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AUTHOR	Reed, Michelle K., Ed.; Costner, Kelly M., Ed.
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ABSTRACT

The Mathematics, Science, and Technology Educators and Researchers of The Ohio State University (MSaTERS-OSU) is a newly formed student organization. Papers from the conference include: (1) "Was the Geometry Course, The Nature of Proof, Taught by Harold Pascoe Fawcett the Best Course Ever Taught in Secondary School?" (Frederick Flener); (2) "A Framework toward the Development of a Holistic View of the Conceptual Change Process" (Rene T. Stofflett); (3) "Student's Motivational Factors Profiles in Conceptual Change Learning in Science" (Lily Barlia); (4) "Learning To Learn Science: Cognitive and Social Factors in Teaching for Conceptual Change" (Michael E. Beeth and Peter W. Hewson); (5) "Learning for All--EQUITY" (Sybil Brown, Melva Grant, and Greta Robertson); (6) "Students CHOOSING To Do Homework: Using Assignment Options To Increase Student Motivation" (Terri Teal Bucci); (7) "Problem Solving Models, Technology Education, and the Permanently and Temporarily Disabled" (Phillip Cardon); (8) "A Framework for Analyzing Students' (Non)Problematic: Experiences in Mathematics" (Richard P. Connelly); (9) "Cooperative Learning: Transitioning from a Traditional Classroom" (Kelly M. Costner and Geri Granger); (10) "Enhancing Mathematics through Writing" (Noraini Idris); (11) "Mathematics Teachers' Beliefs about Instructional Features of Mathematics Education Software" (Asli Koca); (12) "A Comparison of the Teacher Preparation Programs of Colleges and Universities" (John R. Mascazine); (13) "What is Technology Education, Really?" (Chris Merrill); (14) "Using Peer Coaching in Teacher Education Programs" (Michelle K. Reed); (15) "Overcoming Publication Anxiety: Ways To a Healthier Vita" (Michelle K. Reed and Kelly M. Costner); and (16) "Bridging Research to Classroom Practice" (Parisa Vafai). (ASK)

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The Mathematics, Science, and Technology Educators & Researchers of The Ohio State University

MSaTERs

Saturday, May 16, 1998

Arps Hall

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Editors:
Michelle K. Reed
Kelly M. Costner

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Mission Statement

The ***Mathematics, Science, and Technology Educators & Researchers of The Ohio State University*** (*MSaTERs-OSU*) is dedicated to improving the teaching and learning of mathematics education, science education, and technology education through the following objectives:

- to promote improved teaching practices and research in mathematics education, science education, and technology education;
- to encourage commitment to professional growth and continued professional improvement;
- to promote unity and communication between and among students in mathematics education, science education, and technology education;

Membership is open to all those interested in the advancement of mathematics education, science education, and technology education.

Editors' Preface

The Mathematics, Science, and Technology Educators & Researchers of The Ohio State University (*MSaTERs-OSU*) is a newly formulated student organization, which has grown out of the former OSU Council of Teachers of Mathematics (OSU-CTM). As a result of restructuring in our College of Education and newly integrated graduate programs in these three subject areas, members of OSU-CTM and other interested students decided to develop an integrated student group.

In 1997, OSU-CTM held its first annual Spring Conference, a day-long series of presentations on research, teaching, and professional development by and for graduate students. Following this tradition, the new *MSaTERs* group sponsored a similar conference in 1998, the Second Annual Spring Conference, for graduate students in mathematics, science, and technology education.

The first two papers in this collection are from invited speakers for our plenary sessions, and are full reports of their presentations. The remaining papers are from the day's regular sessions, and reflect the essence of the authors' presentations. These proceedings as a whole are intended to serve as a record of the conference events for those who were not able to attend.

Michelle K. Reed
Kelly M. Costner

June 19, 1998

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Was the Geometry Course, *The Nature of Proof*, Taught by Harold Pascoe Fawcett The Best Course Ever Taught in Secondary School?

Frederick Flener, PhD
Northeastern Illinois University*
F-Flener@neiu.edu

Imagine living in Columbus, Ohio in 1932, when the United States, as well as most of the world, was in the middle of a major economic depression. The Ohio State University is about to open it doors to a new experimental high school. It was not a good time for experimentation in education. They will be admitting kids from all over the Columbus area and charge them about $65 a year for tuition--not much money by today's standards, but in 1932...?

An 11 year old tells his parents that his friends will be going to this new school, and he would like to go, too. The school is advertising that it will be a so-called, "progressive" school--following the precepts of the Progressive Education Association (PEA). The school will have a "democratic" curriculum, there will be no grades, and students will learn by engaging in so-called "life activities." Why would any parent who values a college education send a child to this school? This is a school at which a child might not learn the appropriate precollege curriculum, would not be able to send a transcript detailing the courses taken and grades received, and might even avoid college if the "life" experiences were too inviting. Shouldn't parents make sure the kids understand the "basics," to prepare them for college or for employment? Weren't these reasonable goals for schools--and aren't they still today? However, the school did open, and it was a tremendous success.

When the first students did arrive, most of them were from well educated families; 88% of the fathers and 45% of the mothers attended college, which was a much higher

*This project was supported by a grant from the Committee on Organized Research of Northern Illinois University.

percentage than the norm in 1932. Also, although the tuition may have excluded many children from applying, a large number of students were given scholarships. What was the criteria for offering a scholarship? It may have been the same as it is today, the potential for success academically. Whatever was used to select students, one thing is quite clear: These were not a randomly selected cross-section of the adolescent population in 1932 Columbus. They weren't necessarily the most intelligent kids in Columbus, but these were kids who liked school. But the question still remains, why did these parents choose to send their children to this new school?

Some of their concerns (although not necessarily that last one about life experiences being too good) were alleviated by an agreement with some 250 well established universities. The PEA was pushing to establish a group of progressive schools for purposes of research comparisons. A leader in the association, Dr. Wilford Aikin, was able to get these universities to agree to admit students from 30 "progressive" schools (the so-called "30 School Experiment") on the basis of the schools' recommendation and a couple of comprehensive exams to convince the universities that the students could at least read and write. No SATs, ACTs nor even a class rank was needed to be admitted to schools such as Princeton, Stanford or the University of Chicago. That was one carrot that may have appealed to many parents. Another may simply have been that the teachers at the University School were going to be excellent. Whatever the reason, about 150 seventh, eighth, and ninth grade students began in September, 1932.

The Carnegie Foundation funded an eight-year study to examine the records of some of the first college-bound students in the program, comparing 2,000 "progressively" educated students with an equal number of conventional high school graduates. Here are some of the results of that study as reported in a 1938 *Time* magazine article:

- The Progressives had slightly better grades in standard college subjects.
- The more extremely progressive the high school, the better its graduates did in college.

- A group of 46 who deliberately avoided mathematics in high school surpassed their classmates in every college subject, *including math.*
- Conventional students joined more social, religious and service clubs, attended more movies.
- Progressive students went in for more extracurricular activities (except athletics), took more active interest in politics and art, talked more, wrote more, listened to more speeches and music, read more books, went to more dances, had more dates...
- Progressive students did just as much worrying, and had as many personal troubles as their fellows. (*Time*, November 25, 1940)

In general, one would call the experiment a definite success. What happened? Why aren't all schools today like those schools? Are there any? There were probably research design problems that prevented such a program from gaining universal implementation. Although the students were supposedly not selected on the basis of academic or intellectual criteria, one might suspect that families and students who applied for such schools were self-selecting. The teachers in the programs were probably some of the best in the nation, and in particular this presentation will focus on one such teacher, but there were several teachers who had a powerful influence on American education over the next few decades. Furthermore, could universities have modified their admission criteria if the plan had been adopted by all schools or by even many more schools, say 100 or 200? In other words, by its very nature the "30 School Experiment with Progressive Education" might only be applied to a very limited number of schools.

