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AUTHOR	Berg, Craig; And Others
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ABSTRACT

This paper describes a university program designed to upgrade the presentation of course content in the sciences and mathematics to prospective elementary classroom teachers. Presented in the paper are data on efforts to evaluate implementation and perceptions of the science and mathematics faculty (n=5) who played an instructional role in this project. The goals of the revised curriculum were: (1) reduction of teacher's anxiety toward mathematics and science, (2) building a background of understanding of science and mathematics concepts, (3) helping teachers recognize common science misconceptions, and (4) demonstration of appropriate instructional strategies while presenting a conceptually accurate knowledge base in science and mathematics. Results of interviews and observations of teaching showed that the degree of knowledge among the faculty ranged from well-informed and current to minimally aware. Each faculty person elected to become part of the new teacher education program for honorable and laudatory reasons; each spoke of the teacher's background knowledge of content, awareness of hands-on approaches, and ability to provide real-life applications of content. Concerning spoken goals versus current practices, it appeared that the fit between spoken faculty positions and their university classroom practices were congruent. An appendix includes course outlines for the science and mathematics courses. (MKR)

Mathematics and Science Preparation of Elementary Teachers: Implications for Faculty Development

Craig Berg, DeAnn Huinker, and Donald Neuman

Center for Math/Science Education Research
University of Wisconsin-Milwaukee
Milwaukee, Wisconsin 53201-0413

Paper presented at the 1993 Annual Meeting of the National Association for Research in Science Teaching at Atlanta, Georgia.

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Craig Berg, DeAnn Huinker, and Donald Neuman

Center for Math/Science Education Research
University of Wisconsin-Milwaukee
Milwaukee, Wisconsin 53201-0413

In recent years mathematics and science education in the United States have come under attack for a number of reasons and from a variety of directions. Detractors have been particularly critical of these two disciplines at the elementary school level. Though instructional problems (and their causes) are manifold, teachers and their preparation have been singled out for special criticism.

In this paper the authors will describe an innovative university program designed to upgrade the presentation of course content in the sciences and mathematics to prospective elementary classroom teachers. They will also present data on efforts to evaluate perceptions and implementation of the science and mathematics faculty who play an instructional role in this project.

Background

In 1990 with a grant from the National Science Foundation (NSF) the science and mathematics departments in conjunction with the Department of Curriculum and Instruction at the University of Wisconsin-Milwaukee embarked on a new approach to preparing prospective elementary teachers for science and mathematics instruction. The University of Wisconsin-Milwaukee (UWM) program was one of thirty NSF funded projects designed to upgrade the quality of children's elementary science and mathematics experiences.

At the time the new program was initiated the need for change in teacher preparation in these two disciplines seemed compelling. For example, in tests conducted by the International Association for the Evaluation of Educational Achievement, fourth grade American youngsters scored eighth out of 15 in science when compared to children of other industrialized nations. In high school biology American children scored thirteenth out of thirteen countries tested (Eichinger, 1990). When questioned, many classroom teachers admitted to a sense of personal inadequacy when att mpting to teach science and mathematics (National Science Board, 1991; Stepans, Beiswenger, & Dyche, 1986). Maintaining the status quo in the preparation of elementary mathematics and science education could no longer be justified. Recognizing both the needs and the opportunities presented by this situation, faculties from a number of science departments, mathematics, and education met to create a coherent and consolidated science and mathematics curriculum for prospective elementary teachers.

Goals of the Revised Curriculum

A revised science and mathematics curriculum was proposed with the following goals in mind:

1. To reduce anxiety of teachers toward science and mathematics.

2. Build a background of understanding of science and mathematics concepts that are taught in typical elementary programs.

3. Help teachers recognize common science misconceptions and replace misconceptions with more conceptually sound knowledge.

4. To demonstrate appropriate science and mathematics instructional strategies while presenting a conceptually accurate knowledge base.

Assumptions Underlying the Curriculum Revision

Changes in the content and delivery of undergraduate science and mathematics courses were based on the following assumptions (and supported by research findings):

1. Teachers teach the way they were taught. Therefore, appropriate instructional methods should be used by university faculty in presenting the content of science and mathematics. Specifically, science and mathematics are effectively learned by using inductive instructional strategies. Prospective teachers should therefore experience science and mathematics by means of inductive as well as deductive learning strategies themselves.

2. Teachers must understand, not just repeat from memory, the basic concepts of science and mathematics.

3. A positive attitude by the teacher toward a subject increases that teacher's confidence and instructional skills and also increases the likelihood that he/she will provide time in the elementary curriculum for teaching that subject.

The New Curriculum

To reach program goals and build on basic assumptions a new approach to delivering science and mathematics concepts was proposed. This new approach consisted of creating a science core consisting of thirteen one credit minicourses was created. (See Appendix A for a listing and description of the courses.) These courses were designed to provide basic science information in the areas of biology, chemistry, geology, meteorology, and physics. The new approach also consisted of developing a revised mathematics core. Experiences in numeration systems, traditional and non-traditional algorithms, estimation, statistics, probability, geometry, measurement, and uses of calculators were stressed. Close adherence to the *Curriculum and Evaluation Standards* of the National Council of Teachers of Mathematics (NCTM, 1989) was followed in the creation of the series of mathematics courses for elementary teachers.

Changes in the instructional methods courses that follow the content courses were made. They included integrating the content of the science and mathematics courses into the methods courses. Close cooperation was also established between faculty who teach methods courses and the faculty who teach science and mathematics content courses to increase continuity and provide coherence to the total program.

Implementation of the New Curriculum

During the 1989-90 academic year a team of instructors from academic and education departments met to design science minicourses and a series of mathematics courses for implementation in the 1990-91 academic year. Though the specialist from each discipline was ultimately responsible for course content, strong efforts were made to integrate and reinforce student understanding of content by coordinating experiences and presentations. Science courses were to meet in five week sessions while mathematics courses were fifteen weeks in duration. One science course was scheduled during each five week session. Each course consisted of lecture, discussion, and laboratory phases (the balance among the phases was left to the discretion of the individual instructor). Students participated in courses in three of the four science disciplines for four semesters and in a mathematics course for two semesters.

Current Thinking About Elementary Science and Mathematics

Before describing the efforts to assess certain aspects of the innovative UWM science and mathematics program for elementary teachers it is important to look at the school programs for which teachers are being prepared. Elementary science and mathematics programs are varied in content and in implementation. It is impossible to describe a "typical" program. However, it is possible to describe characteristics of programs that meet currently accepted standards of quality.

