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ABSTRACT

There are two major purposes to the Teaching Improvements in Mathematics Education (TIME 2000) project. The first purpose is to develop and implement recruitment strategies, the second is to develop and implement the freshmen year of an integrated curriculum in mathematics and education--mathematics teaching and learning for the preparation of secondary school teachers of mathematics. This evaluation report examines some aspects of student progress and the main project activities of TIME 2000 students and faculty through June of 1999. The evaluation report is organized into sections on students, faculty describing their respective responses to TIME 2000, and a summary and issues. In the section Students, the first part reports on a survey of their entering characteristics and beliefs about teaching and learning mathematics, as well as belief changes at the end of year 1. The second part features results of student interviews at the end of the first and second semesters. These student interviews provide perspectives on connections between mathematics and the psychology of learning, and perspectives on the mathematics courses including their teachers, themselves as learners, applications of mathematics, the development of a community of students studying mathematics, and the use of cooperative groups and technology. In the section on Faculty, the first part provides faculty perspectives on the collaboration between mathematics and education faculty, teaching observations and sample class activities, and faculty perspectives on their collaborations at the end of semesters 1 and 2. The second part provides faculty recommendations for TIME 2000 and for the further development of the integrated program in mathematics and secondary education. Section III concludes the report with an overall summary of the strengths of the project, problems encountered, and general policy issues raised by the TIME 2000 project in its first year. (ASK)

FINAL EVALUATION REPORT

Time 2000

Spring 1998 - June 1999

Center for Advanced Study in Education
The Graduate School and University Center
of the City University of New York

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August 2000

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August 30, 2000

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Teaching Improvements in Mathematics Education (TIME 2000) was funded during the period of this evaluation by the National Science Foundation. There were two major purposes of the project. The first purpose was to develop and implement recruitment strategies; the second was to develop and implement the freshman year of an integrated curriculum in mathematics and education—mathematics teaching and learning, for the preparation of secondary school teachers of mathematics. One unique aspect of the project was the recruitment of high school seniors in the spring of 1998 to become first year students majoring in mathematics for the purpose of becoming high school teachers of mathematics. The second unique aspect was the block scheduling of the cohort for courses in mathematics and in teacher education in their freshman year. The integrated curriculum for first year students involved the development and/or revision of four courses in mathematics—Calculus I and II, Discrete Mathematics, and Probability, taught by two faculty in the Department of Mathematics. The integrated curriculum also involved the development of a course in the School of Education, Department of Secondary Education—Educational Psychology focused on the learning of mathematics, team taught by two faculty, an educational psychologist and a secondary mathematics educator.

In brief, these two broad goals of recruitment and curriculum integration were achieved, in the main, and the project did what it was intended to do:

> thirty-three students were enrolled for the first year, twenty-three remained to enter the second year of TIME 2000; and
>
> the planned courses in mathematics and educational psychology were taught on schedule.

As with any teacher education program development in higher education, meeting the goals is only part of the project. This evaluation report attempts to provide a more detailed description of the recruited high school students and the curriculum integration across the disciplines of mathematics and education/psychology, as well as the project activities—courses, monthly seminars, and faculty weekly review meetings, as seen by students and faculty.

Thus, the evaluation report examines some aspects of student progress and the main project activities of these TIME 2000 students and faculty through June of 1999. The evaluation focus is on students and their responses to aspects of the teaching received and to their own learning, and on faculty reflections on their own teaching and the project activities in which they participated. This more detailed focus is intended to assist the reader in understanding the diversity of both student and faculty responses to TIME 2000. This is particularly important because of the student participants—first year college students. TIME 2000 expanded their goals to include many efforts to assist new high school graduates to succeed in adapting to college requirements and standards. The project provides the context of both a common set of courses and a set of supporting activities. These supporting activities included their own group in the Freshman Year Initiative (of Queens College), a (monthly) special seminar for the project, ready access to TIME 2000 faculty, support for student-initiated activities (e.g., a club for those interested in tutoring high school students in mathematics), and a group of four faculty who met weekly to review individual student progress, teaching methods, and assessments, some of whom attended each other's classes.

Data sources for documenting student perceptions include student survey questionnaires, journals, and interviews. Data sources for documenting project activities and faculty perceptions are classroom observations and videotapes, faculty interviews, and evaluator observations and/or participation in project faculty meetings.

The evaluation report is organized into sections on I. Students, and II. Faculty, describing their respective responses to TIME 2000, and III. Summary and Issues. In Section I. Students, the first part (A.) reports on a survey of their entering characteristics and beliefs about teaching and learning mathematics, as well as belief changes at the end of year 1. The second part (B.) includes results of student interviews at the end of the first and second semesters. These student interviews provide their perspectives on connections between mathematics and the psychology of learning, and their perspectives on the mathematics courses, including their teachers, themselves as learners, applications of mathematics, the development of a community of students studying mathematics, and use of cooperative groups and technology.

In Section II. Faculty, the first part (A.) provides faculty perspectives on the collaboration between mathematics and education faculty, teaching observations and sample class activities, and faculty perspectives on their collaborations at the end of semester 1 and semester 2. The second part (B.) provides faculty recommendations for TIME 2000 and for the further development of the integrated program in mathematics and secondary education. Section III. concludes the report with an overall summary of the strengths of the project, problems encountered, and general policy issues raised by the TIME 2000 project in its first year.

It is important to note that although NSF funding did not continue, the project has continued with recruiting high school seniors, providing tuition for them, continuing collaboration of faculty, and further course development, as the initial 1998-1999 cohort enters its third year at Queens College. New goals are being established for the purpose of providing a full four year curriculum for preparing secondary school teachers of mathematics who see the relationships between their own learning and the teaching of mathematics at Queens College, and who are integrating these ideas into their own thinking about the teaching of mathematics in high school.

I. Students

The first section (A.) describes the general characteristics of the students recruited by using the results of a demographic survey of entering students, their application essays, and a questionnaire on their beliefs about teaching and learning mathematics. The second section (B.) provides results of student interviews conducted for a sample of students at the end of the first and second semesters in the first year of the project.

A. General Characteristics

Demographics. In August 1998 demographic data were collected. There were 31 students who responded to the questionnaire, 22 females and 9 males. A variety of native languages were reported: 18 English speakers and 10 different native languages speakers who typically had spoken English for 8 years (range of 3 to 16 years). Their high school data included an overall mean high school average of 87.5 (range of 78.3 to 97.4, n = 29). Their high school mathematics average was 88.6 (range of 74 to 98, n = 27). The average number of math courses completed during high school was 4.6 (range of 0 to 8, n= 25). The average SAT scores were 571 for math (range of 420 to 730, n = 26), and 477 for verbal (range 310-730, n = 27). Ten students completed Advance Placement courses at least at the calculus level.

Students reported varied experiences with technological tools: 27 reported using a scientific calculator about once a week (mean of 1.7, with 0 = rarely, 1 = once per month, and 2 = once per week); and a graphing calculator with the same frequency (mean of 1.7). They had less experience with computers (mean of .2, n = 21) and less experience in problem solving in small groups (mean of .9, n = 30).

The majority of students (n = 24) began the program with no previous college credits. Seven students' college credits ranged from 2 to 40, with four having earned less than 11. The number of math college courses completed ranged from one to three courses (one course, n = 4; two courses, n = 1; and three courses, n = 2).

Application essays. There were 26 essays available, and the texts were coded for five major categories: 1. Love or liking of math; 2. Experience as a teacher or aspiration to become one; 3. Math teacher viewed as role model; 4. Another teacher or relative who serves as role model; and 5. Commitment to teaching math. In order of frequency, 23 essays included statements of commitment to teach mathematics, category 5. This is expected, as the TIME 2000 project is geared to students who want to teach mathematics. One student stated, "I want to impart my knowledge about a subject that I enjoy to others. I would like others to know how exciting the study of mathematics can be. I want them to realize that they could use it in all areas of life, such as solving problems."