This is a bit of background about the general conditions surrounding Harold P. Fawcett's experiment with a course in high school geometry, entitled *The Nature of Proof.* Fawcett created this course for the University School at OSU. The course was taught to sophomores and juniors over a two-year period, but it was not what we would today consider to be two years of course work. It met for only two hours per week the first year, and three hours per week the second year. It was a unique course, and probably the most popular course at the school. In fact, one might argue that it was the best course ever taught in a secondary school.

When I began this investigation, I fully expected to determine what went on in the course, and what made it so successful. I discovered that the story was intertwined with the school. Immersed in a unique program at a unique time in our nation's history, a group of students were caught up in the school and the program, with a gifted teacher. All of this was tied together with a clever geometry curriculum. I can only share a small part of the story today--an abstract, or a peek into a much larger story.

Who was Fawcett? Who were the students and why did they (and still do today) think so highly of him? What did they learn? What evidence is there that the course was *that* good of a course? First, let me explain what piqued my interest in this project. About a year and a half ago, I was asked by the Illinois Council of Teachers of Mathematics to make a presentation in support of "proof" in geometry. There seems to be a downward slide in the importance of proof as part of the geometry curriculum, and it is being replaced by much more geometric investigations and problem solving. I have always been a proponent of teaching critical thinking in a geometry course because as an undergraduate I was influenced by my professors, especially Robert Pingry and Ken Henderson, who extolled the virtues of Fawcett's 1937 NCTM Yearbook, *The Nature of Proof.* In preparing for that talk, I re-examined that book, but I also recalled a book called *Were We Guinea Pigs?*

I knew nothing about the second book, but I checked and there was a copy of the book in our library. There was also a book called *The Guinea Pigs After 20 Years*, which I soon learned was a book written by Margaret Willis in 1959 that examined the Guinea Pigs after they had lived in the "real world" for 20 years. What did these books have to do with Fawcett's course? The first book was one written by the graduates of the first class of students to complete the full six years at the University School. This book was probably unique in American education. It was a 300-page book written entirely by the students. It described all aspects of these students lives ranging from their own decoration of part of the school, to the long descriptive evaluations sent home to parents. Of course, the second book was a follow up investigation of the graduates 20 years later, a glimpse into the lives of the Guinea Pigs as they approached "middle age."

One of the revealing aspects of both books was the high regard that was given to the Nature of Proof course, first by the Guinea Pigs as graduating seniors, and later by their enthusiastic comments about the influence of the course on their lives. It was close to a consensus among the students that this was an outstanding course, and several thought it was the best course they ever had--elementary school, high school, or college. It seemed that this was a powerful testimonial to using geometry as a course to teach proof and critical thinking.

After collecting information from the three books, I gave the talk and not surprisingly had very little influence on the audience. They said, "That's nice Fred, but we are going to do more with technology, investigations, etc., and there is still going to be less emphasis on proof in our classes." So be it!

It was afterwards that I began to wonder if any of these graduates were still living, and if so, what do they now think about the course? I did a little math--after all, it is my subject--and decided that most of the students would have been born in 1920 or 21, and many are probably retired and living in Florida. However, I had no way of contacting them. I learned that the University School had closed in the mid-1960s and records of graduates were not well maintained. All I had to go on was the list of names from the cover page of the "Guinea Pig book." There were no addresses, married names, or any other information about who these people were. However, the Alumni Association at OSU did have records of about 11 students who graduated from OSU in 1942, and these might have been students from the University School. The Association then forwarded a letter from me to these 11, and as of now I have either located or have learned of the death of 51 of the 57 students from that "Guinea Pig" class. I have met with and interviewed 21 of the former students. (Eventually I hope to interview about five or six more, three in the Columbus area and three on the East coast.) I have also interviewed Fawcett's daughters, Dorothy Zechiel, and Winifred Evans, as well as one of Fawcett's grandchildren. In all my years in education I can honestly say this has been the most rewarding year I have ever spent.

As you can see, an important part of this presentation is the stories of these Guinea Pigs. (Incidentally, whenever I refer to someone as a "guinea pig," I do so caringly. Indeed, they refer to themselves affectionately as "guinea pigs.")

One of the first letters I received was from Tom Bowen, a (retired? still active?) CPA living in the Cleveland area. He wrote a nice letter describing his memory of the course. In the letter he said; "In any discussion of Dr. Harold Fawcett's presentation of geometry, *The Nature of Proof*, one caveat is required: One cannot separate the person and character of the man from his message." Therefore, we need to know the "person" and "character" that was Fawcett.

I have several photos of Fawcett ranging from his youth to a picture of a "scholar" with white disheveled hair. But, in many ways, the photo of Fawcett and his wife, Muriel, is a more significant photograph. During my travels this year I have learned much about Harold Pascoe Fawcett, and why such a photo reflects his character. Let me share a few of the insights I have gained.

In addition to being a highly respected mathematics educator, Fawcett was a very kind and caring person. I learned this from a few of his colleagues, Eugene Smith, and Joe Crosswhite, both past presidents of NCTM; two former students turned professors but now retired, Ken Cummins and Ken Henderson; and from the writings of others such as William van Til, who were fellow teachers at the University School. In almost everything I gathered from these persons, the first thing they talked or wrote about was Fawcett's gentle personality. They did this before they even mentioned his teaching ability or his scholarship. I also learned more about Fawcett through some of his non-mathematics writing, much of which he wrote to his wife and their three children. I have permission from his daughters, Dorothy and Winnie, to show you a little of his personal writing.

The first is one of several poems (doggerel is what he used to call his poetry) that he wrote for his wife Muriel. He often wrote these short poems and left them for her. Dorothy found a few of the notes in an old book. When he wrote this one, he was just going for a walk, but he wanted to let Muriel know:

> my darling ~ 3:45 p.m.
>
> Since sleep has gripped your body
> And closed your tired eyes;
> I've gone into the open air
> To take my exercise.
>
> Since you are nice and drowsy
> I do not wish to talk;
> And so this verse is written
> To say I've gone to walk.
>
> My love for you <u>always</u>
> accompanies me.
>
> Harold

I don't know about other males, but clearly, this makes me feel a lot more insensitive than I believe I am. Maybe my wife would argue with me on that point, but ... Well, let's just say that the probability of my writing such a poem is slightly less than winning the lottery with a single ticket.

He also cared deeply about his children and his friends. His daughter, Dorothy shared a collection of poems he wrote and gave to his family after his wife died in 1966. Here's a poem he wrote for his daughter, Dorothy, when she was a small child and experienced--at least for her--a very traumatic experience. The actual poem is nine stanzas long and this is only four of them, but you should understand the principles he was trying to teach Dorothy.

THE LESSON OF THE LOST RUBBERS

You've lost a pair of rubbers
And I wish it were not so,
But I'd rather lose my rubbers
Than some other things I know.

You haven't lost your eyesight,
And you still have power to see
The glory of the sunshine
Which is shared by you and me.

....

You haven't lost your power
To bring beauty into life,
And I hope you'll always use it
To end bickering and strife.

You've lost a pair of rubbers
That cost a paltry fee.
Just go down town and buy again
And charge them up to me.

Dad

When I visited Dorothy and her husband Leon, I met a very strong caring family. As you might guess, Fawcett's commitment to his family was passed on to his children. I was very impressed by their obvious commitment to their family, but a few other things struck me. Much of their home was "hand made." That is, it was not loaded with Rembrandts or Picasso's but with things that measured their life together--a quilt, candlestick holders passed down in the family. If you visit them you know who they are and where they have been. I have a photo taken a few years ago of the entire Fawcett family. There were 22 children, spouses, and grandchildren, a very happy family, which is a contrast to so many unstable families. I believe this is partially because of Fawcett, the person and his character. There is much more to be shared, but there is not enough time in this presentation. This presentation is more a story about the Guinea Pigs, and of course, *The Nature of Proof*, possibly the best course ever taught.

