least to some extent in every course that I teach. (science instructor, 1/96)

Thus, it appears that one of the most significant impact of the project appears to be a new vision of mathematics and science teaching. This new vision will hopefully impact MCTP teacher candidates' teaching practices. In the meantime, this new vision has already impacted some mathematics and science courses these MCTP instructors are teaching.

Concluding Comments

Throughout our interviews with the teacher candidates, we have asked what they expected of good mathematics and science teachers. Clearly, the discussions above indicate what MCTP teacher candidates considered to be important characteristics of good mathematics and science teachers. According to these participants, good mathematics and science teachers will make their classes interesting through problems and activities that are tied to 'real-world' of their students, encouraging students to explore and investigate to find solutions on their own. Those teachers would create classrooms where much interactions, both students to students and students to instructors, take place. They would utilize appropriate instructional strategies ranging from concrete materials to technologies to cooperative group activities. These ideas are very much in alignment of recommendations

recent reform documents.

Furthermore, this view of teaching is very much in contrast to mathematics and science teaching these teacher candidates have experienced previously. These teacher candidates often compared their MCTP courses with their past experiences, and they usually concluded that MCTP experiences were superior to their previous experiences. One reasons for this conclusion cited by MCTP teacher candidates was that they learned more (or better) in MCTP courses than their middle school and high school mathematics and science courses. Their awareness of better learning is significant. According to the social learning theory, modeling activities that produce desired results are much more likely to be remembered *and* enacted by the learners (Bandura, 1977). In the teaching-learning context, a desired outcome is students learning. Therefore, the fact that many of MCTP teacher candidates are aware of the superiority of their learning in MCTP courses indicates that these teacher candidates may eventually practice some of the teaching strategies that have been modeled.

On the other hand, the social learning theory also points out that "in the absence of any other information, versions of roles that have been 'observed' more frequently will be assumed to be more generally acceptable than versions that have been observed less frequently" (Heiss, 1990; p.112). It has been reported that much of what was learned in preservice education courses is "washed out" (Zeichner & Tabachnick, 1981) once teachers enter their own classrooms. These teacher candidates are taking 8 to 10 mathematics and science courses, not necessarily all taught by MCTP instructors. A significant question is whether or not their experiences in these limited number of MCTP mathematics and science courses can overcome years of experiences of more traditional style of instruction. Will the effects of MCTP content courses be also washed out?

Since the findings we are reporting include the data from the first two years of MCTP programs, a vast majority of the participants were still during their first two years of their undergraduate programs. As we continue to gather additional data from these participants, we hope to address a number of research questions including: (1) whether or not MCTP teacher candidates content knowledge is as good as both teacher candidates and instructors believe to be, (2) how these "positive" experiences in content courses influence learning of the teacher candidates in mathematics and science methods courses, and (3) how the MCTP experiences influence MCTP teachers' pedagogical practices.

Author Notes

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Interested readers are invited to visit the MCTP world wide web homepage to access additional information concerning the project and the Research Group efforts (http://www.wam.umd.edu/~toh/MCTP.html).

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	Mathematics	Science
Content Specialists	7	16
Pedagogy Specialists	6	2