Fifteen essays contained statements coded into categories one and two. For example, in category 1, a student wrote, "Mathematics was always my favorite subject," and another wrote, "I really love math." In category 2, a student wrote that she began tutoring classmates during her junior and senior years of high school, and, "Seeing the difference my tutoring made helping these girls understand math also influenced my decision to teach math." Categories 3 and 4, on role models, were less frequently mentioned—seven mentioned a math teacher viewed as a role model and three mentioned another teacher or relative as role model. One student wrote about a high school math teacher who, "sometimes advises me to be the teacher. I help her teach in the class and she sits in my seat. She is my mentor and I am her protégé." Another wrote about her mother, who had just returned to Queens College to finish her degree and begin teaching math, "My mother has had a great influence on my decision because just like her I want to have a career and a family."

Beliefs about mathematics, teaching, and learning. A survey of student beliefs was developed in the summer 1998, and administered to TIME 2000 students on August 26, 1998 and again on May 27, 1999 to 24 students. The questionnaire drew on items used by Calhoun, Bohlin, Bohlin, and Trucz (1997), McGinnis, Watanabe, Kramer, and Roth-McDuffie (1998), Ruthvan and Coe (1994),and Tittle and Hecht (1990). The belief statements surveyed students' beliefs about themselves as learners, and about the roles of faculty and students in teaching settings (classroom problem solving, groups, independent work), and general beliefs about mathematics (Ruthvan & Coe, 1994). These statements were reviewed for two versions of the questionnaire by the evaluators and project faculty, and the resulting set of 65 items were those administered before the beginning of classes (August) and at the end of the first year (May). Table 1 presents the responses of students to selected items from the questionnaire. The complete questionnaire, TIME 2000 Math Survey 8/98, is in Appendix A.

As indicated in Table 1, there were several shifts in beliefs, toward a more student-centered view of teaching mathematics, items 19, 23, and 35, and towards recognizing the importance of proofs in understanding mathematics. Both of these areas also emerge in the student interviews as discussed below. Item 19 suggested that almost all class time should be used by the college professor, presenting information and demonstrating how to do problems. By the end of the year, fewer students agreed with this item and fewer students disagreed with item 23, that teachers should make students figure a problem out for themselves. An important shift was observed for item 40: Mathematics consists of unrelated topics...In the fall 45% disagreed with this statement, and by the spring 75% disagreed, showing movement toward one of the TIME 2000 goals—student understanding of the connections among mathematical concepts and topics. Related to this goal is the important role of proofs in building understanding of mathematical relationships. As shown in Table 1, items 62 and 63 provide some documentation of students' shifts toward meeting this goal.

Table 1. TIME2000 Students: Ratings of selected beliefs items about mathematics, teaching and learning

Responses of 31 TIME2000 students (questionnaire administered on August 26, 1998)

Responses of 24 TIME2000 students (questionnaire administered May 27, 1999)

Fall 1998: Student responses to the belief items suggest that there is a subset of the class that has different perspectives on mathematics, teaching and learning. In general, this perspective views mathematics traditionally, and teaching as teacher-centered.
Spring 1999: Student responses suggest some shifts in beliefs toward a more student-centered view of teaching mathematics (see items 19, 23, 35), a perspective of connections (relatedness) between topics in mathematics (see item 40), more openness toward multiple solutions (item 52) and the importance of proofs in understanding mathematics (items 62 and 63).

Scale

1=Stongly Disagree;*2*=Disagree;*3*=Neither agree nor disagree;*4*=Agree;*5*=Strongly Agree

Item	Response rate in percentages				
4. Truly understanding mathematics requires special abilities that only some people possess.	***1*** 16.1%	***2*** 35.5%	***3*** 29.0%	***4*** 19.4%	***5*** 0.0%

About half of the students disagree with this statement (choices 1 and 2) while a third neither disagree nor agree, but a fifth of the sample agree (choice 4).

Spring 1999:	*20.8%*	*33.3%*	*33.3%*	*12.5%*	*0.0%*

There was little shift in the responses to this item between fall and spring.

19. In math class almost all class time should be used by the college professor to present information and show how to do problems.	***1*** 16.1%	***2*** 38.7%	***3*** 22.6%	***4*** 16.1%	***5*** 6.5%

Again, one fifth of the students agree or strongly agree with this statement while another fifth are neutral and almost half of the students disagree.

Spring 1999:	*12.5%*	*37.5%*	*41.7%*	*8.3%*	*0.0%*

In the Spring fewer students (8%) agreed with this statement and more were neutral or disagreed with the statement.

	1	2	3	4	5
23. The teacher should make the student figure a problem out for themselves rather than show how to do it.	12.9%	19.4%	38.7%	22.6%	6.5%

The most frequent response (38.7% of the students) was neither agree nor disagree and the remainder of the students were about evenly split, either agreeing or disagreeing with the statement. We expect these numbers to shift toward more agreement as the program progresses.

Spring 1999:	*0.0%*	*21.7%*	*39.1%*	*34.8%*	*4.3%*

There was some shift in the responses in the spring, with no students strongly disagreeing and somewhat more agreeing that teachers should encourage students to figure out problems themselves.

	1	2	3	4	5
25. I generate more solutions to problems when working in a small group.	0.0%	16.1%	32.3%	41.9%	6.5%

The majority of the students agreed with this statement. A third of the students were neutral but again, 16% disagreed.

Spring 1999:	*4.2%*	*0.0%*	*54.2%*	*37.5%*	*4.2%*

These responses shifted some, with more students neutral than in the fall.

	1	2	3	4	5
29. I learn math best by memorizing rules and procedures.	12.9%	25.8%	35.5%	9.7%	16.1%

More than a third of the students chose neither agree nor disagree, and more than a third disagreed. Yet, again, 26% of the students agreed.

Spring 1999:	*12.5%*	*29.2%*	*25.0%*	*16.7%*	*16.7%*

There were few changes in responses here, except for a decrease in the neutral category.

	1	2	3	4	5
35. When I feel confused in math class, I know I am not learning math.	12.9%	45.2%	19.4%	9.7%	12.9%

The majority of the students disagreed with this statement and about 20% were neutral. The remaining 23% agreed, and we would expect this number to shift.

Spring 1999:	*4.2%*	*20.8%*	*58.3%*	*12.5%*	*4.2%*

The main shift here was from 'disagree' to 'neutral,' perhaps a realistic assessment of the relationship between feeling confused and learning.

	1	*2*	*3*	*4*	*5*
39. I learn mathematics best when I work alone.	9.7%	32.3%	25.8%	16.1%	16.1%

A quarter of the students were neutral while 40% of the students disagreed and a third agreed. It will be interesting to see if the agrees shift to disagrees.

Spring 1999:	*12.5%*	*16.7%*	*33.3%*	*12.5%*	*25.0%*

There were some shifts, mainly from '2' to neutral and to strongly agree. This is not unexpected given the difficult time students had in adjusting to college expectations. Many were not used to having to study mathematics, either alone or with other students.

	1	*2*	*3*	*4*	*5*
40. Mathematics consists of unrelated topics (e.g., algebra, arithmetic, calculus, and geometry)	19.4%	25.8%	19.4%	25.8%	6.5%

Again, a third of the students agreed with this statement while one fifth were neutral and almost half of the students disagreed. TIME2000 emphasis on connecting math ideas should mean change to disagree.

Spring 1999:	*41.7%*	*33.3%*	*8.3%*	*12.5%*	*4.2%*

The responses to this items indicate success in one of the TIME2000 goals, increasing student understanding of the connections between mathematical concepts and topics, and 75% of the students disagreed with this statement.

	1	*2*	*3*	*4*	*5*
48. I do not like to have to explore and investigate in mathematics; I prefer to just know the answers.	35.5%	41.9%	9.7%	6.5%	6.5%

About three quarters of the students disagreed with this statement. Again, 10% were neutral and 13% agreed. These should shift over time.

Spring 1999:	*8.3%*	*70.8%*	*16.7%*	*0.0%*	*4.2%*

There were some interesting shifts, overall in the expected direction – fewer agrees, but also a shift from strongly disagree (35.5% fall) to more disagree(70.8% spring).

52. Unlike in most subjects, in math there is a clear cut right or wrong.	*1*	*2*	*3*	*4*	*5*
	9.7%	29.0%	12.9%	32.3%	16.1%

Almost half of the students agreed with this statement, about 40% disagreed and 13% were neutral.