Science in the Elementary School

Science for All Americans (Rutherford & Ahlgren, 1990) presents a number of recommendations for improving the quality of science education in America. Some of their suggestions include the following:

1. Schools should not teach more and more content but focus on concepts that build scientific literacy and present them in depth.
2. Blur the artificial lines that separate the science disciplines.
3. Diminish memorization of details and emphasize large ideas and thinking.
4. Build science around ideas that children find satisfying and serve as foundations for additional learning.

In addition many science educators subscribe to the dicta that children should be allowed to construct their own senses of reality by experiencing science phenomena directly—in a hands-on and minds-on way. Children should also learn to recognize relationships between phenomena in the natural world and (their impact on) society. Finally, science misconceptions should be confronted directly. Unrealized expectations should be recognized, acknowledged, and examined using hands-on/minds-on (inquiry) approaches.

It is no longer adequate for an effective elementary classroom teacher to be a "walking encyclopedia" of science knowledge. Skills in involving children in discovery investigations by organizing and encouraging hands-on/minds-on activities is a necessary condition for designing a meaningful elementary science program.

Mathematics in the Elementary School

While the scientists of Project 2061 were creating a framework to guide the development of appropriate science curricula and activities, the National Council of Teachers of Mathematics was carrying out an analogous venture. Under their auspices, a set of standards for school mathematics was developed in hopes of creating a coherent vision of what it means to be mathematically literate. NCTM also hoped to create standards that would guide future revisions of mathematics curricula (NCTM, 1989). From this work emerged a new vision of school mathematics. Specifically:

1. Mathematics was seen as something a person does; not an endeavor in which rules and procedures are memorized.

2. Mathematics encompasses many fields. Its applications to multiple fields of inquiry is a transcendent quality of mathematics.

3. A modern technologically-oriented society depends on students who possess the knowledge and techniques for applying mathematics to everyday problems.

The NCTM standards for school mathematics have established five goals for all students. They are: (1) To value mathematics, (2) To reason mathematically, (3) To communicate mathematically, (3) To be confident in their mathematical ability, and (5) To be a mathematical problem solver.

Thus it is no longer adequate for an effective elementary teacher to simply drill children in basic algorithms and lead them to solve mindless "story problems" by applying memorized procedures. Children must understand basic mathematical concepts. They must address mathematical problems in a hands-on/minds-on way.

The Study

The following two part study was undertaken with these purposes in mind. This paper presents an overview of both parts of the study and reports on the data collected in part one.

Part 1: Assess accomplishments to date

The investigators: (1) Evaluated project faculty's knowledge of the current thinking about elementary science and mathematics education, what teachers ought to know about each of their disciplines, and how each of their courses contributes to a teacher's skill in providing children with proper experiences; (2) Assessed the degree to which faculty of disparate departments and disciplines share common goals and common understandings of elementary science and mathematics education; and (3) Evaluated the extent to which university faculty's spoken goals relate to their course objectives and classroom behaviors. To reach the goals of part one of the study it was necessary to answer the following questions:

1. Understanding: Is the faculty able to demonstrate an understanding of the science and mathematics needs of elementary children and their teachers?

2. "Pulling in the same direction": Is there a common set of goals among faculty in the project?

3. Fit: Is there a discernible relationship between stated goals and the classroom behaviors of the project faculty?

Part 2: Develop a model for changing faculty behavior

Based on the findings from part one of the study, the investigators will attempt: (1) To develop a set of in-service experiences designed to inform present project faculty of the current status and suggestions for assessing the quality of current offerings; and (2) To develop a model for the in-service training of other faculty who wish to work with prospective elementary teachers. To reach the goals of part two of the study it will be necessary to answer the following questions:

1. In-service of current faculty: Can a set of experiences be designed that acquaint science and mathematics instructors with the current status of the project and how to adjust course offerings to make them more meaningful for prospective teachers?

2. In-service of future faculty: Can a model be developed (derived from in-service experiences of current faculty) to serve as in-service preparation for new faculty?

Subjects

The subjects for this study were the instructional faculty for the revised mathematics and science curriculum. This included professors from five academic departments. All possessed Ph.D.'s in their discipline. They were:

- Biological Science. Associate Professor. Fifteen years experience on the UWM faculty.
- Chemistry. Associate Professor. Twenty-seven years experience on the UWM faculty.
- Geosciences. Associate Professor and department chairperson. Eighteen years experience on the UWM faculty.
- Physics. Associate Professor. Twenty-six years experience on the UWM faculty.
- Mathematical Sciences. Associate Professor and Associate Dean of Natural Sciences. Twenty-five years experience on the UWM faculty.

Procedures

Investigators sought to answer the three questions that made up part one of this study. Specifically, methods were designed to elicit answers to each of these questions:

- Does the faculty understand the needs of children and teachers and their role in meeting those needs?
- Are faculty "pulling in the same direction"?
- Is there a fit between stated philosophies and behaviors?

In an effort to answer these three questions two methods of data collection were utilized.

Personal interviews were conducted with all five subjects. Each subject was also videotaped while teaching his or her respective mini-course.

Personal interviews. Each of the five instructional faculty was interviewed by the same investigator. Each interview was tape recorded and notes were taken by the interviewer. The same set of protocols was used for the purpose of carrying out each interview. The interviewee was questioned in his or her office on the UWM campus. Each agreed to being audiotaped during the interview. The interviewer knew each responder from previous professional interactions.

Each person was asked to respond to the following three questions:

1. From your point-of-view, what do you perceive elementary science (or mathematics) to be and what ought it to be?

2. In a broad sense, what skills and knowledge about your subject do elementary teachers need to possess?

3. How does your course reflect your feelings about those needs?

All interviews were transcribed. The transcriptions were given to each of the three investigators. It was decided that two of the investigators would take responsibility for evaluating the interviews. Two matrices (see table 1 and table 2) were used to evaluate responses.

Table 1. Common set of goals

Question	Faculty A Responses	Faculty B Responses	Faculty C Responses	Faculty D Responses	Faculty E Responses
1. What is/ought elementary science (mathematics) to be like?					
2. What should teachers know about your subject?					
3. How does your course reflect your feelings about questions 1 and 2?					

In applying matrix one (shown in table 1) each evaluating investigator read transcripts of interviews and noted key terms, phrases, and points stressed by the interviewee. Those were recorded in the appropriate cell of the matrix. The two evaluating investigators worked independently in completing Matrix 1. They then met to compare results, discuss differences, reconcile differences, and create a final matrix. Matrix 1 represents a profile of faculty goals for their classes and, by inference, a statement of philosophy about science and/or mathematics education. Investigators compared profiles of each faculty person to determine consistency of beliefs from person to person.