Maybe this course can never be replicated. It was a unique time in our nation's history, a unique educational experiment, and a teacher with gifts very few of us can emulate. However, what about the mathematics course itself? What went on? What do the Guinea Pigs remember about the course? What do they remember about the school itself, and is what went on in the course independent of the school?

Having interviewed 21 of the Guinea Pigs and Fawcett's daughters and grandson, I have probably about 50 hours of audio- and videotapes and cannot possibly hope to discuss all of the conversations in this short presentation. What I would like to do is simply select a few highlights that I hope you may find interesting.

My first visit was with Elizabeth Stocking Seale, who now lives in Moscow--Idaho, that is. Her husband, Bob is a retired professor of forestry. When we visited we spent a couple of days in their cottage on a lake in northern Idaho. One of the things that triggered my interest was when Elizabeth, responding to my initial letter said, "I went to Stevens College, Ohio State, and the University of Idaho, and I never had a more influential course [than *The Nature of Proof*]." Powerful words. Did she really mean it? Throughout the visit, she repeated comments similar to these. Yes, she still believed what she learned in the course influenced her thinking throughout her life. One of the benefits of seeing her first was that she was the photo editor for the book and she knew who most of the people were in the photos. (Incidentally, she was in many of the photos in the book. Her explanation was simple and concise, "Of course I'm in many of the photos--I was the photo editor, wasn't I?")

Throughout the visit, she continued to insist that the type of thinking she learned in the Nature of Proof course influenced her, but she also gave me my first insight into the whole University School environment. We spent a lot of time discussing the Guinea Pigs book--especially the photos.

One of the photos from the book that impressed me was the inscription over the math/science door: *Prize the Doubt, Low Kinds Exist Without.*. When I first saw it, I liked the first clause, but was a bit concerned about the second. There must have been some controversy among the students as well because I heard from most of them that what the "low kinds" referred to were "lower order animals." However, one person I interviewed was Joseph Levinger. He thought the quote was from Shakespeare, and he said, "It probably referred to lower class people, because that was the way things were in Elizabethan times." Whatever the second clause meant, the first did have an impact on the students, because most of the guinea pigs that I interviewed were very open minded, whether it was politics or social mores.

In a letter, Helen Spencer Lynch wrote the following:

> About three weeks before your letter came, I attended a very emotional and turbulent meeting determined to listen and learn but not open my mouth and add to the conflict. Finally, I had to speak and what I said came entirely from my University School experience and was based on our *Nature of Proof* thinking. To my great astonishment the room full of people applauded. They calmed down and we were able to reach a reasoned conclusion.

Later when I visited with her, I asked what the issue was. She said it was related to a couple of controversial issues in her church: homosexuality and female ministers. Here is a 77-year-old woman speaking in support of some very liberal positions.

When I visited with Warren Mathews, I learned he had retired after being a vice president of Hughes Aircraft Corporation. I asked him what he got from the course. His comments were, "I remember all our work with definitions. When I was a vice president at Hughes, and now in my work with my church, I realize how important definitions are. It is amazing that when we can agree on our definitions most of the conflict ends."

I thought about this. In the field of education we probably argue at cross purposes more because we do not have the same definitions in mind. For example, I don't think I have ever heard someone argue for lower standards, or lower quality in schools. However, we usually cannot agree upon what constitutes "standards" or "quality." At one time I was a school board member, and I recall some parents coming to a meeting chastising the Board for allowing incompetent teachers into our schools. (Obviously we didn't have high enough standards, or we permitted teachers to have low quality performance.) What were the criteria for their judgment? There was a teacher who had given the students assignments that contained several spelling errors. (This occurred, by the way, before "spell checkers.") Spelling was something the parents perceived as a way of evaluating teachers, and her poor spelling meant poor quality. But let's look at a different set of criteria.

This teacher was an art and photography teacher at the junior high level, and her work with photography was superb. She taught the kids the technical skills of taking photographs and developing their own. The composition of the photography was excellent, and the kids' photos were on display throughout the community. They understood the principals of enlarging, improving resolution, and even some of the chemical reactions that brought about the images during the developing process. Furthermore, the kids tended to love her as a teacher. My own children really enjoyed the course, and I must admit probably preferred this course to their mathematics class. From a curriculum and pedagogy perspective, this teacher was excellent, but her spelling skills were awful. (In fact some of her spelling errors were fairly blatant.) What the administration and the public differed on was the concept of what constitutes high quality among teachers. What we needed was a dose of the *Nature of Proof* thinking.

What the students in the *Nature of Proof* class learned was how important definitions are. However, I still haven't told you much about the course itself, and how Fawcett emphasized definitions and critical thinking. Indeed, Fawcett begins the NCTM yearbook with the statement, "There has probably never been a time in the history of American education when the development of critical and reflective thought was not recognized as a desirable outcome of the secondary school."

In his view, the best course in the secondary school in which to teach critical and reflective thought was geometry. To support this, he cites several other mathematics educators. Here is one of those quotes: "The purpose of geometry is to make clear to students the meaning of demonstration, the meaning of mathematical precision and the pleasure of discovering absolute truth. If demonstrative geometry is not taught to enable a pupil to have the satisfaction of proving something, ..., then it is not worth teaching at all" (W.D. Reave, 1930).

Fawcett was concerned that in 1937 schools weren't doing a good job of getting students to think critically, and some might argue that this is still true. To support this he cites the following:

> Even for exceptional students demonstrative geometry is bad educationally because they reason about geometrical concepts before they know what these concepts are; they then apply the same reasoning to more complex ideas of which they are completely ignorant; they become vain in their specious knowledge; they have no joy in the study of mathematics. (John Perry, 1902)

However, for Fawcett, this was not a call to eliminate demonstrative geometry from the curriculum, but rather to change the pedagogy. "Would it not be possible for children to be trained in observation, reflection and experiment, as well as deduction so that their mathematics should always be connected with concrete understanding" (E. H. Moore, 1902).

Fawcett is also concerned that the textbooks used in the geometry courses are detrimental to the goals he had--which were to help students become better at critical thinking. "Geometry texts are patterned more or less closely after the model of Euclid, who wrote over two thousand years ago, and whose text was not intended for boys and girls, but for mature men" (John Wesley Young, 1925).

So, with his views of the importance of critical thinking in schools, and his belief that the geometry course was the best place to teach this, Fawcett wanted to try his new approach. And, what better place than at the University School?

To begin his work, Fawcett described his concept of critical thinking. He believed that if a person were truly a critical thinker, then he or she would be able to:

- select the significant words and phrases in any important statement and ask that they be carefully defined;
- require evidence in support of any conclusion one is pressed to accept;

- analyze evidence and distinguish fact from assumption;
- recognize stated and unstated assumptions essential to the conclusion;
- evaluate assumptions, accepting some and rejecting others;
- evaluate an argument, accepting or rejecting the conclusion; and
- constantly re-examine the assumptions that are behind one's beliefs and that guide one's actions.

Fawcett also made several assumptions about the students before beginning his study. Furthermore, the experiences of the students he would be teaching at the University School were more likely to fit this image, than the experiences of students from traditional schools. The assumptions were:

- Students have reasoned and reasoned accurately before beginning the study of demonstrative geometry. (Sort of an evolutionary skill.)
- Students should have the opportunity to reason about the subject matter of geometry in their own way. (A constructivist viewpoint?)
- The logical processes that guide the development of the work should be those of the students, not those of the teacher. (A blend of the first two assumptions.)
- There should be opportunities for the application of postulational methods to non-mathematical material. (Transfer must be an overt commitment.)