Spring 1999:	*27.3%*	*27.3%*	*27.3%*	*18.2%*	*0.0%*

There was a definite shift in responses , toward more disagreement and neutral responses in the spring, indicating a more flexible perception of mathematics as a subject.

62. A proof of a mathematical relationship makes it clear exactly how it depends on other relationships.	*1*	*2*	*3*	*4*	*5*
	0.0%	3.2%	51.6%	38.7%	6.5%

About half of the students chose neither disagree nor agree indicating that this could be an idea that they have not thought about. The remaining students agreed with the statement for the most part with only 3% disagreeing.

Spring 1999:	*0.0%*	*9.1%*	*27.3%*	*40.9%*	*22.7%*

By Spring 1999 students had a shift in understanding of the importance of proof in understanding mathematical relationships, with 63.6% agreeing with the statement compared to 45.2% in the Fall 1998.

63. Being shown a proof of a mathematical relationship does not help you to understand it fully.	*1*	*2*	*3*	*4*	*5*
	12.9%	29.0%	32.3%	22.6%	3.2%

A quarter of the students agreed with this statement while a third were neutral and about 40% disagreed.

Spring 1999:	*27.3%*	*45.5%*	*22.7%*	*4.5%*	*0.0%*

As with item 62, above, there was a shift in responses, from 42% disagreeing in the fall to 73% disagreeing in the spring. Again, these responses indicate student appreciation of the importance of proof in building understanding of mathematical relationships.

B. Student Interviews

Student interviews were conducted at the end of the fall 1998 and spring 1999 semesters. A sample of eight students were interviewed each semester, and five students were interviewed both times. Three of the five were in the same core courses both semesters; two had to retake calculus. The interviews were audio or video taped and focused on student reflections about their experiences in the Calculus, Discrete Mathematics and Educational Psychology courses (SEYS; fall only) and Calculus and Probability (spring). The interview questions asked for examples of mathematical ideas learned, connections between the ideas in the mathematics courses (and also with educational psychology fall semester), about themselves as learners of mathematics, about working in small groups, about use of technology, and experiences with other TIME2000 students and faculty (see Appendix B for questions). The spring questionnaire had the same questions with the expansion of requesting specific examples of classroom events about teacher and students interacting and about what it means to think mathematically and to understand mathematical ideas. The spring sessions were videotaped instead of audio taped.

Four interviews are used here to provide examples of student responses to the structured interview questions. Students are indicated as A, B, C, and D, and their comments are specific to a mathematics or educational psychology (SEYS) course. The examples of student responses are followed by a summary of the main areas of the interviews:

Thoughts at the beginning of the calculus course;
The teachers;
Aspects of class/teaching they would use when they started teaching;
The connections—math classes;
The connections—educational psychology class and math classes;
Characterizing their learning/understanding of mathematics;
Small group work—supporting learning/mathematical ideas
Technology use in math class
Experience with other TIME students: In/outside classroom
Student transition to teacher
Summary

Thoughts at the beginning of the calculus course:

A: It was familiar material,...kind of easy...went through in high school
(end semester 2): Calculus-beginning was easy because we were covering material from the end of the semester; Probability: It was good; it made lot more sense this semester than...last...We had a book this semester with examples and that helped.

B. ...I took AP calculus before, I feel confident, ...
Discrete math: ...it was the first time taking that different kind of math so I had a really difficult time...I knew how to do probabilities...but proving PMI, those kinds of things

were very interesting so we had a group project proving one of the …equations…I never knew this kind of thing existed….
(end semester 2): Calculus: I thought it was hard and I was a bit worried…course is getting harder.
Probability: I think generally I did not like probability. It is a hard subject. It involves word problems and you have to elaborate.

C. Dr. S. seemed very nice, …to know what he was doing and talking about in calculus, …and the subject was pretty easy what we did at the beginning…and we got to know each others names cause Dr. A. made us go around the whole room and repeat names …and we kept seeing people (in the 3 classes)…
Discrete math:…the first two days, I was like 'oh man' since I never took discrete math before…I was lost, completely lost…
Ed Psych: …in the beginning I had different thoughts about it, I was like to become a teacher all you had to do was put work up on the board, have a lesson plan, do a certain amount of examples, the kids understand you good, they don't, you have to go on cause you have to finish a certain amount of work but then in the SEYS class I saw how different things were used such as the zone of proximal development, scaffolding, all these techniques were used to help a kid and to see where kids are. That totally changed my perspective of teaching and I think that its really good that we have the SEYS class in our freshman year, cause now I tutor a student, I tutor him totally different than I did the first day, the first time I met him and I tutored him. I completely revised the way I tutored him now because of the SEYS class, and what I learned in the SEYS class.
(End semester 2): I am in calculus 111 because I didn't pass it the first time. I have Dr. K. who is a really good teacher….He writes a lot of notes and goes over the homework everyday. You ask him a question and if he can't answer it in class he will stay or say come to his office hours. He told us about books we can buy from the math dept. and we can go to the math library and get videotapes of the topics we are doing. Maybe because it is the second time but it is easy the way he explains it. He showed us new ways to do it from Dr. S. so now I have two or three ways to do a problem.
Probability: Dr. M. I like him last semester and I like him now. The probability stuff we are doing isn't really that hard. …The problems make sense. I know how to play cards and that's what a lot of the problems were. And I know odds and I was interested in the topics…

D. Calculus: …I figured maybe it would be a good experience. Dr. S is a great teacher, he writes certain things on the board….everybody tells me its going to be different than high school, they're not going to write on the board and this and that but I found it interesting and I enjoy it….The first class was great…just the way he explained himself he didn't leave anybody hanging.
Discrete math: …I didn't understand a thing, I think it was PMI …so I was pretty lost, but then somebody (I think it was…student) showed me how to do it and then I started clicking in.
Ed Psych: I thought it was a very interesting class because I had never taken anything like this in all my schooling years and Dr. A and Dr. AT are good teachers and they make it

interesting. I think the first day we did group work, I was like wow, I didn't think we would do this in college.
(End semester 2): Calculus: I thought it was going to be hard…It is hard. So many theorems and formulas.
Probability: I don't understand what is going on in there. I don't think anybody does. Dr. M. is a good teacher but I think he teaches to a level for people like him—really smart people.

The teachers
A. It was good because they were putting a lot more effort…attended more to the student needs,…made sure students…are following, more concerned.

C. They're great. They stay after class a lot of times to help us for a test…And Dr. M, we need a review sheet for the final or midterm…the next day he brings in a review sheet for us.

Aspects of class/teaching they would use when they started teaching
A. Calculus: He just doesn't…throw the answer at you and you just copy it. He makes us understand so we can get it ourselves.
Discrete math: he doesn't give up…willing to go over the same thing 80 times if 80 students don't understand it.
Ed Psych: I like how the class interacts,…a lot of class-teacher-student interaction, we are all involved discussing in group work.

(end semester 2): I like the way they (faculty) plan. They don't just get a book and go through the material…make sure everyone understands. And they use constructive methods of teaching like the group work.

B. Calculus: …I feel the class is just awesome,…teaches in the best possible way, he brings things that …I would never relate to…a practical situation…really made me study harder, …the practical example really motivated me.
Educational psychology: I enjoyed it very much, it was…discussion, I read textbooks and everything and did the homework but that wasn't really hard like math…
(end semester 2): Calculus: teacher should be funny…makes things really interesting by bringing in examples….Dr. S waited for us and came back after probability class…he wanted to help us with the subject. I though about how important it is for the teacher to help the students who are left behind. I study but I was lost…That kind of teacher will be a role model for me in the future. If I ask other students without doing some work myself it doesn't help.
Probability: Dr. M…style more like lecturing and when he speaks he is really eloquent….