Table 2. Knowledge of current status of elementary mathematics or science

Question	Faculty A	Faculty B	Faculty C	Faculty D	Faculty E
Knowledge of elementary content					
Getting children involved/hands-on					
Inquiry/Problem solving/critical thinking					
Teacher as a facilitator (not just a transmitter of knowledge)					
Importance of developing children's attitudes					

Matrix 2 (shown in table 2) was completed by using a Likert scale reflecting the emphasis each faculty person placed on each factor being evaluated. The Likert scale is shown in table 3. Again, evaluators completed the matrix independently. They then met to compare results and determine interevaluator reliability. Differences were discussed and reconciled and a final matrix was completed. This matrix was used to determine the knowledge of "current thinking" by each faculty person.

Table 3. Likert scale reflecting faculty emphasis

Score	Interpretation
1	None: Not mentioned in interview
2	Minimal: Mentioned one or two times
3	Somewhat: Mentioned three or four times
4	Strong: Mentioned five or six times
5	Very strong: Mentioned more than six times

Vic..otaping of Instruction. Each course instructor agreed to have two lecture sessions and two laboratory sessions videotaped. A video camera person was trained by one of the investigators on what to record, how to be unobtrusive, how to effectively use the videocameras, and the use of the remote mike. Classes were taped in their entirety. Much of the time the camera was focused on the instructor and a portion of the time on the students. Camera operators were trained to capture the instructor and any interaction with the students.

An evaluator was trained to observe the videotapes and record interactions using a structured computer assisted format. An investigator with extensive experience in interaction analysis identified a graduate student with suitable classroom observation and evaluation experience, described and explained the coding categories within the Training and Assessment System (TAS) developed by Ron Bonnstetter at the University of Nebraska at Lincoln (Crow & Buckley, 1988). The investigator viewed and coded videotapes with the evaluator until the evaluator and investigator developed reliability in coding the interactions. The categories are listed in table 4. A compiled set of coded interactions for each professor was created and analyzed using the statistics available within the TAS software resulting in a profile of behaviors for each instructor. Additional observations were recorded after viewing the tapes or during a second viewing.

Table 4. Teacher and student behavior categories: TAS Analysis

Code	Description
1	Lecture/give directions
2	Statements
3	Short answer question
4	Asks extended answer question
5	Rejects student comment
6	Accepts student comment
7	Confirms student comment
8	Repeats student comment
9	Clarifies/Interprets
0	Answers student question
Q	Asks student to clarify
W	Uses student's comment
E	Student asks question to teacher
R	Student Talk - Responding
T	Teacher observing student
Y	Teacher redirects question
U	Student asks question to student

Results

The results from the interviews and the videotaping are summarized below. Additional data from the analysis of the videotapes can be found in Appendix B.

Interviews

The results from the interviews with the five project faculty are summarized in Table 5 and Table 6. Table 5 lists key terms, phrases, and points stressed by each of the faculty. Table 6 shows the rating given to each faculty for the emphasis he or she placed on each the identified characteristics of quality instruction in science and mathematics.

The first question concerned the faculty's perception of what elementary science or mathematics ought to be like. Four of the faculty spoke of hands-on experiences and the other referred to investigations which most likely implies hands-on activities. Three faculty indicated that rote memorization and learning needs to be avoided or de-emphasized and a fourth person stated that facts ought to be incidental to the activity which implies a de-emphasis on rote memorization. Faculty C and D specifically stated that real-life examples should be used and Faculty E mentioned collecting data which implies using real-life examples.

Table 5. Profile of faculty goals

Question	Faculty A Responses	Faculty B Responses	Faculty C Responses	Faculty D Responses	Faculty E Responses
1. What is/ought elementary science (mathematics) to be like?	Facts ought to be incidental to activity. Investigate, conjecture, validate. Follow NCTM Standards.	Hands-on, exploration, experimentation. Sense of wonderment. Avoid rote memorization.	Hands-on. Classification. Real-life example.	Hands-on experiences. Not just memorize. Relate to real-life.	Hands-on. Discover cause and effect relationships by collecting and analyzing data. See questions, not answers. Diminish emphasis on rote learning and vocabulary acquisition. Willingness to try and to fail. Teacher should not be answer givers.
2. What should teachers know about your subject?	Connections to real-life, practical problems. Solving problems. Make tables. Look for patterns.	Basic body of knowledge. Where to find facts. Understand the scientific method (how to solve problems). Be able to use real-life examples.	Classification. Basic mathematical relationships to chemistry. How to conduct themselves in a lab. Establish framework for making relationship among facts.	Get facts straight. Concepts clearly defined. Quantify, e.g., mass, temperature.	Acquire broad general concepts and develop framework. Know processes of looking for similarities and making connections to past history. Ability to question.
3. How does your course reflect your feelings about questions 1 and 2?	Models thinking processes when solving problems. Uses varied mathematical models. Stresses organizing information in tables and charts to build excitement and confidence.	Demonstrates the scientific method. Applies scientific method to non-scientific problems. Teaches students to ask questions about the world. Gets students directly involved in lab exercises.	Builds confidence and security in preparation for lab work. Studies graphing and rations. Carefully organizes and directs labs.	Defines terms. Provides information. Begins with concrete examples and moves to abstraction.	Engage students in open-ended classification and inquiry activities. Takes field trips. Studies local geology. Stresses geological processes.

The second question concerned the skills and knowledge teachers need to possess about mathematics or science. Faculty A and B mentioned real-life examples. Faculty D stated that teachers need to get facts straight and Faculty B pointed out that teachers need to acquire a basic body of knowledge and know where to find facts. Faculty C and E spoke of teachers needing to establish a framework for understanding the subject.

The third question concerned what the faculty do in their course that reflects their feelings about the needs of elementary students in science and mathematics and about the needs of teachers. Faculty D mentioned beginning with concrete examples, as well as defining terms and providing information. Faculty A spoke of "thinking out loud" when solving problems and the importance of organization information. Faculty B stated getting students directly involved in lab exercises and Faculty E indicated getting students engaged in open-ended and inquiry activities, as well as taking field trips. Faculty A and B mentioned something about building confidence in the prospective teachers.

The numerical data displayed in Table 6 reflect the emphasis each faculty member placed on factors that have been identified as characteristic of quality instruction in science and mathematics. A rating of 1 indicates that the factor was not mentioned by the faculty member during the interview. A rating of 5 indicates that the faculty member mentioned it repeatedly (seven or more times).

Table 6. Emphasis placed on each factor by faculty

Question	Faculty A	Faculty B	Faculty C	Faculty D	Faculty E
Knowledge of elementary content	4	2	3	5	4
Getting children involved/hands-on	4	5	2	2	4
Inquiry/Problem solving/critical thinking	5	3	1	2	4
Tea_her as a facilitator (not just a transmitter of knowledge)	3	2	1	1	4
Importance of developing children's attitudes	3	2	2	1	2

Faculty A, D, and E discussed aspects of the elementary school curriculum a minimum of six times, thus rating high in their knowledge of elementary science or mathematics content. Faculty B and C demonstrated some knowledge of elementary school content. Faculty C and D alluded to the inclusion of hands-on experiences, whereas Faculty A, B, and E repeatedly mentioned the importance of getting students involved in hands-on experiences. Faculty A and E often mentioned the importance of inquiry, problem solving, or critical thinking, and Faculty B spoke of it three.