When I first began this investigation I knew little about the school itself. Remember, most of the Guinea Pigs had been at the University School for about three years, and they were used to open-ended investigations. Many of their courses were taught without textbooks, and students learned by engaging in projects. For example, in English classes the students probably wrote more than their peers in traditional schools, but they were never taught the rules of grammar. The school was truly "student centered" so when

Fawcett began the course, he had students who were potentially different from those we might see today.

On the first day of class, Fawcett's comments were

> There is no great hurry about beginning our regular work in geometry and since the problem of awards is one which is soon to be considered by the entire school body, I suggest we give some preliminary consideration to the proposition that 'awards should be granted for outstanding achievement in the school.'

Following that introduction, he had the students try to determine what a "school" was, so that the board could decide whether to give, say, someone who wins a mathematics competition, an award. Was this "outstanding achievement in the school?" Here were the students' initial definitions of "school":

- 12 considered "school" a building set aside for certain purposes;
- 10 considered "school" a place for learning things; and
- 3 considered "school" to be "any experience from which one learns."

Following that conversation, other controversial definitions were discussed. Here are some definitional issues raised on that first day:

1. Is the librarian a teacher?
2. What is 100% American?
3. How do I know if I am tardy?
4. What is a safety in football, or a foul ball in baseball?
5. What is the labor class?
6. What is an obscene book?

When he brought up the topic of what is a "restaurant," he provided them with the Ohio legislature's definition: "A restaurant is a place of business where 50 per cent or more of the gross sales accrue from the sale of food-stuffs consumed on the premises."

Using that definition he gave the students data to determine whether certain businesses were restaurants or not. For example, because more than half of the gross sales at a local White Castle "Restaurant" were for "take out," this seemed to contradict the definition. Whether a local drug store was a restaurant or not seemed to hinge on whether "candy" was consumed on the premises or not.

This was the first day of a geometry class! As you can see, his approach was not to teach geometry specifically, but to focus on elements of critical thinking. Did Fawcett have a receptive class when he began? In some ways he did. Remember this was the University (open, progressive, no curriculum) School. But he didn't begin with a *highly* receptive group of kids. When the class began, he interviewed the students and recorded their preconceived notions of what they were getting into. The kinds of comments made by students ranged from "if this course were not required, I would not take it" (19), to more pragmatic statements like "I need the course for college" (15), or to a few positive comments such as "I know I shall like this course, I have always liked mathematics" (2).

When the course was completed, Fawcett interviewed students, parents, observers --and, according to the guinea pigs, there were observers in the class all the time. Here are a few of the comments made by their parents: "course has been of real value to my child" (17), "the most profitable course my child has ever taken" (13), or "doubt the course will prepare my child for college" (2). In general, there was almost a complete reversal of the attitudes of the students from the beginning of the course to its completion. Furthermore, the students took the *Ohio Every Pupil Geometry Test*, and the median score for the classes was in the 80th percentile. Fawcett's comment was, "...even though [they] had covered only a small part of the geometric content usually studied in plane geometry, they knew at least as much about those aspects of the subject which this test measures at the larger group throughout the state." In general, the course was a success.

What surprised me when I first began this study was that none of the Guinea Pigs knew they were part of Fawcett's research. None had ever seen the 13th yearbook, so I asked the NCTM to give me complimentary copies to distribute to the Guinea Pigs. They seemed to be surprised that he used them as real "guinea pigs." Incidentally, none of them could identify their own comments or parents' comments in Fawcett's book. It may actually be that the subjects in the *Nature of Proof* study were not the Guinea Pigs, but rather the subjects were in the class that preceded the Guinea Pigs. It would have been difficult for the dissertation to be completed, and an abridged version put together by the NCTM from the time the Guinea Pigs finished geometry and the yearbook's publication date. I don't think it makes that much difference, because the reactions of the guinea pigs were as positive as those reported in the *Nature of Proof* yearbook--and I suspect their parents were as pleased as the parents reported in the yearbook.

Fawcett continued to teach at the University School until about 1946, after which he focused on teacher education at OSU. Many of his colleagues were former students. In talking with several of them, the person and character of the man was evident. Eugene Smith, a former president of NCTM, was one of Fawcett's students. Gene said that whenever he went to see Fawcett during the writing of his dissertation, he usually went in about "one inch high, but came out a mile high." Fawcett had the ability to build up a person's character. My own advisor, Ken Henderson did a study similar to Fawcett's, and Fawcett was on his thesis committee. Henderson wrote:

> Through the study Harold sustained me. ... He was a great guy. Gene Smith knew him better than I did for he spent more time in residence than I was able to do. Gene was one of Harold's favorites. But perhaps he [Fawcett] had no favorites for he was so supportive of all his students.

Fawcett was president of NCTM from 1958-60, in 1961 was named Ohio State's teacher of the year, and in 1988 was named to the OSU Education Hall of Fame. He had many, many publications as well as leadership roles in mathematics education. He was a superb teacher and scholar, which leads me to my closing remarks.

When I began this endeavor, I realized the course was a good one. In the book *The Guinea Pigs after 20 Years*, Margaret Wills reported that almost everyone who took the course remembered it 20 years later, and she included a few of their comments. Here is one that struck me:

> I can not well remember science courses taught at the University School, and how they were taught. I can think of nothing, except for the wonderful laboratory equipment .... Contrast this reaction with the host of references to the benefits

> received from the *Nature of Proof....* But, if science had been presented in the manner that *Nature of Proof* was taught, then it is possible that several of us would have had our lives changed. (p. 190)

Willis herself was somewhat surprised by the reaction. She writes: "The fact that after twenty years the responses to *Nature of Proof* are so favorable is particularly interesting because at that time it was a very radical departure from the traditional way of teaching mathematics" (p. 189).

When I received my first written responses, they were all positive comments about the course. However, I did not know about the school or Fawcett, the person. Nor did I know about these graduates from the school, the Guinea Pigs. I don't know whether my goal should simply be to report the history of the school, the course and the guinea pigs, or if I should be an advocate for another experimental endeavor. Helen Spencer Lynch was one of the guinea pigs I mentioned before. Helen is one of the most prolific readers I have met--I don't think I know anyone who has read ALL of James Michner's books, each of which is about a zillion pages in length. She continues to send me materials that she feels are related to this study. I get copies of editorials from the *New York Times* or *Wall Street Journal*, but one time she shared with me a copy of her Swarthmore Alumni Bulletin. In it there was as an article by a professor, Barry Schwartz, who argues that grades, SAT scores, and other such objective criteria have had an impact on admission to most universities including those like Swarthmore. He advocates a more open-ended admission policy, with less emphasis on grades and test scores. He states: "Is 'good enough' good enough for Swarthmore?" In many high school classrooms today, experimentation is discouraged because so much is riding on the results [of the tests]" (September, 1997, p. 16).

His argument is that schools like Swarthmore, Harvard, and others of comparable caliber, usually accept about 10% of the applicants. Why not have a broader range of acceptance, then once a pool is established, accept the students randomly? He believes that there is not that much difference between those accepted and those who are almost, but not quite "good enough." He states:

> With a procedure like this, the desperate efforts by high school students to climb to the top on the backs of their classmates could stop. Schools could one again be places for experimentation. Learning could once again be driven by curiosity rather than competition (p. 17).

Helen believes that there may be a place for another "30 School Experiment" to allow schools like Swarthmore, Harvard, and others to admit a few students who might attend high schools that have no grades, no fixed curriculum, and their students can be admitted on the basis of counselors' recommendations. Is it possible in 1998? Are there enough Fawcetts around to teach the students to reason critically? I don't know the answer, but it might be worth the effort. As well as I can tell, each of the guinea pigs that went through the experiment 60 years ago will serve as testimony that it can't hurt. Their minds are filled with positive memories, and they certainly were not limited academically.