C. Calculus: we learned about limits….I don't know how Dr. S. managed to do it, they all have to tie in, everything we did at the beginning of the year…now at the end of the semester and today even, for example in today's class we did limits again, limits were used in a way to solve whatever problems we were doing today …and everybody thought it doesn't make sense but he seems to be able to tie everything we learned

together....definitely use the calculator a lot. He uses it and its been so helpful...I am hoping I can become some sort of an expert in the...T183...and I'd never seen before the first day we had class he gave us a diagnostics test ...He said don't worry about it this ... is not going in your grades, just take it and show me what you know...and he saw that a lot of people were having troubles in limits and then he spent a lot more time on limits... and I definitely think I am going to use a diagnostics test to see what level students are at.
Discrete Math. ...class is really confusing for a lot of students; for me it's not...and he shows us (many) ways to work a problem....and, he never gives us the answer. That's the thing. He waits till we figure it out ...
Ed psych: Besides everything...I don't know, well I mean absolutely everything ...Dr. A. the day before we...have to do a reading she'll ask us, why do you think this and this and everybody gives a different answer and she puts them all on the board ...she knows how to make us think before we do the reading and Dr. A and Dr. AT just let us go on and try to prove your point...everything we did learn in that class...definitely use in teaching.
(End semester 2): Calculus-Dr. K-write a lot of notes...That is what I would do, write a lot of notes and check homework.
Probability: Dr. M gives us homework...and goes over it...also gives review sheets and lets us figure the problems out and then gives us the answer sheets. It is very helpful. And example of students arguing about which car gets stolen the most. Dr. M walks out and starts talking about the probabilities of each and said just buy a Cadillac, they are not stolen often. And we said we can't afford a Cadillac and he said just buy a car and then it gets stolen and you have to buy a new one. Can you afford that?...(laughed) He integrated what we were talking about with probability... ...if the teacher knows where the students are coming from he might give problems that relate.... And also we didn't think we were talking mathematically at first but it makes you think that almost anything can be talked about mathematically.
General: When I teach I want to use small groups. ...We meet and do homework and talk about it. I definitely think group work benefits people. It benefited me. I am going to use it in my teaching.

D. Calculus: Dr. S. explains what he says if someone doesn't understand it. I want to be able to do that to my students, you know. (How?)...if some one has a problem...he'll show you another way or another meaning of the word derivative....
Ed Psych:...I like to learn how to teach and how to tutor because I used to tutor and I think I did a good job. But now I see it, I didn't do x or this stuff; I'm like wow, so yeah, that's it.
Dr. AT explains things and I really like how Dr. A...(before a major topic) she'll start talking about something else and finally just leads into what we about to talk about...Dr. A makes it exciting and I want to do that for my students.
(End semester 2): Calculus: Dr. S., he writes on the board and will stop if you have a question and he answers very clearly. He will write a problem and solve it. It is a great help.
Discrete math: He doesn't give concrete examples...I would use concrete examples.

<u>The connections –math classes</u>
A. ...function in calculus sometimes we have to prove it is true by mathematical induction from discrete math class

(end semester 2): Just now with integration and the area under a curve. You can find the probability.

B. in calculus…had to come up with a formula and that formula has to be proved by discrete math, PMI…
(end semester 2): Last semester we didn't have any connections but this time we used integration in the probability class to find the average probability. You graph it and integrate and the area gives you the average probability. Summation of parts is also used in both..

C. in discrete math…learning about probability and factorial we also used it in calculus two days later…and learned how to take the sum of the first n-odd integers…and used that yesterday and today in calculus class…

D. ...recently we were learning something about area under a curve and we found it was like something…we learned in PMI or something else…but it was related, and Dr. S says if you remember back to Dr. M.'s class you'll know this…
Discrete math: like functions when we are doing sets and…
(End semester 2):…for some of the probability things we have started to look at integrals, and Dr. S told us how it works…

<u>The connections—educational psychology class and math classes</u>
A. ..ideas about scaffolding,…and see that that's the way that the teacher's teach (math)

B. …the concepts from psychology…showed scaffolding kind of theory with partners and we help each other. The things that we learned from the psychology class pretty much gave us an example in doing the calculus class…

C. talking about experts and how one becomes an expert and were math teachers experts in their field? And Dr. S tries to use a lot of practical applications with things we see everyday in life…vocal box and coughing, construction beams bending, …

D. …we were learning about steps to take to do a math problem and we were doing a problem in calculus and Dr. S. went step by step. Nobody really realized it but afterwards in the SEYS class Dr. A. told us we specifically wrote down a plan and it's easier to solve the problem…

<u>Characterizing their learning/ understanding of mathematics</u>
A. I think I understand a lot of concepts better, like before I knew a lot of things like I knew how to do...mechanically, but I didn't really know…like concept of derivatives.
(discrete math): …my abstract thinking level is higher now….when you have a problem you have to …find the answer yourself, there (aren't) really steps to follow.
(end semester 2): Thinking mathematically is relating everyday life to math. Relating it to mathematical concepts…

B. Discrete math: At the beginning I only relied on the class. …And now I sort of figured that I need more textbooks to read. So actually went to the library to get discrete math textbooks…

C. At the beginning of the semester…whatever we learned in class go home, do the home work, you either understand it or didn't, bring it next day to class to copy down what was on the board. But now I go home, I do the homework, I do the steps, when I have a question I just write it down on my paper on my homework right next to where…I'm stuck and the next day when I come to class…ask the math teacher or go to him and say can you look over my homework and tell me what I did wrong… I changed the way I do my homework and I put much more effort in my homework… try one or two methods. … at the beginning I thought I knew math,…if you give me 2 times 3 now, I will take me a second to think about it and say okay the answer is six, but why is it six? You know I could prove to you what it is six now…before …it just is, its on the times table… and other examples from SEYS class…and now we learn to question every answer and now …(take) a totally different look at the questions to see if they (answer) make sense now.

D. I mean I'm not used to college completely yet but when I first came in I was like oh, it would be easy, and they started hitting me with some PMI…I just got lost and I had to start paying more and more attention…I think I find I pay more attention now and I socialize with the people, like if I have a problem I'll ask someone in my class, because you know, they're all great people, I guess they're all friends. Also, I'm encouraged to do better. I guess I am more motivated 'cause I don't want to lose the scholarship, that's the major thing…(and) my parents and I'll have to pay for the class myself.
(End semester 2): …For the first semester…They didn't check the homework and I was like I don't even need to do any. They still don't check homework but I do it now because I need to practice the problems to do well on the test. The class members relationships are different now. We are closer to each other and can ask questions without being embarrassed. In the beginning I wouldn't ask any questions but now I ask questions…It is really good. Maybe other people want to be by themselves. It will help everybody because everyone is asking questions and helping each other like in the group work. I wish I could do group work on tests. Some people in the class will slack off in the group but everyone is close and can ask each other questions.

<u>Small group work—supporting learning/mathematical ideas</u>
A. At beginning of semester…I didn't really do group work…I liked working by myself…we learned that learning together …is better…share ideas …get to let others show you when you are wrong…and being in groups all the time I am beginning to think that (it is)…a better way…(do you notice anything different about the way you learn math when you are doing things independently, because of your work in groups?) Yeah you are more careful, you look at things, you think of how another person would look at it, and how another person would look at it, and how you would look at it…
…you learn how to look at things from different aspects, different points of view, you just don't see it your way and…you just put it together and take the best out of it.

B. At the beginning it worked very fine…the project that I proved the equation, we (group) members sat down and discussed things together, …but now …only a couple maybe one or two people do all the work…Somehow at the end of the term it didn't come out really well….(although follow-up query—in class groups ok, because his partner was one who got 100 on all the tests.)
(end semester 2): I do not see the advantage of group work. It helps but I would rather study by myself. Not because I don't like people but because when you are working in a group you have to stop and explain it to everybody. I know myself and would just rather go on. By studying together and teaching them it takes time even though it helps me learn it more solidly.

C. Oh it definitely supported it (mathematical learning)… you know to ask a question and you aren't embarrassed (others may not understand also), and …the more the interaction we had the better we did at the problems…and I guess we tutored each other on our method and it helped a lot because you saw different ways of doing the problem… I saw that other people had different methods I'd be like oh wow your method is so much easier and …we indirectly tutored each other in the group work and it completely helped.
(End semester 2): Supported a lot because my group goes out for lunch and we will do a problem. Can you explain it? Do you want me to explain it? It is easier for me to ask my group a question than have to ask it in class with 32 people looking at me. So small groups have supported a lot.