However, Faculty C did not refer to the importance of inquiry at all, and Faculty D mentioned it only once.

In regards to the teacher as facilitator factor, Faculty E spoke of it often and Faculty A mentioned it three times. Faculty C and D made no reference to the idea of teacher as facilitator and Faculty B mentioned it once. Faculty B, D, and E mentioned the importance of developing positive attitudes towards science and mathematics once each while Faculty D did not mention it at all. Faculty A spoke of developing positive attitudes four times.

Videotapes of Instruction

As a summary of the quantitative data obtained, table 7 reports the number of minutes observed, percent of time given over to direct lecture, number of questions asked to the students per standardized time period (per 30 minutes), number of student responses per 30 minute period, and number of student initiated questions per 30 minute period. Refer to Appendix B for additional data on patterns of interactions and actions.

Table 7. Summary of Faculty and Student Actions

Action	Faculty A	Faculty B	Faculty C	Faculty D	Faculty E
Percent of class time used for lecture	48.0%	97.0%	81.0%	99.9%	88.0%
Number of short answer questions (per 30 minutes)	37.0	7.0	34.0	0.5	17.0
Number of extended answer questions (per 30 minutes)	19.0	0.0	1.0	0.0	4.8
Number of student responses (per 30 minutes)	60.0	1.0	30.0	0.3	8.9
Number of student initiated questions (per 30 minutes)	0.0	0.0	3.0	0.0	2.3
Total minutes observed	67	91	136	196	171

The TAS observation and analysis software has the ability to search for patterns of interactions. The patterns found reflected the data listed in table 5. For example, Faculty B lectured while asking an occasional question. The patterns of interaction usually indicted a lecture, followed by a short answer question (usually a rhetorical question with no students response), followed by the instructor lecturing. Whereas, Faculty A's patterns of interaction revolved around asking both short answer and extended answer questions with students responding to the questions. See Appendix B for the major interaction patterns for each Faculty member.

Discussion

If "teachers teach the way they were taught" then prospective teachers should learn science and mathematics through the instructional methods which they will eventually use when they become teachers. For university faculty to teach with appropriate methods they need to be aware of the characteristics of programs that meet currently accepted standards of quality. Project 2061 and the NCTM Standards, as discussed earlier in this paper, describe the characteristics of such programs. The findings of this study indicate that the faculty have some knowledge of appropriate instructional strategies, but that understanding varies considerably among the faculty and their implementation of those instructional strategies also varies.

Understanding: Is the faculty able to demonstrate an understanding of the science and mathematics needs of elementary children and their teachers?

Faculty A and E demonstrated the greatest degree of understanding of the science and mathematics needs of elementary children and their teachers. Faculty B seemed to be the next most knowledgeable, with Faculty C and D showing less clear understanding. Contradictions surfaced in several of the faculty interviews concerning how elementary children best learn and how prospective teachers should learn. All faculty made mention of children learning through "hands-on experiences" (a catch-phrase in current favor). However, three of the faculty emphasized the importance of prospective teachers learning facts through readings, listening to lectures, and watching demonstrations.

Faculty A provided numerous examples of mathematics as something one does in which facts are incidental to the activity (through students' engagement and investigation both elementary children and prospective teachers, learn or discover facts). For example, Faculty A made the following comments:

- The main thing is to make teachers comfortable with mathematics--not equip them with a large number of specific facts."
- Encourage them to see each problem done in as many ways as possible, so that they don't just have a single approach, but have many approaches."
- Teachers should learn to make connections between mathematics, science, and society by discussing practical problems found in the newspapers or around them in schools.
- Calculators are an integral part of mathematics courses--even for testing.

Faculty E demonstrated understanding of current thinking in the teaching and learning of science. This individual emphasized the following:

- Elementary children and prospective teachers, should become directly engaged in inquiry activities, so that they can construct their own understandings. First and foremost they need the opportunity to get their hands on things, discover things, make their own associations between cause and effect.
- There's been, and there continues to be, too much rote work.
- It is a very useful thing to get the students involved in data acquisition in some form in order to find out what information is available to them, rather than just simply being given the information.

- Students should collect and analyze data while making connections between science and mathematics and history.

Faculty B demonstrated understanding of the needs of elementary children but showed less understanding of the needs of prospective teachers. In discussing elementary school science, Faculty B indicated:

- There should be a hands-on type of science with as much manipulation as possible. Keep that wonder.
- Students are turned off to science when teachers start using prepared ditto sheets and emphasize rote memorization.
- Regarding prospective teachers, it is important to impart "the basic body of knowledge to make them comfortable with what they are or will be teaching." Prospective teachers should get involved in lab exercises.
- However, they should be given the facts. Methods instructors will give them the way to really integrate those facts in an elementary science program.

Faculty C demonstrated limited understanding of the needs of elementary children and even less understanding of the needs of prospective teachers. For example, this person discussed:

- Connections among the sciences and between science and mathematics, emphasizing artificial lines that separate these disciplines.
- Concern over the lack of confidence and knowledge of prospective teachers concern about allowing them to experiment in the lab until they were prepared.

Faculty D demonstrated knowledge of the content taught in elementary school science, but revealed little understanding of "how" students should learn this content. He also showed limited understanding of the needs of prospective teachers. Faculty D stated:

- There are some things aspiring teachers have to memorize. They have to have acquire concepts, but they also have to be able to relate them to something in the real world.
- University science courses should start with real life examples, and then move into the abstract.
- A way must be found to teach an irreducible minimum to the elementary school teachers and still give them an ample amount of content.

"Pulling in the same direction": Is there a common set of goals among faculty in the project?

All project faculty have a common goal in that they are dedicated to the teacher education project. Beyond this common, overarching goal, some disparities, as well as some commonalties, surfaced in the project faculty's attempts to "pull in the same direction." Two common goals expressed by faculty were a concern with "hands-on" experiences and use of "real-life examples."

All faculty discussed or gave examples of real-life occurrences of specific scientific or mathematical ideas which they have used with prospective teachers. However, the rationale for using real-life examples and the way in which they were used varied among the faculty. Two faculty stated that if a student could relate a scientific concept to a real-life example, then it must mean they understand the concept. Two faculty used real-life hands-on examples as ways of increasing the level of student understanding. Three of the faculty stated a need to produce real-life examples and describe them to students. Two of the faculty encouraged students to generate their own real-life examples and real-life problems (students were then asked to discuss and investigate these problems in order to reach a possible solution).