My last remark was made a couple of weeks ago by Elaine Bucher Lyons, a Guinea Pig now living in Sarasota Florida: "It was the depression, my parents were divorced, I had much less money than most of the other students at the University School, but I can say without a doubt, it was the happiest time of my life."

How many of us can say that about our high school experiences? Thank you for listening. I hope you enjoyed the story.

A Framework Toward the Development of a Holistic View of the Conceptual Change Process

René T. Stofflett, PhD
University of Illinois at Urbana-Champaign
r-stoff@uiuc.edu

The conceptual change process is viewed from many lenses and has many facets. Kuhn's (1962) revolutionary science, Piaget's (1975) cognitive equilibration theory, learners' accommodations of scientific knowledge structures (Posner, Strike, Hewson, & Gertzog, 1982) and pedagogical conceptual change (Stofflett, 1994) are but a few. Each of these theoretical frameworks is reductionistic in its description and application of conceptual change theory (hereafter referred to as CCT), with a global model yet to be developed. A global model would encompass sociological, cognitive, behavioral, and affective domains, linking each to all others in a broad model that would help us to understand the complex process of conceptual change in a larger context. Perhaps the model that comes closest to this already is Piaget's theory, which offers the epistemic subject as a philosophical model from which a broad psychological research base in cognitive development and change has resulted (despite Piaget's objections). The dominant reductionistic paradigm in science and psychology persists within this extensive line of research, examining cognition without emotion, sociology of science without the cognition of the scientist, teaching knowledge and behavior without affective or contextual considerations, and so on. The goal of this paper is to point to the eventual development of a theory of conceptual change that describes the ecological relationships involved in the pedagogical conceptual change process. This move to a nonreductionistic model will integrate the research findings of the last 50 years and will frame the conceptual change process in a model that encompasses sociological, psychological (cognitive and affective), and instructional theories within a singular conceptual change global model (CCGM). This paper will develop and define issues as a beginning toward the development of a global model of the Pedagogical Conceptual Change process, with hopes that the future will demonstrate that this a workable model for scientific and psychological conceptual change processes as well.

Scientific Conceptual Change

Much debate has ensued over sociological studies of science. These studies tend to be situated within the social reconstructionist paradigm and have received stark criticism from members of the scientific community, many of whom reject constructivism *of any type* as a legitimate representation of the scientific process (see, for example, Gross & Levitt, 1994; Kragh, 1998; Suchting, 1998). While recognizing this distention, my primary operational assumption in this paper is that the social reconstructionists make a significant contribution to the development of an understanding of how Knowledge (with a capital K) develops in science, i.e., the accepted knowledge base of the scientific community. Some scholars have extended the work in these studies in the development of the psychological conceptions (see, for example, Cleminson, 1990) and conceptual change in science learners (Posner, Strike, Hewson & Gertzog, 1982).

Conceptual Change in Science Learners

Since the publication of Posner and his colleagues' article (1982) outlining the conceptual change process in science education, considerable attention has focused on research in the area of students' alternative conceptions, or "misconceptions" in science. There exist volumes of studies outlining students' thought processes in science, what they bring to the science classroom in terms of factual knowledge and knowledge structures, and how this information can be either replaced or restructured. This theory (Posner et al.'s Conceptual Change Model--the CCM) has two main frameworks: (1) learners' conceptual ecologies, or the knowledge structures that are accessed during the learning process; and (2) the process of cognitive replacement involving dissatisfaction with existing conceptions, development of intelligibility and initial plausibility of scientific knowledge, and the development of an understanding of the fruitfulness of the new knowledge in real-world application and for developing new programs of research. The research on conceptual change coming out of Leeds and Monash Universities, while recognizing the value of these constructs, views the CCM as a transformative or reconstructive process, rather than one of cognitive replacement. The majority of research in the area of conceptual change seems to support this second hypothesis.

Pedagogical Conceptual Change

Pedagogical Conceptual Change Defined

The constructs of the CCM are fruitful in their application to understanding the process of teacher change. The teacher's conceptual ecology--those metaphors, representations, analogies and exemplars that are accessed during the conceptual change and teacher education process--forms the framework through which teachers can become dissatisfied with their existing teaching cognition and practice, develop understandings of more effective models, find those models plausible in their own instances, and useful for their classroom practice and research on practice. A number of factors affect the conceptual change process and it is upon reflection about these factors that we can develop a broader theory of conceptual change.

Factors Affecting Pedagogical Conceptual Change

Content Knowledge. What is known about science content by the teacher? How is that knowledge structured? What learning processes led to the development of these structures? Considerable research looking at the first two questions has led to an understanding of the importance of the third. Gess-Newsome and Lederman (1992) showed that secondary preservice science teachers commonly have knowledge structures that mirror their college-level science textbooks. Stofflett and Stoddart (1994) demonstrated through an experimental investigation that teachers' content knowledge--not just the factual knowledge and its structure but also the method through which it is learned--impacts greatly in the learning process of teaching for conceptual change. The findings of these studies and others contradict the Holmes Group recommendation of increasing numbers of science courses required for teacher candidates, suggesting instead that it is the quality of the curriculum and instruction in science rather than the quantity of courses that will lead to better science teaching.

The Conceptual Ecology and Formal Teacher Education History. The conceptual ecology involved in pedagogical conceptual change is akin to Shulman's construct of Pedagogical Content Knowledge (PCK). It is through this lens that new teaching methodologies are learned and practiced. Assimilation is the easier and less painful process, thus teachers will usually try to fit what they learn to what they already know. However, as Chinn and Brewer pointed out in their study of science learners, anomalous data are typically discarded or weighed with selective attention by the learner. On the other hand, accommodation is a lengthy, difficult and painful process and difficult to implement in formal teacher education in both content and methods courses (see Stofflett, 1994; Stofflett & Lum, 1998).

Teacher education courses that occur in isolation may provoke a high level of disequilibrium in both the students and the professor. It is unlikely that in a single semester in a single course that significant disequilibrium will be resolved satisfactorily for either the teacher candidate or the teacher educator. Given that student course evaluations are a core part of the teaching evaluation process, as well as the emotionally draining process of teaching for conceptual change, even the most determined and committed conceptual change teacher educator may find herself deeply discouraged. It is clear from my own research (see, Stofflett, 1991, 1994, 1996) and that of others (see, for example, Pintrich, Marx & Boyle, 1993) how important the role of affect is in the pedagogical conceptual change process (a role that Strike and Posner, 1992, illuminated as a potentially important facet of the scientific conceptual change process).

Life History (including Informal Teacher Education). Much of the teacher's conceptual ecology will consist of informal learning that occurs as learners in science content classrooms and as a member of society and gender and culture groups. Factors such as demonstration that was particularly powerful for the preservice teacher while in a content class, the curriculum structure of science courses taken, role models, and emotional support available can all play a role in the pedagogical conceptual change process. Significant life changing events, such as the death of one's parents or living under Apartheid, can also cause one to change permanently in one's philosophy of life and teaching (Stofflett, 1996). Portrayals of the teaching profession in the media can also influence the teachers' conceptual ecology, as can the presence of a spouse in the science professions (Stofflett, 1991) and a supportive or unsupportive cooperating teacher (Stofflett, 1994).

One's cultural make-up and gender contributes to the conceptual ecology for science and pedagogical content knowledge and can influence the conceptual change process. This is of particular importance to underrepresented groups in science--females and non-Asian minorities--who experience ways of knowing that are often different from scientific rationalism. These views and ways of knowing must be acknowledged and valued if the necessary trust is to be developed in order for conceptual change to occur.