D. I love working in small groups, I write that in my journals all the time….(e.g.) if I don't understand Dr. M's way of teaching it to me…maybe I'll understand somebody else in my group…I try to help if I understand, I'll try to explain it in different ways to make it clear to my ..class mates. (and) I think it helps me also; if I'm able to teach them that means I'm getting more knowledge as I teach…and that enables me to remember it better and …it's gonna set in my long term memory (!)

<u>Technology use in math classes</u>
A. graphing calculator and has helped understanding—graphs…where curve is increasing, decreasing.

B. Calculator, overhead projector, CBL (motion detector), and a TV set., videos

C. Calculus: calculator T183 and CBL
Discrete math: Brainpower… because a lot of the stuff we do is not concrete…I guess his technology is our brain because he makes us think in different ways and by making us think in different ways we see problems differently and sometimes seeing it a different way helps you solve it…. (if you don't get it) he said all right don't think of it as numbers think of it as letters, OK, it makes sense now.
Ed Psych: overhead, use for a lot of the things we read about and tables…

D. T183 graphing calculator, the motion detector…. Calculator—I like to check it to make sure it's right, especially on tests, even if I graph it.

Experience with other TIME students: In/outside classroom

A. ...we get along fine, we work together outside of school, we hang out together, ...

B. We're very comfortable, very friendly,.. I see people try really hard, I see people take it as a joke. I don't know why they do... I just want everybody to be, to finish this course. (I: why?) We started out together, we finish together, I really want that.

C. Fun, I mean we have fun all the time even though we are serious learning.... And each of the faculty makes a joke once in a while. And because you have the same students in the classes you make many friends... and can ask different ones for help... and we have everybody's phone numbers.... And Dr. A passed around a list when nobody knew PMI except (two students) and said, I'm passing around a list. Whoever thinks they can tutor their fellow classmates in PMI sign up. And we saw who was on the list and .... I said I saw that you were on the list, do you mind tutoring me? ...

D. I really enjoy being around them; I made a lot of new friends here; and we'll go out to lunch; and the small groups—help each other.
(End semester 2): A lot of the students in the class are like me. We go to class to help people, sometimes we need help. The experience I have had with the other students talking about math has been a positive experience.

Student transition to teacher

B. ...In the beginning I thought I was a student. I'm a student, but as I come along I changed. Even though I am a student sitting in the class, I am a teacher also so that motivates me to study harder to act like more teacher instead of a student who complains all the time....It's like standing in the teacher's side, understanding the students feelings....

Summary

The students interviewed at the end of each semester of the first year varied in their feelings about the difficulty of the courses. For calculus, some students thought at the beginning it was not harder than high school AP calculus, but by the end of the year it was generally agreed it was a difficult course. The discrete mathematics course was agreed to be difficult, particularly since there was not a text for the course. Also, this course was viewed as "a different king of math," very different from other mathematics courses students had taken, and they experienced feeling lost at the beginning. One student recalled that Dr. A, a faculty member sitting in on the discrete mathematics class, "...passed around a list when nobody knew PMI (mathematical induction) except (two students) and said, I'm passing around a list. Whoever thinks they can tutor their fellow classmates in PMI sign up. And we saw who was on the list and...I said I saw that you were on the list, do you mind tutoring me?..." Students rapidly developed the sense that it was acceptable and helpful to ask questions both of faculty and their fellow students, and the use of cooperative groups and discussions in the educational psychology course supported this strategy for learning.

The educational psychology course (SEYS) was not perceived as difficult, and the concepts and principles related to learning and teaching mathematics are found throughout the student interviews. As one student said, "...in the beginning I had different thoughts about it, I was, like to become teacher all you had to do was put work up on the board, have a lesson plan, do a certain amount of examples, the kids understand you good, they don't, you have to go on cause you have a certain amount of work ... (SEYS concepts) That totally changed my perspective of teaching and I think that it is really good that we have the SEYS class in our freshman year..." (see student C, thoughts at the beginning of the courses, above).

The four faculty teaching during the first semester were almost universally well regarded, particularly because of the their emphases on student understanding. The interviews provide ample anecdotal evidence of faculty responsiveness to student concerns—focussing on student understanding, providing review sheets, helping students expand their learning strategies, staying after classes to tutor, and so on. Students included these and other examples such as cooperative groups, class discussions, and class-teacher-student interactions when they were asked about what aspects of class/teaching they would use when they started teaching. Students commented specifically that faculty were using practical, applied examples in teaching, and students could give examples of connections among different topics in the two math classes, and connections between the educational psychology class and their own learning in the math classes. Students could also describe some use of technology in the calculus classes—graphing calculator TR 183, CBL (motion detector), overhead projector, and additionally, videos in the educational psychology class.

When asked to characterize how their learning and understanding of mathematics differed from when they started at Queens, students gave examples of (calculus), " I think I understand a lot of concepts better (e.g., derivatives)...before I knew how to do a lot of things mechanically...(discrete math), "...my abstract thinking level is higher now." And, end of semester 2, "Thinking mathematically is relating everyday life to math. Relating it to mathematical concepts." Changes in learning strategies were also cited, such as understanding that when you have a problem you have to find the answer yourself, there (aren't) really steps to follow. And, in doing homework, from thinking that, "you do the home work, you either understand it or don't, and next day copy down when is on the board," to a strategy of, "do the homework, do the steps, when I have a question I write it down on my homework ...so the next day ask the math teacher, and also put more effort into my homework."

By the end of year one, small group work was almost universally seen as supporting learning and having a number of benefits for understanding mathematics. For example, Student A (above) described becoming more careful in his own independent work because, "...you think of how another person would look at it and another...you just don't see it your way and...you just put it together and take the best ...." And another student talked about the more the interaction the better they did at problems, and also that students were tutoring each other on different ways of doing the problem. However, one student interviewed (B) did not see the advantage of group work and ended up saying that he would rather study by himself.

A separate question asked students about their experience with other TIME 2000 students both in and outside of class. All of the students interviewed, and in journals as well, describe the development of a close-knit group, with some students working together and hanging out together outside of classes. The admission of a group of students and then scheduling the majority together in three classes the first semester and two the second had a positive effect of creating interactions, knowing the names of all their colleagues, and fostering study and social groups. Although not specifically addressed in the interview questions, a tutoring club was started for TIME students to tutor students in local high schools. The tutoring experience also supported student interactions, as well as providing examples of mini-teaching experiences for those students who were tutoring. As one student (C) said, "now I tutor a student, I tutor him totally different than I did the first day....because of what I learned in the SEYS (educational psychology) class."

The full impact of having the connections among the three courses, the four faculty, and the intensive interaction among all the students in the first semester was expressed by one student (B),

> ....In the beginning I thought I was a student. I'm a student, but as I come along I changed. Even though I am a student sitting in the class, I am a teacher also so that motivates me to study harder to act like more teacher instead of a student who complains all the time....It's like standing in the teacher's side, understanding the students' feelings.

II. Faculty Perspectives

The TIME 2000 project staff consisted of a core of four faculty, two mathematicians in the Department of Mathematics, and one secondary mathematics teacher educator and one educational psychologist, both teaching in the Department of Secondary Teacher Education in the School of Education. For the 1998-1999 academic year, one mathematician taught Calculus (Math 111, 112) fall and spring semesters, the other mathematician taught Discrete Mathematics (Math 220) fall semester and Probability (Math 221) spring semester. The two education faculty team taught SEYS 221, fall semester, a course in educational psychology that focused on the psychology of learning mathematics.

These core faculty met weekly at lunch to review project activities, student progress, plan course work and develop other project activities. Since the evaluators had videotaped three sessions of each class for each of the two semesters, some of these meetings were also used to view videotapes of the mathematics classes and discuss teaching methods. Evaluators attended a number of these meetings during the year and summarized observations and audio tapes of the meetings. Individual interviews with each of the four core faculty were conducted at the end of the fall and spring semesters. The protocols for these interviews included items from Fox (1997) and items specific to the TIME 2000 project.

A. Faculty Perspectives on Teaching and Collaboration: SEYS and Mathematics Courses

A unique element of the project was that the secondary mathematics teacher educator attended each of the two mathematics classes both semesters, observing and occasionally commenting and/or making suggestions about student participation. The fact that she attended the mathematics courses meant that the SEYS course could highlight examples of student classroom mathematics experiences, homework assignments, and so on, linking them to content/concepts in the psychology of learning and development. One mathematician—the calculus teacher-- sat in on all the SEYS classes and some of the Discrete Math classes.