All faculty mentioned the need for "hands-on" experiences for prospective teachers and their pupils. However, the interpretation of this term varied widely among the faculty. For example two faculty persons described their role as facilitators by challenging prospective teachers to become directly engaged in hands-on/minds-on experiences with science and mathematics phenomena. Two faculty persons described activities which were carefully directed so that the prospective teachers were involved with hands-on, but not necessarily minds-on experiences. One faculty person provided limited hands-on experiences, preferring that prospective teachers watch the faculty demonstrate a hands-on activity. Note, the last two interpretations of "hands-on" allow the instructor to remain the "transmitter of knowledge" by telling or showing students what to do with concrete materials and what information to derive from activities.

Fit: Is there a discernible relationship between stated goals, philosophies and the classroom behaviors of the project faculty?

The discussion in this section is based on a comparison of the interviews with the observations and analysis of videotapes of faculty instruction. The numbers in parentheses in this section refer to frequency counts from Appendix B.

Faculty D used lecture strategies for 99.95% of the time; asking students three questions during three and one-half hours of teaching. Thus, there was not much teacher-student interaction occurring. Yet, in the interview session when talking about effective science teaching, Faculty D stated that "hands-on experiences are important" and that "students should not just memorize." In the videotaped sessions the instructor attempted to do this by defining terms, providing information about a variety of things, often referring to and using the concrete objects to demonstrate a concept. The instructor also demonstrated a knowledge that new concepts should be introduced "concretely before moving to the abstract" by starting with the objects and ego-centric viewpoints (as in the earth, moon, sun relationships) before moving to discussion and explanations of more difficult perspectives. The videotapes show the instructor manipulating the objects not the students. The students did not get the opportunity to manipulate real equipment. They simply watched the instructor demonstrate from the front of the room. They asked few questions, were asked few questions, and were for the most part very passively involved in the lessons. Thus, we conclude that there is not a close fit between the stated goals, philosophies, and observed classroom behavior for this faculty person.

Faculty C exhibited a more diverse set of teaching behaviors. Lecturing was used about 92% of the time. This instructor had significantly different interaction patterns than some of the other faculty. Faculty C asked numerous short-answer questions (151) and the other associated behaviors that accompany teacher-student interaction such as repeating student's answers, students asking some questions (14), and the faculty answering student questions (13). This created a less passive atmosphere in class.

In the interview phase of this study Faculty C stated that "hands-on, classification, and real life examples" are important. Although Faculty C occasionally taught in a manner that resembled her stated goals, much of the instruction was still very teacher-directed with minimal hands-on, minds-on experiences. Hands-on is seemingly defined by students being in the chemistry lab. No indication of hands-on occurred in the lecture sections. Laboratory experiences were very carefully organized, teacher-directed, confirmation type labs. A sense prevailed that the labs should be rehearsed before doing them to reduce the uncertainty. The reference to classification by Faculty C indicated an emphasis on the students having a real understanding of the periodic table and why the relationships of the elements contained in the table exist. The instructor attempts to build this framework by asking many questions in class, by sketching in pieces of the periodic table, and by teaching about physical properties such as density and mathematical relationships such as ratio/proportions before moving into the specifics of elements, chemicals, and chemical reactions.

Faculty B exhibited lecture/statements 97% of the time. Twenty short answer questions were asked, many of which were "Do you have any questions?" This was a good indicator of the quality of teacher-student interaction occurring and a probable reason for few student responses (4) and students asking few questions (3). The pattern of interactions indicated predominate lecture, with an occasional question asked, followed by the instructor waiting a bit for a response. If there was no response, the instructor was likely to go right back to lecturing. Less frequently, the faculty would ask another question if the students do not respond.

Observations not categorized on the TAS analysis showed that Faculty B used many diagrams and overhead transparencies to give concrete examples—more so than the other instructors. He provided quality explanations and made connections to information that the student was already familiar with, such as past experiences with allergies and controlling allergic reactions. Faculty B also incorporated relevant and important topics into the course material such as AIDs information. He was careful to limit the use of confusing scientific language by careful descriptions of terms, by writing definitions on the board, and sometimes by using a general layman's term before incorporating the scientific term into the lecture and explanation. A fit did exist between his stated goal of "teachers should know a basic body of knowledge" and the carefully dispensed information in his classes. A discrepancy existed between his goal of elementary science being "hands-on, exploration, experimentation, [creating a] sense of wonderment, while avoiding rote memorization" and what was observed in the segment of instruction observed on videotape.

During the interview, Faculty B did mention getting prospective teachers involved in lab exercises but also stated, "I will give them the facts and you [the methods instructor] will give them the way to really integrate those facts to an elementary audience."

Faculty A facilitated a very interactive class. Very little lecturing occurred for the purpose of dispensing information (21% of the total time). Teacher talk and the statements made were often for the purpose of initiating an activity or to stimulate student responses. In this faculty's class, students were observed working in small groups for purposes of problem solving, sharing their ideas with the instructor, writing their ideas on the blackboard (a protracted, small-group brainstorming session). Numerous questions were asked, both short answer type (83) and extended answer type (41). Students responded freely and often (131) and seemed quite comfortable with the casual and friendly interaction and atmosphere created by the instructor. A question posed by the instructor would often evoke multiple student responses. In short, there was a close fit between Faculty A's stated goals and their description of what should happen in this class, what is good for elementary science, and what is actually happening in this class. This faculty member had developed a class in which students were investigating, solving problems, looking for patterns, and were having their thinking abilities challenged as well as seeing the instructor model his thinking processes.

Most of the instructors have many years of teaching experience which enables them to know which topics provide learning difficulty for college level students. How their instruction was modified to apply this information varied greatly. One instructor forewarned the students that specific subject-matter difficulties would show up while they were teaching. The other attempted to ask many questions to get the students involved in lecture. Other faculty set up a very active learning environment in which the students played a key role in learning. All instructors had as a stated goal to "relate" science content that these pre-service teachers are learning "to real life." One instructor used common substances to help students learn basic concepts, while the another instructor talked about the real world of teaching elementary science, stressing curriculum expectations for elementary students in specific local school districts, common misconceptions, and other difficulties that young students will have in acquiring science. Obvious and sincere attempts were made by all of the instructors to make the science and mathematics topics more relevant and meaningful to their students.

Conclusion and Implications

Investigators examined university science and mathematics faculty behaviors who elected to participate in an innovative approach to teacher education. The investigators developed qualitative data designed to identify the faculties'' understanding of real and ideal science and mathematics education practices in the elementary school. They examined the degree to which the faculty subscribed to complementary purposes in educating teachers. They compared the spoken goals of faculty with the operationalization of those goals (classroom and laboratory instruction). Based on data collected, the following conclusions seem justified.