Implementation Process. As mentioned earlier, the presence of role models, spouses in the science professions and supportive cooperating teachers can greatly increase the probability that conceptual change will occur. Teachers may encounter significant opposition to their teaching practice and need trustworthy allies in order to create an emotionally safe environment in which change can occur.

Conclusions

This paper raises more questions than it answers (see Table 1)--it is a theory in the making. The reader is encouraged to contact the author at the address on the title page with feedback about the ideas either presented or omitted here.

How to facilitate the content learning of classroom teachers
How to facilitate PCK in teachers, professors, and other teaching professionals
How teachers' biographies impact the implementation process
Cultural and gender factors influencing the implementation process
Power relationships in the implementation process
Emotional responses that occur
How emotional responses are related to culture, gender and life history
How emotional responses are influenced by power structures
How to facilitate healthy and productive emotional expression
How to appropriately deal with the emotional response
Mentoring and other support available

Table 1.

Implementation Process Issues to Think About

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Student's Motivational Factors Profiles in Conceptual Change Learning in Science

Lily Barlia
The Ohio State University
barlia.2@osu.edu

Scientific understanding is considered by science teachers as a major goal of school science education today. Science teachers have been concerned that a lot of students do not expend the necessary efforts in classroom activities to achieve scientific understanding that has frequently been conceptualized in terms of conceptual change. The Conceptual Change Model views student learning as a rational process analogous to the way in which many contemporary interpretations in history and philosophy of science picture change in the knowledge of scientific communities. The scientific knowledge based on conceptual change model is constructed based on persons' current understanding of a phenomenon and the impact of new information or new ways of thinking about existing information bearing on that phenomenon.

A number of criticisms have been directed at the conceptual change model where its lacks attention to affective aspects of learning, including motivational constructs. The model is a highly rational view of learning with little or no reference to students' motivational constructs such as goals, value beliefs, self-efficacy and/or control beliefs.

This study sought to describe the link of students' motivational factor profile to students' engagement in conceptual change learning of science. Three research questions were examined: (1) What profiles can be constructed to describe motivation factors (i.e., goals, values, self-efficacy, and control beliefs) of students participants in the learning science? (2) How are profiles of students' motivational factors linked to: (a) students' engagement in learning science i.e., behavioral and cognitive engagement, (b) students' interpretation of the classroom science tasks i.e., content objective and difficulty of classroom task as perceived by student, (c) student's attitude and interest toward science, and (d) student grade in science ? (3) What instructional strategies did the teacher use to both promote students' learning for conceptual change and increase their motivation in learning science? And how did the students respond to these strategies?

Eleven senior students of a physics class were participated in this study in which the teacher has a conceptual change view of teaching and learning. During nine weeks of study, various types of data were collected through student's self-report questionnaire using the Motivated Strategies for Learning Questionnaire (MSLQ), classroom observation, and structured interviews. Data analysis consisted of both informal and formal analysis techniques.

So far, the results show that all of students participating in the study, based on their responses to the MSLQ, are highly motivated to learn science. Of the four motivation constructs, task values and control beliefs seem to be the most important factors for the students of the class to engage in science learning activities. Each of the 11 student participants has a different motivational factor profile. The following is a description of case of Rina's motivational factor profile.

Rina has a mean total motivation score of 3.5. Rina's average for individual motivation factor is: 4.2 for goal orientation, 6.8 for task value, 4.4 for self-efficacy, and 5.8 for control beliefs. Rina's total motivation to learn science consists of 20% goal orientation, 32% task values, 21% self-efficacy, and 27% control beliefs. Task values comprise an extremely large portion of Rina's motivation score average. This means that task value is the most crucial motivational factor for her to learn science.

Her task value score average of 6.8, a score that is far above that of the class (5.8), can be explained by the fact that Rina strongly perceives science course materials as interesting, important, and useable. This may lead her to be more involved in conceptual change learning activities. For example, it can be inferred from the following statement that she found how interesting, important, and useable the science is in her daily life. Rina wonders how every phenomena found in her daily life can not be separated from science.

So, she is motivated to learn science because she understands the valuable of science in her life.

> I suppose that physics and science in general is a mean of discovering things, of understanding how the world, and the things in it works. Science has showed me things like how the body works and why plants grow. Physics has taught me about gravity and acceleration and a bike wheels turn around or a door opens when we turn the handle. All the little things that happen in the world around me, things I take granted, can be explained by science. Science helps me to understand all the things that happen in the world. This world is constantly changing and science makes new advances all the time. Science for me is a mean of helping me understand things that already exist but new discoveries are constantly being made and science is a big part of that too. New species are discovered here on earth. New stars are found out in the space. Science is an ongoing thing that must change as the world changes.

Rina continues her explanation of how science/physics is useable, interesting, and important to her. She perceives that science is a tool for understanding and appreciating the greatness of the world around her:

> Since I have begun studying physics, I apply my new physics perspective to more and more things that are happening around me in my everyday life. I see things and I put things in terms of physics and it has helped me see just how great the effect of physics in everything that happens in the world around me. I am motivated to do well in this course by my interest in the subject and my will to understand what is happening in the world and why it happens.

Further, Rina explains why learning science/physics is so important, useable, and interesting to her. She likes science/physics because science is a key for understanding the world. Also, she believes that science can be a tool to explain the past and the future and the way to understand that the environment and technology are constantly changing.

> I study science/physics for many reasons. One of most important to me is because I like it. Another reason is because to keep up with world and the way the environment and the technology are constantly changing. I study science, I believe that science is a tool to discover things and therefore the key to the future. It is hard to explain, but science helps me understand things of the past and the present, but it will also help to uncover and explain things in the future. Physics is also important to me because I can use what I learn in that class to help me with calculus since it is the same material and I use physics concepts to understand more complex calculus ideas and ideas in calculus to understand physics.

The useable, important, and interesting science/physics course materials may lead her to more involvement in conceptual change learning as explained by how she does understand the physics ideas better.

> I try to find examples of the concept in every day things or talk to my friends about it and see if they have better understanding they can share with me or I look in [physics book] because it is easy to read or I do example problems. A lot of the time I ask Mrs. Scott for help in understanding it. Just about all the ideas of physics are hard to understand because they are new to me and I have to completely change my perspective on things.

For Rina, getting a good grade, rewards, positive evaluation by other students, and competition are not her concerns. She learns physics initially for conceptual understanding. The following is her answer of what grade she expects to receive for the physics class.

> I am hoping to receive a high B at least for this class [physics class]. If I could get an A I would have it but I understand that the course material is a lot harder than some other courses I took. I will try my best to do good in this course and no matter what grade I get I knew I tried hard. With courses like this I don't think the grade is so important as learning and understanding the material.

In daily physics class, Rina gets involved actively in most of the activities. She has several reasons for such active participation. Understanding the science concepts is the main reason for her. She believes that science concepts are interrelated. Thus, understanding one concept can lead her to understanding another.

> I do work in physics class because I have to do work to fully understand. The concepts and especially the math involved with physics are sometimes very complicated for me and hard for me to understand. I have to read from [physics book] and do the problems and experiment with the data collection devices to understand the concepts. If I didn't do my work I would fall behind and often one concept leads to another, so I have to understand one to understand the other.

Rina is a quiet student in class and was rarely involved in social conversations, even with student sitting next to her. In group activities, like hands-on experiments, she worked together with her permanent group mates, Nur and Fany. She set the equipment for the group and the group always worked together quietly.

In summary, Rina is motivated to learn science because she highly values science in her daily life. She is strongly concerned with how interesting, important, and useful the science is in her life. She understands that life cannot be divorced from science/physics. She recognizes that science is a tool for understanding phenomena found in the world around her. So, these reasons may lead her to work hard in science class for conceptual understanding.