<u>SEYS Team Teaching</u>. The combination of the mathematics educator and the educational psychologist proved to provide an excellent integration of the subject matter and psychology. From the student perspective, student journals document the strengths of this direct connection in applications in the SEYS course. For example, Journal 10, requested toward the end of the fall semester, asked students for feedback on all the fall courses, including suggestions for improvement. With the SEYS course, comments were favorable and included,

> Really interesting to talk about our experience in math while we learned new concepts.
> Extremely meaningful course since it linked our mathematical studies in Calculus and Discrete Mathematics into the study of how we as students learn.

> Changed my perspective in learning.
> I thought it was interesting to learn the difference in the many ways there are to learning.
> It was interesting to see the ideas of the seventh graders because they were at a lower level of mathematics (when solving a nonroutine problem with coins).
> Dr. A helped us to understand discrete mathematics (relating strategies about problem solving to examples).
> I'm glad we had this class in the beginning, it's going to help us improve in college (e.g., learning strategies, etc.).
> We learn about the way we think and how a child would think.
> We were shown ways of approaching a problem and solving it.
> Made me realize how I learned math.

The SEYS course also included a high school field experience requirement, observing and/or tutoring:

> I enjoyed (math) tutoring...I was able to facilitate (the student's) understanding by using a lot of the ideas that we discussed in class, such as behaviorism, constructivism, motivation and cognitive approaches to learning.

> I learned many new teaching techniques and strategies when teaching mathematics.

Faculty were interviewed and asked to reflect on their experiences at the end of the academic year, a semester after they had taught SEYS 221. From the faculty perspective, the course was a challenge to develop and teach. Both faculty commented on the challenge of team teaching, and described their own teaching styles as very different in the beginning. While there were differences both faculty recognized, they also had the same goal—integrating the content of math with educational psychology principles. In the end both faculty said they had been "able to get into a rhythm," as one of the faculty stated. And the student evaluations of the class were almost uniformly very positive, commenting on the group work, class discussions, readings, value of the class for understanding and studying for their mathematics classes, and generally providing a foundation for college work (e.g., study strategies, problem solving models). The three videotapes for the fall 1998 semester show use of pair and cooperative learning groups, class discussions and involved students and faculty.

By the end of the second year of the TIME 2000 project, the faculty team had taught the course a second time in the fall of 1999. Their general description of the course was as using a constructivist approach, in which "new concepts were introduced through the use of a question that "launched" an initial question for students to consider," for example, What is a problem? (VT 12/3/98). "Using their own experiences as a reference, in small groups students constructed the relevant psychological concepts." These concepts were further developed and organized in the whole class discussion that followed. In the classroom videotape the discussion included presentation of problem solving processes proposed by Polya and Schoenfeld, as well as examples of research on problem solving involving seventh grade cooperative learning groups. This published research had been conducted by the two education faculty members.

Co-requisite Mathematics classes: Calculus, Discrete Mathematics, and Probability. These courses had generally different structures, using more traditional college teaching practices. Videotapes of the classes in the fall and spring of 1998-1999 show somewhat different patterns in the Calculus and Discrete Mathematics classes.

For Calculus the videotapes show fast paced and organized classes, with the pattern of the classes one in which the teacher is typically writing and talking at the board. Both the video tapes and the student journals (Journal 10) indicate that students feel free to ask questions and some note that calculus applies to 'real life' problems. The faculty member's end of the year interview indicates some level of frustration with the problem of "covering" the required content and trying to use different pedagogical techniques, e.g., cooperative groups. However, overall, "All in all, I think the program went well. ....I think had they been in a regular class the results would have been drastically different. Some of them would have failed...I think the number of people who would have gotten A's last semester would have been two rather than the six or seven and the number of people who failed was 5 or 6, would have been closer to 12 or 13. There was a support system ..." (June 1999 interview, p.2).

Later in the interview, when asked, How is this group different from groups you have had in the past, his answer indicated that he knew the students, "...better than I have ever known students. In this class there is all this interaction that goes on. I talk to them and they talk to me, everybody talks to each other. So that is different." He also experimented with changing some class procedures, some he felt comfortable with, others not—for example, asking students questions about the homework they put on the board. There is (apparently) an inherent conflict between student interactions/discussions and content coverage, as he described it,

> There is one topic that is usually deadly boring and they all got into it and what I normally spend an hour and a half on I spent five or six hours on. It was improper integrals. They all found it fascinating and had all these ideas about it. So that was a lot of fun, but of course I lost a week and a half. Is it worth losing the time? A part of me says yes, because the discussion was very valuable. But then I always worry that they will go onto the next course and say we don't have what we need. We weren't taught what we need. I don't know what the solution to that is.

Procedures he felt he had changed in the classroom as a result of the TIME 2000 project included, "wait time" for people to respond to questions and not letting them go when they don't want to answer, and putting problems on the board.

In the Discrete Mathematics class, first semester, the student responses were more mixed. Both math faculty acknowledged that the course is less coherent, as the teacher of the Discrete Math (DM)course said, I think in the case of DM they had a right to be confused because the subject itself is diffuse and not all the topics are connected so there is no general theme to the course. It is just a collection of different subjects. They are all brought together in what they are not—they are not calculus. That is how it came about. It was put together by computer science professors who wanted to give their students a chance to see some of the ideas in mathematics that were part of the developments in computer science that were not calculus. They depended on combinatorics and graph theory and set theory and logic. (DM June 1999, p.2).

The faculty member indicated that he had made changes in classroom teaching, including the way homework was done and the organization of the class so that he had more time to introduce ideas and topics.

I think in my own teaching I have made changes because of the program. I am more aware of the psychological nuances of getting the students interested in the work....I try to praise students more when they do something fairly well....I have to be a little more careful about the planning of the course...(DM June 1999 p.2)

He also had asked students to write out explanations in the past, and now had used that on tests as well. He summarized the changes as, "More attention to the involvement of the students, a discussion, not just lecturing to them. More attention to introducing problems before giving a general treatment of a subject, individual relationships with students and making them feel better about their abilities and contributions." (DM June 1999 p.4)

Participation of math education faculty in math classes. The secondary mathematics education faculty member who observed and participated to some degree in the calculus class and the discrete mathematics class also provided an overall response that a lot went well in the math classes the first year. Both mathematics faculty suggested that feedback from the education faculty member was,

...really good because she sat in and would interrupt and ask questions to try to get the students to ask questions (to) lead the class back to what she thought might be important. I think that was really good because sometimes I wouldn't realize that the students might not understand something...(DM, June, 1999, p.3)

I thought it was very helpful. It didn't hold me back, and it was something that improved the classes. (DM, June, 1999, p.3)

...was always positive force....She would often zero in on things that I would miss. I wouldn't realize that certain things were bothering the students and she would be more in touch with that (Calculus, June 1999, p.3)

The videotapes were another form of feed-back, and viewing the videotapes was not as easy to do, Very depressing information. You see yourself teaching, you don't realize how you come across. There are certain things you can't change...that you never noticed. The way you stand in front of a classroom... I did see the lack of involvement in the tapes also. It was much better when it was a give and take. The lesson seemed to go over much better and there seemed to be a better understanding when the students participated and asked about their doubts or gave their own solutions.(DM, June 1999, p.3).

When there were discussions with the education and math faculty they sometimes reflected the tension that the education faculty had not, in fact, taught the calculus course, for example.

There were times she would say why didn't you do it this way and I would say, well you need to know these formulas in biology and chemistry to do it and they are not going to figure out these things themselves. So there was always that problem of perspectives...(Calculus, June 1999, p.5)

Observation of the SEYS class by a mathematician. One of the education faculty said that the observations by the calculus teacher was helpful,

That was really a turning point for helping (us to) be more together with our procedure for team teaching. I think what (he) did was point out that we both may be right and we will have to find a way to let those both right ways reflect in what we do. From his observation he was picking up some disconnect so when he joined the meeting—(we) debriefed every time—before we taught a lesson we planned, after we taught it, we debriefed. And it was in one of those debriefing sessions that (he) helped. ....