Table 1 Faculty Participants' Specialities

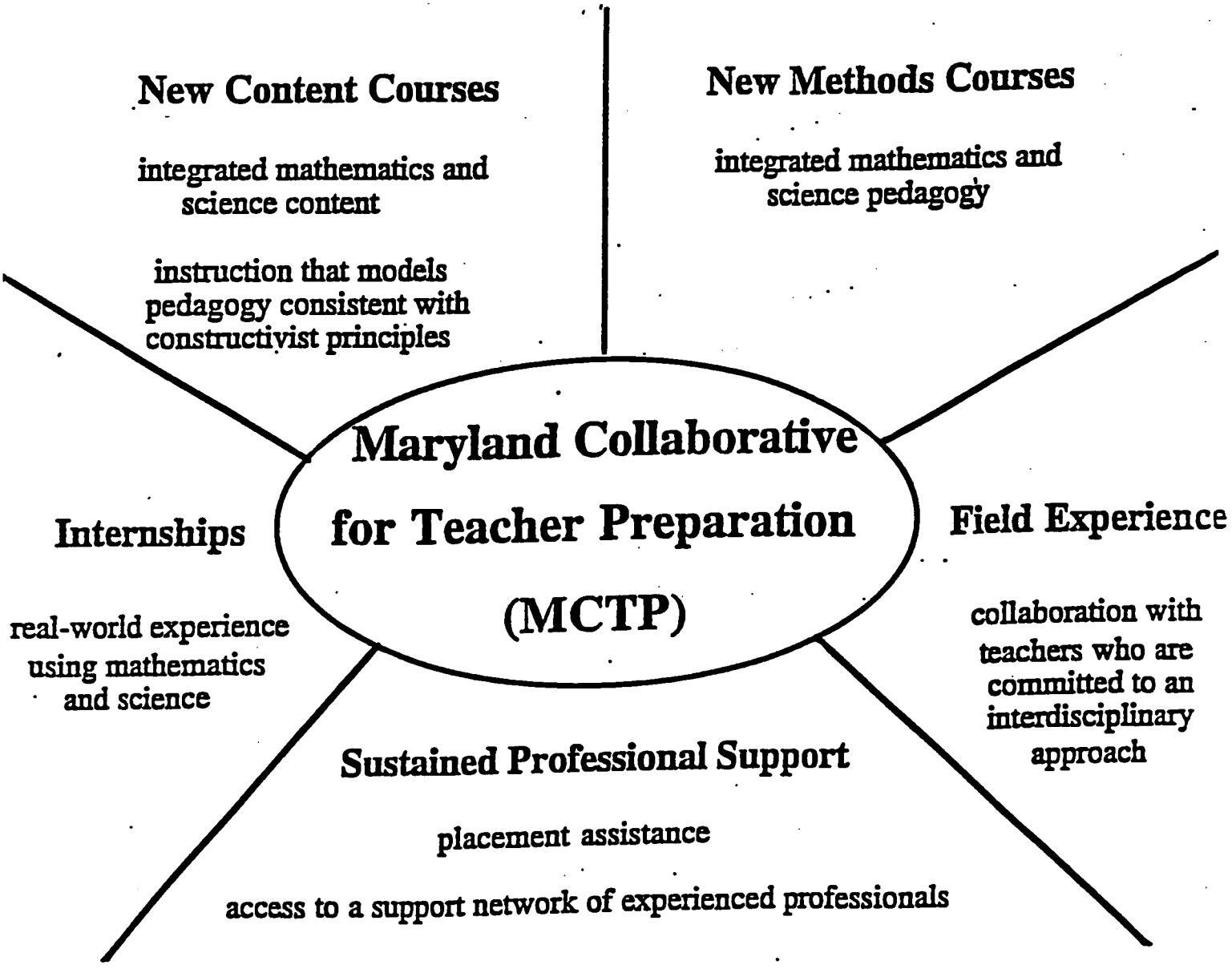

Figure 1 Components of Maryland Collaborative for Teacher Preparatin program

Appendix A
Faculty Interview Protocols

Interview 1

1 To what extent is the instruction in your class planned to highlight connections between mathematics and science?
2 To what extent will this class involve the application of technology, such as e-mail, Cds, computers, calculators, etc.?
3 To what extent will you make significant attempts to access your students' prior knowledge of a topic before instruction? What techniques will you use?
4 To what extent do the tests and exams stress reasoning, logic, and understanding over the memorization of facts and procedures?
5 In what ways do you think your teaching models the type of teaching that you believe should be done in grades four through nine?
6 To what extent will you explicitly encourage your students to reflect on changes in their ideas about topics in your class?

Interview 2

Reflecting over this semester's MCTP class, what new thoughts do you have on these areas:

1 instruction planned to highlight connection among math and the science?
2 instruction involving the application of technologies
3 need to access students' prior knowledge of a topic before instruction
4 use of assessment techniques that stress reasoning, logic and understanding as opposed to memorization of facts and procedures.
5 modelling the type of teaching that you believe should be done in grades 4-9
6 need to explicitly encourage your students to reflect on changes in their ideas in the class

New set of questions:

7 Reflecting back, have you seen what you have learned and experienced with MCTP courses and experiences come through in any other professional areas?
8 Reflecting over your course, what are the pieces unique to MCTP that stand out in your mind that worked well or that you might change?
9 Projecting into the future, do you have plans to teach another MCTP course?
10 How do you feel about teaching another MCTP course?
11 Has your involvement with MCTP enabled you to make connections with other MCTP faculty.
12 What kinds of things that have been part of the MCTP project have provided support to you or have contributed to your wanting to continue in the project?
13 What constraints?

Interview #3 (repeat this for any additional interviews)

1. Please review the MCTP courses you have taught in the past (and when), and any courses you might be teaching now.
2. What do you perceive as your role in teacher education? Has there been any change? Can you identify factors that led to change - both within and outside of MCTP?
3. Has your view on teaching/learning changed during your association with the MCTP? If so, how? Can you describe your view on teaching/learning?
4. Has your view of what content should be taught to prospective teachers changed during you association with the MCTP? How?
5. As a science/mathematics expert, has your view of mathematics/science changed as a result of your MCTP association? How?
6. If you have taught an MCTP course for more than one semester, what kind of changes have you made in the course? Why?

Appendix B
Student Interview Protocols

Interview #1

1 What does it take for a student to be successful in mathematics?
2 What d you expect of a good math teacher?
3 What does it take for a student to be successful in science?
4 What do you expect of a good science teacher?
5 Can a student do well in both mathematics and science?

Interview #2

Repeat Questions 1 - 5 from Interview 1, preceeded by statements, "Reflecting on your experiences this semester".

1 Has instruction in Dr. _____'s class helped you make connections among mathematics and the sciences?
2 To what extent has this class involved the application of technologies (e-mail, cd's computers, calculators, etc.)?
3 Has the instructor made significant attempts to understand your understanding of a topic before instruction?
4 To what extent has this course stressed reasoning, logic, and understanding over memorization of facts and procedures? Did the tests reflect this emphasis?
5 Do you think the teaching you experienced in this course models the type of teaching that you believe should be done in grades 4-9? How? Why?
6 Did your instructor explicitly encourage you to reflect on what you learned in this class?
7 After participating in this content class, what are your expectations regarding your science methods class? How should it be taught? What should be in the curriculum?

Interview #3 (repeat this for any additional interviews)

Questions Interview #2

1 What do you see as the similarities among MCTP classes you have taken?
2 What are the differences among MCTP classes?
3 What are the similarities *in your learning* in the MCTP classes?
4 What are the differences *in your learning* in the MCTP classes?

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