Learning to Learn Science: Cognitive and Social Factors in Teaching for Conceptual Change

Michael E. Beth, PhD
The Ohio State University*
beeth.1@osu.edu

Peter W. Hewson, PhD
University of Wisconsin-Madison*
pwhewson@facstaff.wisc.edu

Over the course of the past eight years, the conversations (both spoken and written) of many elementary school students in the classroom of Sister M. Gertrude Hennessey have captured the attention of science educators, scientists, and cognitive psychologists. Research studies describing conversations that occurred in Sister Gertrude's classroom have been presented at professional meetings such as the National Association for Research in Science Teaching (Beeth, 1993; Beeth & Hennessey, 1996; Hennessey, 1991, 1993, 1994; Hewson, Bell, Grimellini, Balandi, Hennessey & Zietsman, 1995), the American Association of Physics Teachers (Hewson & Hennessey, 1991), the American Educational Research Association (Hennessey & Beeth, 1993), the European Science Education Research Association (Beeth & Hewson, 1997), and an International Workshop on Research in Physics Learning held in Germany (Hewson & Hennessey, 1992). Many attending these presentations have been quite favorably impressed with the conversations of the students. In response to the transcript of a class discussion about the forces acting on a falling parachute, a college chemistry professor commented: "Is this a real 5th grade class? I would love to have that discussion with my first year college students." (Arce, private communication in response to Beeth, 1993).

The focus of attention throughout research conducted in this classroom has been on the students, and with good reason. There are many unique aspects of learning that these students exhibit during their conversations with one another and their teacher. The extraordinary performance of these students inevitably raises the question: How does Sister Gertrude do it? What are significant components of her instruction that support the student

*This paper is an abridged version of a manuscript currently in review.

outcomes reported in the studies above? One approach to answering these questions has been to synthesize a set of guidelines that can inform teaching for conceptual change (Hewson & Beeth, 1993; Hewson, Beeth, & Thorley, 1998; Hewson & Hewson, 1988). The most recent guidelines proposed by Hewson, Beeth, and Thorley (1998) include the need for: (a) students' ideas to be explicitly considered in the classroom, (b) classroom discourse to be explicitly metacognitive, (c) the status of students' ideas to be discussed and negotiated, and (d) students' ideas and status decisions to be an explicit component of the curriculum. This synthesis has drawn heavily from the research conducted in Sister Gertrude's classroom, as well as several other classrooms. Yet the synthesis of these guidelines does not get to the details of Sister Gertrude's teaching.

The goal in this presentation is to provide details that can help us understand how this teacher facilitates conceptual change learning. In doing so, we are conscious of the implications that answers to these questions could have for other teachers. In other words, we are interested in whether the learning that takes place in Sister's classroom is the product of a unique and singular environment, or whether the instructional principles she uses, once incorporated into the practices of other teachers, might result in similar student outcomes.

With respect to the second issue related to learning science, increasing attention has been paid to notions of the situated nature of learning (Brown, Collins, & Duguid, 1989) in which the social contexts of the classroom and beyond play an essential role in student learning (Driver, Asoko, Leach, Mortimer, & Scott, 1994). Many recent studies are framed by the notion that students and teachers create discourse communities in which learning about social aspects regarding the construction of scientific knowledge are a significant part of the curriculum (e.g., Roth, 1993). Student learning outcomes that result from this instruction are viewed as highly desirable in that students and their teachers co-construct discourse communities that are similar to those of the scientific community (Driver, Asoko, Leach, Mortimer, & Scott, 1994).

Driver, Asoko, Leach, Mortimer, and Scott (1994) suggest a theoretical perspective on science teaching and learning that takes into account many of these developments in science education research. Driver et al. suggest that the knowledge produced within the discipline of science needs to be understood by students as socially constructed. Understanding science then implies that learners would "'appropriate' the cultural tools [of science] through their involvement in the activities of the culture" (p. 7). Driver et al. recognize the consequences this position would have for science educators in the following:

> [If] learners are to be given access to the knowledge systems of science, the process of knowledge construction must go beyond personal empirical enquiry. Learners need to be given access not only to physical experiences but also to the concepts and models of conventional science. The challenge lies in helping learners to appropriate these models for themselves, . . . If teaching is to lead students toward conventional science ideas, then the teacher's intention is essential, both to provide appropriate experiential evidence and to make cultural tools and conventions of the scientific community available to students. (p. 7).

The suggestions immediately above are that science teaching that meets the expectations of the science education research community need to involve students in the development of the "cultural tools and conventions of the scientific community." Concurrently, teachers would need to support students as they learned to apply these tools and conventions to their thinking about science content (Beeth, 1998).

In this presentation we argue that science teaching that meets the current expectations of teachers and researchers needs to involve students in the development of the "cultural tools and conventions of the scientific community" as described by Driver et al. (1994) and that teachers need to support students as they learn to apply these tools and conventions while learning science content. In particular, we argue that a teacher's instruction needs to create social contexts within which the justification of ideas and the determination of status are explicit components of the curriculum (Hewson, Beeth, & Thorley, 1998). We believe that these positions are compatible with each other, and that when both are applied to interpret the outcomes of science instruction, they provide an enhanced understanding of the relationships among instruction and student learning.

Thus in this presentation we address the question: What are the significant components of Sister Gertrude's practice that lead to the kinds of student outcomes so many find extraordinary? In doing so, we describe and analyze Sister Gertrude's instruction in light of the student outcomes that have been reported elsewhere (Beeth, 1993; Beeth & Hennessey, 1996; Hennessey, 1991, 1993, 1994; Beeth & Hewson, 1997; Hennessey & Beeth, 1993; Hewson, Bell, Grimellini, Balandi, Hennessey & Zietsman, 1995; Hewson & Hennessey, 1991,1992). Next, we address the different aspects of students' conceptual ecologies that are the explicit focus of her instruction. Finally we summarize the findings and consider them in the larger context of implications emerging from this research in science education.

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Learning for all - EQUITY

Sybil Brown
The Ohio State University
Colulmbus Public Schools
brown.109@osu.edu

Melva Grant
The Ohio State University
grant.121@osu.edu

Greta Robertson
The Ohio State University
Columbus Public Schools
robertson.60@osu.edu

One of the societal goals addressed in the National Council of Teachers of Mathematics' (NCTM) 1989 publication of the *Curriculum and Evaluation Standards for School Mathematics* is that there will be opportunity for all. The passage reads as follows:

> The social injustices of past schooling practices can no longer be tolerated. Current statistics indicate that those who study advanced mathematics are most often white males. Women and most minorities study less mathematics and are seriously underrepresented in careers using science and technology. Creating a just society in which women and various ethnic groups enjoy equal opportunities and equitable treatment is no longer an issue. Mathematics has become a critical filter for employment and full participation in our society. We cannot afford to have the majority of our population mathematically illiterate. Equity has become an economic necessity. (p. 4)

As we consider creating an equitable mathematics classroom environment, the focus must also tend toward a more holistic meaning of equity. By this do we mean only equal opportunity? Or does this include equal learning? What about equal treatment? Or equal outcomes? Does it also include equal excellence? And should we have equal expectations for all? Equity is defined as "fairness; application of principles of justice to correct or supplement the law (Oxford Dictionary, American Edition, 1996). Transferring this notion to the classroom, an operational definition of equity provides opportunities for everyone to learn.

The importance of the notion of equity in mathematics is also evidenced by two recent NCTM publications dedicated solely to this issue: *New Directions for Equity in Mathematics Education* (1995), and JRME's special issue, *Equity, Mathematics Reform, and Research: Crossing Boundaries in Search of Understanding* (1997). The chapters and articles presented in these texts cover a wide spectrum, from looking at how equity is accounted for in certain mathematics reform projects to exploring critical dimensions of the issue of equity itself. A major theme found in both of these is the necessity of not ignoring cultural diversity while attempting to resolve problems of inequity. Secada (1995) suggests that the equity issue tends to gloss over the complexity of student diversity and of the notions and traditions under which people work in this area. Tate (1997) posits that equity models should not only focus on content taught and tested as the framework for equity, but also on cultural factors in student learning. Ladson-Billings (1995, 1997) speaks to the notion of culturally relevant pedagogy in order to provide equitable classroom experiences for students.