This quote also reflects the informal observations by the other educational faculty member. And, as noted earlier, by the end of the second year of team teaching the course both faculty stated that the course is now more integrated.

B. Faculty Recommendations for TIME 2000

As part of the end of year (1998-1999) interviews the faculty were asked, Do you have any suggestions for the development of a "program" –the sequencing and integration and/or content across the various mathematics courses needed for teachers to be excellent teachers of secondary mathematics in high schools? Faculty suggestions fell into several areas—mathematics, psychology of teaching mathematics, adding new faculty and use of videotaping of classrooms.

Mathematics. Several suggestions related to the discrete math and probability courses. These included doing more interesting things that are finding their way into the high school curriculum; topics that are more accessible for students (DM); probability may not be the right class to take the first year. One comment was to have their own courses for the math education students, so that the course could be designed leaving out some topics that are not as important from high school curricula standpoint. Other changes included using a problems section with the professor or a graduate student, since students need more and they don't get it, and the development of computer program that allows students to review the subject in an interactive way. It was suggested that the calculus course needed an extra hour or so of class time--that would be helpful. The issue of cooperative learning groups has not been resolved for the mathematics classes. There has been an informal effort at peer-led learning groups in calculus (second year students working with first year students).

SEYS. Teaching educational psychology with a content focus on mathematics was very positive. It showed the possibility of ensuring that the psychology of learning and teaching are interwoven with the content. The idea could well be extended to the other content areas (in the secondary education program). It suggested rethinking the two educational psychology courses, so that the first course would focus on development, social development, and learning. The second course would be on learning and teaching—motivational theory, assessment, and classroom and organizational management.

The fieldwork component of SEYS was problematic and it was also very useful. Although the requirement is there, the supporting placements are not easily located, and the integration with the classroom assignments were not always well-synchronized. Among the positive aspects were that students were in schools, observing, tutoring, and these experiences were brought to class for discussions.

Adding new faculty as program extends beyond Year 1 and videotaping. "It would be helpful to have a videotape of some of the better lessons where the interactions are really there, we could show that." As the other math faculty member put it, "Well the experience of having a lively class rather than just a lecture. That can be difficult to manage but you have to try." Further, as noted above, viewing videotapes of themselves teaching was not easy for faculty. Yet many campuses have instructional development groups who work with faculty to improve teaching, and this typically includes videotaping of class lessons for review and feedback. This is a proactive, supportive form of faculty development.

From another perspective, the issue of professional development for faculty was also raised. Faculty became familiar with portfolios and journals, learning experiences that are in line with the new state accreditation and standards requirements. However, it was a major challenge to work on the mathematics course revisions as recommended by the NCTM standards and the integration of the mathematics content with psychology. As new courses in mathematics and education are developed for the remainder of the undergraduate program, the need for professional development for faculty new to this project is apparent. There was a further suggestion that the education and content departments (foreign languages, literature, and so on) should develop teams for teacher education, as is being done with the TIME 2000 program in mathematics.

III. Summary and Issues

Summary

TIME 2000 had two major goals—recruitment of high school students and developing an integrated curriculum for high school students enrolled as freshmen in 1998-1999. These goals were essentially achieved for that first year, with 33 students admitted and with 23 of the 33 students completing the second year of the project (1999-2000). Student and faculty perspectives on the curriculum, course teaching, and other project activities (e.g., seminars, faculty support of student initiatives) are generally very positive.

The initial design for recruiting assumed that high school students recruited each spring and enrolled in the fall would comprise a cohort that would move through the course curriculum sequence as a unit. However, even in the first year cohort some students entered who were more advanced mathematically; these students were advised on other mathematics courses to take. And, other mathematics majors learned about the program and wanted to become part of it. Thus, the faculty now view recruiting and designation of a 'cohort' from a more flexible perspective. The implementation of this more flexible perspective will be challenging, as students will have a more varied curriculum and the project faculty need to design experiences to ensure the standards of experiences and outcomes desired for TIME 2000 students meet both state and national standards for teaching secondary mathematics.

Challenges remain in integrating faculty teaching more advanced courses in mathematics and education. Because of the teaching and learning goals for TIME 2000 both faculty development and faculty integration into regular faculty meetings will be important.

Issues

The TIME 2000 program, both in its strengths and developmental problems, has raised important issues for teacher education, departments of mathematics, college support of faculty professional development, and resources. As indicated above, the four core faculty were extraordinarily involved in the full development and coordination of the project. What started out as a planning and one year implementation grant has evolved and taken on a life of its own. Although the project faculty wrote a NSF grant to extend the program for an additional three years, the grant was not funded. However, the project director has located additional funding for student scholarship money and the project has just completed its second full year, after admitting a smaller group of students for the second cohort. Recruitment continues and a third cohort will be admitted in the fall of 2000. Work to integrate additional faculty from both mathematics and the department of secondary education continued, so that students from the first cohort were able to be block scheduled in both mathematics and education (foundations of education) during their second and third years. The majority of students have formed a community and appear to keep in touch with each other.

To date, the Department of Mathematics and the Department of Secondary Education have been supportive of scheduling both faculty and courses so that the block scheduling can be maintained. Both education and mathematics faculty continue to think about and change aspects of courses from the first year, and the faculty continue to meet regularly. As new faculty are integrated into teaching TIME 2000 mathematics students, additional resources are needed to support faculty development and the planned development of new mathematics courses, particularly the 'capstone' course that will work to further connect the major mathematical ideas across the mathematics courses.

Issues for the completion of the program development as a prototype model and for the continued implementation of the program include:

1. Recruitment and scheduling—developing flexibility in recruiting both high school seniors and mathematics majors already in college and extended cooperation in scheduling by the mathematics and education departments;

2. Resources for faculty release time and administrative support of the program;

3. Campus resources for faculty development for TIME 2000 project, as well as other faculty development—i.e., videotaping support and instructional resource personnel.

There are other issues that are project specific. These include issues of student choice of courses and experience with a variety of mathematics professors. Another project-related issue is that of maintaining contact within and across the TIME 2000 cohorts as they complete their college years. This issue is linked to the need to plan post college teacher development—perhaps related to work on preparing not only for state certification but for National Board Certification.

The formative evaluation data collected during Year 1 provide strong support for the allocation of college resources to the program. The data also indicate the difficulty in supporting and sustaining faculty development of new teaching methods and the integration of student-focused programs across disciplines. The student and faculty interviews provide evidence that the project is well-worth supporting to completion, despite the evident (and inevitable) tensions that occur in changing college programs. The positive student responses suggest that all the effort and challenges met are worthwhile.

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Appendix A

TIME 2000 Math Survey 8/98

Student characteristics and beliefs about mathematics, teaching and learning

TIME 2000
Math Survey 8/98

Name: ______________________________ Date: ______________________________

Date of Birth: ______________ F____ M____

First language: ________________________ Number of years speaking English: ______________________

College: ________________________ Title of this class: ____

College Major: ________________________________ Minor: ______________________________________

College credits completed : __________ Number of college math courses completed: ________________________

If first-year college student, number of high school math courses completed: ______________________________

Name(s) of Mathematics AP courses completed: ____

How often did you work in a small group to solve problems in math class in high school?

About once a week _______ About once a month _______ Rarely_______

Describe if and how this helped you learn math problem solving.

____

____

____

Place a check next to the tools you used in math class in high school to solve problems, and how often used.

Scientific calculator ____

About once a week _______ About once a month _______ Rarely_______

Graphing calculator ____

About once a week _______ About once a month _______ Rarely_______

Computer ____

About once a week _______ About once a month _______ Rarely_______

Please describe the computer programs you have used (if any).

____

____

____

Please describe how any of these tools helped you learn math problem solving skills.

____

____

____

The questions on the following pages ask you about what you think and feel about math. This is *not* a test. You will not be graded on your answers and the information will not affect your grades or your school work. Please answer each question carefully.