In regards to knowledge of elementary school practices, the word uneven seems to best describe the state of knowledge among program faculty. Their knowledge ranged from well-informed and current to minimally aware and out-of-touch. Two of the five faculty knew and sought to implement standards recommended by professional organizations in science and mathematics (American Association for the Advancement of Science and National Council of Teachers of Mathematics). The other three faculty appeared to build their belief systems on personal biases, intuition, or recollections (of their own or their children's schooling).

From an analysis of interview data it is clear that each faculty person elected to become part of the innovative teacher education program for honorable and laudatory reasons. Each person expressed a strong interest in the welfare of children, a recognition of the role of classroom teachers in providing for children's welfare, and the centrality of their role in preparing classroom teachers for meeting that responsibility. Each spoke of teacher's background knowledge of content, awareness of hands-on approaches, and ability to provide real-life applications of content. Again, however, unevenness in emphasis and approach seemed to best describe the findings of the investigators. When prodded, some faculty dedicated themselves to emphasizing specific content knowledge. Others chose to build confidence and dedication in their students. At least one faculty person cited process and inquiry as the primary course emphasis. One can only wonder how such disparate emphases appear to the prospective teachers. Do they attribute these differences in approach and stress to individual, but acceptable, differences among the faculty? Or do they develop a sense of schizophrenia about what and how to teach science and mathematics? Is program coherence adversely affected? More data, based on student evaluations, are needed to answer these questions.

Concerning spoken goals versus current practices, it appears that, in general, the fit between spoken faculty positions (as measured by the analysis of audiotaped interviews) and their university classroom practices are congruent. Those who believe that knowledge acquisition is the sine qua non of appropriate teacher education courses employ lecture and laboratory methods that emphasize uninterrupted dispensing of information. Few opportunities for student feedback are provided. Questions are closed-ended and somewhat perfunctory. Information flows on a "one way street." Those who verbally subscribe to discovery learning and inquiry arrange their lectures and laboratory sessions so that interaction between faculty and students is the dominant activity. In other words, the fit between stated beliefs and practices of the faculty is "tight.. They are consistent. They provide experiences for students that conform closely with their personal beliefs.

Clearly no single approach or philosophical position is ideal for all teachers and all situations. However, it is useful for teacher education faculty to agree on what experiences are important for prospective teachers and how those experiences should be provided. If teachers teach the way they were taught (and all faculty interviewed for this study agreed on this dictum), at minimum faculty should represent appropriate role models. Evidence that faculty persons understand their roles as models of appropriate teacher behaviors is, at best, uneven.

It is equally clear that the problem is not owned entirely by the science and mathematics faculty who were interviewed. The science and mathematics education (pedagogical specialists) faculty must examine their roles in providing leadership and understanding to the content specialists. A cohesive and amicable team approach to establishing philosophical and practical underpinnings for this innovative program is needed. The second phase of this study calls for the development of "in-service" (a term one dare not use with university faculty) experiences for the content faculty. Data collected for the phase being reported on assumptions, beliefs, and practices will be used to help the science and mathematics faculty to examine their personal strengths and weaknesses and to work towards improving their instructional practice.

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Appendix A

Course Outlines

Astronomy 175	Introduction to Astronomy
Atmospheric Sciences 177	The Atmosphere
Biological Sciences 175	Introductory Cell Biology
Biological Sciences 176	Introductory Animal and Plant Biology
Biological Sciences 177	Introductory Ecology
Chemistry 175	Chemistry: Concepts and Models
Chemistry 176	Elements and Compounds: The World Around Us
Chemistry 177	Chemical Reactions: New Substances From Old
Geosciences 175	The Earth's Surface
Geosciences 176	The Mobile Earth
Physics 175	Motion and Heat
Physics 176	Electricity and Light

Astronomy 175
Introduction to Astronomy

A one-credit five-week minicourse in astronomy with laboratory. It meets two times per week for a fifty-minute lecture/discussion and once per week in a two-hour laboratory.

Lecture/Discussion Topics

Week 1. The Earth's rotation and revolution. Development of the calendar and units of time. Obliquity of the ecliptic and change of seasons. Essential ideas of ancient astronomy: Ptolemy vs. Aristarchus (Copernicus).

Week 2. Phases of the Moon. Theories of the origin and history of the Moon. Parallax method of determining distance. Astronomical measurements before the Middle Ages.

Week 3. Physical characteristics of the planets. Kepler's laws of motion. Satellites: moons, comets, and meteors. Newton's universal law of gravity. Scale model of the solar system.

Week 4. Physical characteristics of Sun and stars. Thermonuclear energy production. Seasonal and circumpolar stars. Northern hemisphere constellations and stars. The Milky Way and galaxies.

Week 5. Space exploration: past manned and unmanned missions. Big Bang theory of cosmological evolution. Black holes, supernovas, and search for extra-terrestrial intelligence.

Laboratory Topics

Lab 1. Examining shadow positions. Motions of the Earth. Scale model of the Earth-Sun system.

Lab 2. Determining the motion and phases of the Moon. Measuring distances using parallax method.

Lab 3. Models of the planets. Recognition of planets and their satellites.

Lab 4. Recognition of stars and constellations using Olson Planetarium.

Lab 5. Video tapes of lunar mission and unmanned missions.

Atmospheric Sciences 177
The Atmosphere

Introduction to the earth's atmosphere and its impacts on man. Not open to students who have had Meteorology 100 or 105. (Two hours of lecture, 2 hours of lab each week for 5 weeks.)

Lecture/Discussion and Laboratory Topics

Week 1. Composition, structure and temperature of the atmosphere.

Lab 1. Measurement of humidity, temperature and barometric pressure. Demonstration of convection. Set up week long project to monitor temperature, pressure and humidity and note weather changes associated with it.

Week 2. Moisture in the atmosphere.

Lab 2. Cloud observations. Lab demonstration of cloud formation. Video on cloud types. Set up week long cloud observations project.

Week 3. Pressure and wind.

Lab 3. Exercise on global weather patterns. Exercise on reading barographs. Demonstration of wind patterns using a rotating tank filled with water. Quiz.

Week 4. Weather patterns and severe storms.

Lab 4. Exercise on reading weather maps. Severe storms video. Visit UWM weather station.

Week 5. Human impact on the atmosphere.

Lab 5. Demonstration of producing smog. Exercise to map wind direction, wind speed and temperature around campus.

Biological Sciences 175
Introductory Cell Biology

There will be two 50 minute lectures and one two-hour laboratory/discussion each week for the five week duration of the course.