Please circle one number on the indicated scale:

1= Strongly Disagree; 2= Disagree; 3= Neither agree nor disagree; 4= Agree; 5= Strongly Agree

1= Strongly Disagree; 2= Disagree; 3= Neither agree nor disagree; 4= Agree; 5= Strongly Agree

1.	To understand mathematics, students must solve many problems following examples provided.	1	2	3	4	5
2.	Getting the correct answer to a problem in the mathematics classroom is more important than investigating the problem in a mathematical manner.	1	2	3	4	5
3.	Solving problems in a small group helps me learn math.	1	2	3	4	5
4.	Truly understanding mathematics requires special abilities that only some people possess.	1	2	3	4	5
5.	I participate more fully in problem solving in a small group rather than the whole class.	1	2	3	4	5
6.	I am looking forward to taking more mathematics courses.	1	2	3	4	5
7.	I can explore more alternative ways of solving problems using a calculator/computer.	1	2	3	4	5
8.	When working in a small group of students often another student can explain a math idea/concept to me more clearly than the professor.	1	2	3	4	5
9.	When I solve problems in a small group of students I understand math better.	1	2	3	4	5
10.	The use of technologies in mathematics is an aid primarily for slow learners.	1	2	3	4	5
11.	The primary reason for learning science is to provide real life examples for learning mathematics.	1	2	3	4	5
12.	I work better by myself when doing mathematics problems for homework.	1	2	3	4	5

1= Strongly Disagree; 2= Disagree; 3= Neither agree nor disagree; 4= Agree; 5= Strongly Agree

13. A student should rarely be confused in math class.	1	2	3	4	5
14. I work harder on solving math problems in a small group of students.	1	2	3	4	5
15. The most productive problems a teacher can pose are open-ended.	1	2	3	4	5
16. In math class students should not analyze different approaches to a problem.	1	2	3	4	5
17. I do better work in math when working in a small group than by myself.	1	2	3	4	5
18. I like mathematics.	1	2	3	4	5
19. In math class almost all class time should be used by the college professor to present information and show how to do problems.	1	2	3	4	5
20. Using a calculator/computer in math class helps me to think more about the mathematics.	1	2	3	4	5
21. It is important for teachers to understand students' initial comprehension of a topic before the lesson is taught.	1	2	3	4	5
22. Students should not work in small groups on problems in math class.	1	2	3	4	5
23. The teacher should make the student figure a problem out for themselves rather than show how to do it.	1	2	3	4	5
24. I learn more math if I write about how I solve a math problem.	1	2	3	4	5
25. I generate more solutions to problems when working in a small group.	1	2	3	4	5
26. The primary reason for learning mathematics is to learn skills for learning science.	1	2	3	4	5

1= Strongly Disagree; 2= Disagree; 3= Neither agree nor disagree; 4= Agree; 5= Strongly Agree

27. When working in a small group we can correct each others mistakes better than in a whole class discussion	1	2	3	4	5
28. In math class students should discuss different ways that they can solve particular problems.	1	2	3	4	5
29. I learn math best by memorizing rules and procedures.	1	2	3	4	5
30. It is more important to demonstrate good reasoning than to get the correct answer.	1	2	3	4	5
31. In math class students should not do problems that have more than one solution.	1	2	3	4	5
32. Using a calculator/computer can help me understand math relationships better.	1	2	3	4	5
33. In math class students should discuss their ideas and solutions with members of the class	1	2	3	4	5
34. I enjoy learning how to use technologies in mathematics classrooms.	1	2	3	4	5
35. When I feel confused in math class, I know I am not learning math.	1	2	3	4	5
36. Students should make conjectures and explore different methods to solve a problem in math class.	1	2	3	4	5
37. When a teacher uses a calculator/computer it helps me understand math better.	1	2	3	4	5
38. Calculators/computers do not help me in problem solving in math class.	1	2	3	4	5
39. I learn mathematics best when I work alone.	1	2	3	4	5

1= Strongly Disagree; 2= Disagree; 3= Neither agree nor disagree; 4= Agree; 5= Strongly Agree

40. Mathematics consists of unrelated topics (e.g., algebra, arithmetic, calculus, and geometry).	1	2	3	4	5
41. Students should conduct a self-assessment of how well they have learned a concept or skill in math class.	1	2	3	4	5
42. I am able to solve more problems and check my work using a calculator/computer.	1	2	3	4	5
43. Students should use mathematical modeling in math class.	1	2	3	4	5
44. I come up with alternative ways to solve problems better when I work alone.	1	2	3	4	5
45. The teacher should ask students to find more than one way to solve a problem.	1	2	3	4	5
46. Teachers should check to make sure students understand the material before moving on to a new topic.	1	2	3	4	5

Part B

47. A proof of a mathematical relationship shows it is true.	1	2	3	4	5
48. I do not like to have to explore and investigate in mathematics; I prefer just to know the answers.	1	2	3	4	5
49. Learning is quicker if you are taught the ideas directly instead of having to find out for yourself.	1	2	3	4	5
50. Once you have proven a mathematical result then you can be certain it is true.	1	2	3	4	5
51. Trying to prove a mathematical relationship for yourself helps to convince you it is true or false	1	2	3	4	5

1= Strongly Disagree; 2= Disagree; 3= Neither agree nor disagree; 4= Agree; 5= Strongly Agree

52. Unlike in most other subjects, in math there is a clear cut right or wrong. 1 2 3 4 5

53. You can learn better and remember something for longer if you have to discover it for yourself. 1 2 3 4 5

54. Trying to prove a mathematical relationship for yourself does not usually help you to understand it better. 1 2 3 4 5

55. I prefer to discover things for myself rather than to be told 1 2 3 4 5

56. There is no point in trying to prove a mathematical relationship unless you are sure it is true. 1 2 3 4 5

57. The process of trying to prove a mathematical relationship can change your mind about it 1 2 3 4 5

58. The ability to investigate new situations in mathematics is not as important as knowing mathematical facts. 1 2 3 4 5

59. If a teacher tells me something that is true then I don't need to check it for myself. 1 2 3 4 5

60. If a mathematical relationship is obviously true, there is no need to justify it or to prove it. 1 2 3 4 5

61. I never believe anything until I can see why it might be true. 1 2 3 4 5

62. A proof of a mathematical relationship makes it clear exactly how it depends on other relationships 1 2 3 4 5

63. Being shown a proof of a mathematical relationship does not help you to understand it fully. 1 2 3 4 5

1= Strongly Disagree; 2= Disagree; 3= Neither agree nor disagree; 4= Agree; 5= Strongly Agree

64. Doing well in mathematics is more important to me than enjoying the subject.	1	2	3	4	5
65. There is no point in learning anything in mathematics that is not on the course syllabus.	1	2	3	4	5

Appendix B

Student Interview Questions

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Student Interview Questions

Thanks for taking the time to come talk with me about your experiences in the TIME2000 program to date. As you know, we are involved in documenting what students are doing in the program. I have some questions to ask you. We are very interested in what you are thinking so far. I am going to audiotape the interview.

Think back to the beginning of the semester, about the time of your first classes. What were your thoughts reactions, and feelings to what was going on in the

1. Calculus course?
2. Discrete Mathematics?
3. Educational Psychology?

Can you give me some examples of mathematical ideas you have learned about

1. Calculus?
2. Discrete Mathematics?

What kinds of connections in math ideas have you noticed between Calculus and Discrete Mathematics ?
What kinds of connections have you noticed between Educational Psychology and either or both of the math classes?

What aspects of each class and/or the teacher would you want to use when you start teaching?

1. Calculus
2. Discrete Mathematics
3. Educational Psychology

Think about yourself as a learner of mathematics and learning about the learning of math. How were you learning in the beginning of the semester and how is this different from the way you learn now?

When you think back about how you learned math before and now, how would you characterize your *understanding* of mathematics or mathematical ideas?

(follow up) *If and how has your level of understanding changed in*

1. Calculus?
2. Discrete Mathematics?

As you approach the end of the semester, how has working in small groups supported, or not, your learning and understanding of mathematical ideas?

What technology are you using in connection with the project in

1. Calculus? How does it help you understand Calculus? Please give me an example or two.
2. Discrete Mathematics
3. Educational Psychology

How would you describe your experience with the other TIME students

1. in the classroom?
2. outside the classroom?

Specifically, how would you characterize your experience speaking with the TIME students about mathematics?

How about your experience with the professors

1. in the classroom?
2. outside the classroom?

All questions followed by request for further examples.

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