<u>Lecture/Discussion Topics</u>

Week 1. Scientific Method and the study of life

Weeks 1-2. Chemical basis of life: Water, Carbon, Macromolecules, and Energetics

Week 3. Cells: The cell concept, Cell structure and function, Prokaryotes and eukaryotes, and Viruses

Week 4. Cell division: The cell cycle, Mitosis, and Meiosis

Weeks 4-5. Genetics: Classical genetics and Genes and genetic engineering

<u>Laboratory/Discussion Topics</u>

Lab 1. Scientific method

Lab 2. Microscopes

Lab 3. Movement of liquids/gases and role of unit membranes

Lab 4. Enzyme action

Lab 5. Genetics

Biological Sciences 176
Introductory Animal and Plant Biology

There will be two 50 minute lectures and one two-hour laboratory/discussion each week for the five week duration of the course.

<u>Lecture/Discussion Topics</u>

Weeks 1-2. Plants

A. Classification of plants

B. Structure and function of plants: Roots, stems, leaves, seeds and fruit; Water and mineral absorption and transport; Food translocation; Tropisms and photoperiodicity

C. Plant reproduction: Alternation of generations, Flower structure and function, Hormonal control

Weeks 3-5. Animals

A. Classification of animals

B. Structure and function of animals: Major systems—Animal nutrition, Transport, Homeostasis, and Coordination

<u>Laboratory/Discussion Topics</u>

Lab 1. Plant structure

Lab 2. Photosynthesis, plant pigments

Lab 3. Classification

Lab 4. Physiology

Lab 5. Zoo field trip

Biological Sciences 177
Introductory Ecology

There will be two 50 minute lectures and one two-hour laboratory/discussion each week for the five week duration of the course.

<u>Lecture/Discussion Topics</u>

Weeks 1-3. Ecology
- A. Energy flow in ecosystems: Food chains and Trophic levels
- B. Population growth and regulation: Age structures and Birth and fertility rates
- C. Community interactions: Intraspecific interactions, Inter-specific interactions, Succession, and Major biomes

Week 3. Behavior
- A. Stereotyped and learned
- B. Biorhythm
- C. Social behavior

Weeks 4-5. Human Ecology
- A. Human role in nature: Resource management and Pollution
- B. Ecology and economics

<u>Laboratory/Discussion Topics</u>

Lab 1. Ecosystems
Lab 2. Museum field trip
Lab 3. Aquatic ecology
Lab 4. Terrestrial ecology
Lab 5. Behavior

Chemistry 175
Chemistry: Concepts and Models

A five-week course that meets three times a week in a fifty-minute lecture/discussion format.

<u>Lecture/Discussion Topics</u>

1. Chemistry in the scheme of things: What is it? How do we use it? How is it different from other natural sciences? What is required for understanding chemistry?
2. The meaning of a model; scientific models.
3. The atomic model; why this one?
4. Development of the atomic model (Atomic Theory): classic experiments. The processes of observing, questioning, theorizing, testing.
5. Digression: How small is small? Sizes of fundamental particles. How large a number of atoms in a grain of sand?
6. The language of chemistry: symbols and names of the elements.
7. The nucleus of the atom; radioactivity; energy sources: fission and fusion.
8. Electron arrangements as predictors of properties of the elements.
9. The periodic table as a predictor of properties of the elements.
10. Molecules and ions: How are they formed? How are they different from atoms? How are they different from each other? Are these models consistent with the atomic model?
11. Real substances: of what are they composed? How can you tell? How are they named? Of what use the chemical formula?

Chemistry 176
Elements and Compounds: The World Around Us

This five-week course meets two times a week for a fifty-minute lecture/discussion and once a week in a two-hour laboratory.

Lecture/Discussion Topics

Week 1. How do we know what we know about matter (elements, compounds)? (a) personal observations, (b) historical, on-going research, (c) educational and scientific literature.

Week 2. Order out of chaos: Systems for classifying substances.

Week 3. Oxygen is a gas, water is a liquid, iron is a solid. When? Where? Always and forever?

Week 4. Solutions and solubility (Laboratory Exercise #2). Predicting precipitation reactions (Laboratory Exercise #3).

Week 5. Common Solvents (Laboratory Exercise #4): What are they? How are they safely used?

Laboratory Topics

Lab 1. Introduction to the chemistry laboratory. Safety considerations. Standard equipment and its use. Using a balance. Measuring liquid volumes.

Lab 2. Experiment 1: Observation

Lab 3. Experiment 2: Solubility and solvents

Lab 4. Experiment 3: Predicting a precipitation reaction

Lab 5. Experiment 4: Solvents in the house and garage

Chemistry 177
Chemical Reactions: New Substances From Old

This five-week, one-credit course meets for one fifty-minute lecture/discussion per week and two two-hour laboratories per week.

Lecture/Discussion Topics

Weeks 1-2. Types of chemical reactions.

Weeks 3-5. Chemical reactions and energy.

Laboratory Topics

Lab 1. Introduction to laboratory. Safety considerations. The handling of chemicals. Information on danger and toxicity, where is it to be found?

Lab 2. Combination, decomposition, replacement, metathesis reactions.

Lab 3. Organic synthesis, medicinal drugs; Acids, Bases and Salts.

Lab 4. Chemical energy.

Lab 5. Household chemicals and their reactions.

Geosciences 175
The Earth's Surface

Lecture and laboratory study of minerals, rocks and surficial processes. Not open to students who have had 422-100, 101 or 105. (2 hours of lecture, 2 hours of lab each week for 5 weeks)

Lecture/Discussion and Laboratory Topics

Week 1. Introduction to classification of natural materials. Minerals - the building blocks of the earth.

Lab 1. Classification of a variety of natural and manmade materials. Mineral identification based on physical properties.

Week 2. Igneous, sedimentary and metamorphic rocks. Video showing rock formation, and relationship of rock texture to environment of formation.

Lab 2. Rock identification, and an overview of Wisconsin Geologic map for rock types in the state.

Week 3. Weathering, soils, mass wasting and running water.

Lab 3. Stream table study or field trip to beach depending on weather. Quiz.

Week 4. Ground water, wind and glaciers.

Lab 4. Video on groundwater resources, or visit with D.N.R. on groundwater problems or field trip to look at glacial features.

Week 5. Oceans and shorelines.

Lab 5. Topographic map study of shorelines, and shoreline erosion. This will also be a general introduction to topographic maps. Final exam.

Geosciences 176
The Mobile Earth

A study of the tectonic processes which shape the earth's surface. Not open to students who have taken Geol. 100, 101, 105, 115.

Lecture/Discussion Topics

Week 1. Geologic time and the dating of the earth.

Week 2. Earthquakes and the interior of the earth.

Week 3. The history and present theory of plate tectonics.

Week 4. Igneous activity and the ocean floor - plate boundaries in action.

Week 5. A look at North American Geology with respect to tectonic models. A look at Wisconsin geology with respect to tectonics.

Physics 175
Motion and Heat

This a one-credit five-week minicourse meets two times per week for a fifty-minute lecture/discussion and once per week in a two-hour laboratory.

Lecture/Discussion Topics

Week 1. Newton's laws of motion: velocity mass, force, and acceleration. Gravity and weight. Metric and English units, measurements.

Week 2. Work, kinetic energy, potential energy. Conservation of energy. Perpetual motion machines.

Week 3. Conservation of linear momentum: collisions, rocket flight, and airplane flight. Conservation of angular momentum: skating, ballet, and diving.

Week 4. Temperature scales. Expansion and contraction. Internal energy and heat. Heat transfer: conduction, convection, and radiation. Wind-chill factor.

Week 5. Change of phase: melting, boiling, and sublimation. Evaporation and relative humidity.

Laboratory Topics

Lab 1. Inertial balance and weight scales. Acceleration of gravity using spark tapes. Motion on an air-track.

Lab 2. Simple machines: levers, pulley, block and tackle, inclined plane.

Lab 3. Super-8 films and video tapes of astronauts in orbit.

Lab 4. Liquid nitrogen experiments on expansion of gas volume and bimetallic strip. Human perception of temperature (heat flow).

Lab 5. Bunsen burners and propane torches. Dry ice and wet ice.

Physics 176
Electricity and Light

This one-credit five-week minicourse meets two times per week for a fifty-minute lecture/discussion and once per week in a two-hour laboratory.

Lecture/Discussion Topics

Week 1. Charges, forces, and Coulomb's law. The structure of the atom: electrons, protons, and neutrons.

Week 2. Current, voltage, and Ohm's law. Current flow as AC or DC. Electrical hazards and safety devices.

Week 3. Series and parallel circuits. Electrical energy and power. Description of lightning.

Week 4. Light represented as a ray. Reflection and mirrors. Refraction and lenses. Comparison of the eye and camera.

Week 5. Dispersion and prisms. Production of light from a gas discharge tube. Lasers, holograms.

Laboratory Topics

Lab 1. Triboelectricity and static electricity. Hand held Tesla coil. Smoke precipitator and charge detectors.

Lab 2. Dry cells and flashlights. Meters and measurements of current, voltage, and resistance.

Lab 3. Wiring diagrams and circuits. Slides and video tapes of lightning.

Lab 4. Image formation with concave mirror and convex lens. Compound lenses: binoculars, microscope, and telescope.

Lab 5. Laser and white light holograms.

Appendix B

Teacher and Student Behaviors and Interaction Categories

Teacher and Student Behaviors and Interaction Categories for Faculty A, B, and C

	Faculty A			Faculty B			Faculty C		
	Frequency	Time	% of Time	Frequency	Time	% of Time	Frequency	Time	% of Time
Total Time		1:07:13			1:31:35			2:16:37	
Teacher		48:54	76.76		1:29:53	98.14		2:06:02	92.25
Student		14:15	21:20		:23	.43		6:13	4.55
Wait-time		4:03	6:04		1:18	1.43		4:22	3:20
1. Lecture	11	13:50	20.58	27	1:28:05	96.17	71	1:49:09	79.90
2. Statements	95	18:35	27.66	11	:29	.53	22	1:06	.81
3. Short ?	83	2:46	4.12	20	:28	.51	151	6:29	4.75
4. Long ?	41	1:17	1.91				6	23:59	.29
5. Reject ans							20	59:82	.73
6. Aknldg "	25	:35	.88	2	:01	.76	8	12:71	.16
7. Confirm "	54	2:04	3.08				36	1:36	1.17
8. Repeat "	81	7:11	10.69	3	:03	1.03	67	2:03	1.50
9. Clarify "	14	2:34	3.82	1	:03	3.07	5	51.31	.63
0. Answers "				3	:43	14.35	13	2.11	1.59
Q. Asks st. to clarify							2	3.32	.04
W. Uses st. comment							1	46.64	.57
E. St asks ?				3	:15	.28	14	52.43	.64
R. St answers question	133	6:31	9.71	4	:08	.15	136	4.45.59	3.48
T. Teacher observes st	14	7:15	10.81				2	34.98	.43
Y. Teacher redirects ?							6	10.31	.13
U. St to St interaction	32	:27	.68						
Wait-time	69	4:03	6.04	17	1:18	1.43			

Frequencies of Significant Patterns of Interaction for Faculty A, B, and C

Faculty A

29 (4*R) Extended question, wait-time, student response
28 (24*) Statement, extended question, wait-time
21 (UUU) Student-student interaction
18 (*R8) Wait-time, student response, repeats student response
17 (3*R) Short answer question, wait, student response
15 (R87) Student response, repeat student response, confirm student response

Faculty B

12 (13*) Lecture, short answer question, wait-time
10 (121) Lecture, statement, lecture
9 (3*1) Short answer question, wait-time, lecture
6 (*13) Wait-time, lecture, short answer question
5 (212) Statement, lecture, statement
5 (213) Statement, lecture, short answer question

Faculty C

41 (3R8) Short answer question, student response, repeat answer
33 (R83) Student response, repeat answer, short answer question
28 (83R) Repeat answer, short answer question, student response
21 (13R) Lecture, short answer question, student response
17 (3R3) Short answer question, student response, short answer question

Teacher and Student Behaviors and Interaction Categories for Faculty D and E

	Faculty D			Faculty E		
	Frequency	Time	% of Time	Frequency	Time	% of Time
Total Time		3:16:51				
Teacher		3:16:45	99.95			
Student		:02	.02			
Wait-time		:03	.03			
1. Lecture	87	3:15:05	99.10			
2. Statements	89	1:30	.77			
3. Short ?	3	:09	.08			
4. Long ?						
5. Reject ans						
6. Aknldg "						
7. Confirm "						
8. Repeat "						
9. Clarify "						
0. Answers "						
Q. Asks st. to clarify						
W. Uses st. comment						
E. St asks ?						
R. St answers question	2	2.41	.02			
T. Teacher observes st						
Y. Teacher redirects ?						
U. St to St interaction						
Wait-time						

Frequencies of Significant Patterns of Interaction for Faculty D and E

Faculty D

78 (121) Lecture, statements, lecture

Faculty E

30 (13*) Lecture, short answer question, wait-time
24 (3*1) Short answer question, wait-time, lecture
23 (*13) Wait-time, lecture, short answer question
21 (121) Lecture, statements, lecture
17 (*3*) Wait-time, short answer question, wait-time
14 (3*3) Short answer question, wait-time, short answer question
11 (4*1) Long answer questions, wait-time, lecture