Furthermore, in the *Professional Standards for Teaching Mathematics*, NCTM continues this discourse on providing opportunity for all students by speaking to the issue of developing worthwhile mathematical tasks. These student-engaging tasks, whether they be projects, constructions, problems, applications, etc., should align within the following framework, where they:

- provide stimuli for students to think, problem solve, and reason;
- provide connections to other mathematical ideas and concepts;
- provide connections and application to real-world contexts;
- require students to communicate mathematically;
- build on students' diverse backgrounds and experiences; and
- involve sound and significant mathematics.

We then, feel as though any discussion on equity must include a search for answers to the following questions:

1. With respect to the physical environment in your school, what are the queues that suggest equity?
2. Think about the "culture" that exists within your school environment. What is done that enables newcomers to "fit" in?
3. Within your classroom, how is equity addressed?
4. What is equity?

These are important questions for reflection. In further examination of the word "equity," we find that its contents provide some good insights. Forming an acrostic with equity words we have:

* E - encouraging and engaging
* Q- questioning
* U -understanding
* I - inspiring , including, and inquiring
* T - thinking, NOT telling
* Y - yielding.

Of course, this list can be expanded to fit our respective personalities and classroom needs. The important thing is that all of the words indicate action, and are strong descriptors for a mathematics classroom with equity as its operating paradigm--a classroom in which diversity is respected and all students' contributions are valued, a community of learners (including the teacher) is established, and students see themselves in the learning rather than detached from it.

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Students CHOOSING to Do Homework: Using Assignment Options to Increase Student Motivation

Terri Teal Bucci
The Ohio State University
bucci.5@osu.edu

Developing student motivation and increasing our students' critical thinking skills are concerns for most teachers. How can we increase our students' motivation, expand their interest in mathematics, and aggrandize their critical thinking skills thus increasing their level of understanding of the many areas of mathematical knowledge? I have found a way that works for me.

One of my personal goals as a teacher is to increase the critical thinking skills of my students. I believe it is through this that students begin to think independently and grow as learners and mathematicians. I sought assignments that would encourage critical thinking skills for my students. Through research, I found that one way to increase critical thinking skills was to create assignments that are within the students' ability and seem, to them, to be attainable. Another quality needed in assignments designed to increase critical thinking skills is student ownership and a sense of involvement in the assignment process (Keeley, Shemberg, Cowell, & Zinnbauer, 1995).

I also found that there are ways to increase the intrinsic motivation of our students. There are three constructs of intrinsic motivation; arousal, personal control, and interests (Middleton, 1995). Arousal is the stimulation afforded an individual by an activity. The student must relate an activity with one that has been previously labeled as fun. If there is no relation to an activity, one is developed through the perception of the degree of arousal. Interest is another construct related to intrinsic motivation. Interest is the degree to which a student likes an activity and perceives it as being "do-able".

The third construct in determining intrinsic motivation is one that is addressed in this paper and of great interest to me, personal control. My goal was to create assignments that not only would increase critical thinking skills, but also develop an attitude of "fun" and increased motivation in my students toward mathematics. I began by evaluating my teaching methods and determined points of instruction and assessment that could be varied to include student choice. I began with the areas of study habits and formal assessment.

Study Options

I first determined issues that needed to be addressed with respect to my views on assessment. I needed to realize that not all students learn the same way and that they most likely did not need the same methods to develop a study program that suits them. To give them ideas, though, I felt it was necessary to demonstrate some of the typical study options I have used. After they tried some of these options, they could see what works best for them. Because of this, I required all of my students to use the following study tools: daily assignments, textbook reviews, group projects, computer drill and practice, written essays, and journals. After using these tools for one marking period, I would have the students choose the options that worked best for them. I have provided a copy of the study option choices at the end of this paper. Not all students chose the same options. Because of this, the grading system varied with each student in my class. Yes, this was a bit more work, clerically. However, I was very pleased with the results.

I found that students who rarely did homework when I assigned it before, were now bragging to their friends that they did their homework and they, "didn't even have to." (It wasn't one of their choices). I discovered that the students were doing their homework (and other study options) for them, not me. They expressed that they were working to understand the concept, not because I told them they had to. That is intrinsic motivation.

Of course, we did revisit the options each student choose at the end of each six weeks. Some students did well and decided to keep the choices they made. Some students realized that they needed a different program. Still other students needed some initiative on my part to force an option change. Regardless of the situation, the students felt responsible for their learning and developed ownership in their assignments.

Formal Assessment

I wanted to continue this student choice practice further in my class. I decided to develop options for more traditional assessments. First, I created an option list for the semester exam. In our school, semester exams are not a major part of a student's overall grade. Because of this, they put little effort into studying for the traditional test. I wanted to create an assessment that didn't simply assess knowledge of the concepts but developed interest in mathematics and gave the students an opportunity to learn, not simply to show me what they had learned.

To do this, I created a semester exam that had two parts. The first part was computational, demonstrating knowledge of and learning the concepts of mathematics; the second was what I called global, learning about the relevance of mathematics to our world. Within each part, the students were given choices. They were, though, required to choose one component of each part. I have provided a copy of the exam options at the end of this paper.

I thoroughly enjoyed reading the exams. It was obvious that the students put much effort into their exams. I believe the students not only learned a great deal, but found the assignments interesting and, hopefully, fun.

Conclusion

I believe that through this exercise of choice, the students were able to find a piece of mathematics to which they could relate. Many students expressed, through their writing, that they have a keen sense of the relevancy of mathematics in their lives.

I definitely saw an increase in student motivation. Students were excited to show their knowledge of mathematics through an avenue of their choice. They learned a great deal about the concepts we had been studying. They also learned about themselves. They learned that they can control and determine their level of knowledge of mathematics. Moreover, they had fun.

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Study Options Handout

Dear Students and Parents,

To further develop student responsibility with respect to mathematics coursework, I have decided to give the students a choice of possible study and practice tools. It is my strong opinion, based on much research and years of teaching experience, that most students need daily practice and extended study time before tests/quizzes to perform at their personal best. Nevertheless, I also realize that each student is different and that s/he needs to see that s/he is doing homework for his/her benefit, not mine. Because of this, I am searching to find a way for the students to create their own 'best practice' in terms of their mathematics studies. I am hoping they will find what works best for them. It is my opinion that if the student decides for him/herself what is necessary to be successful, they will be more apt to put it to practice.

Please discuss the potions below with your student and sign your name in the designated spot. I would appreciate any comments or reactions to this letter.

Sincerely,

Terri Teal Bucci

I am choosing the following practice and study options.

(Please circle **one or more** of the options)

Homework check: 80 points

Composition book check: 20 points

Individual study/practice method: points to be determined

Specify method:

____

Semester Exam Options Handout

Semester Exam Options

Research has shown that there is higher intrinsic motivation (personal drive to learn) and therefor a higher retention of material if there are choices by which learning occurs. Because of this, I have developed the following choice options for your first semester exam. You are to make one selection from each of the two categories; computational and global. Each half is worth 50 points for a total of 100 points for the semester exam. Please notify Ms. Bucci, in writing, of your option choice by Friday of this week in the space provided below. I suggest you begin working on this assignment as soon as possible. You will need to spend a considerable amount of time outside of class to prepare properly for the exam. If you have an idea of a demonstration of knowledge that is not on this list, please consult Ms. Bucci for approval.

I have chosen to do the following

Student signature ______________________________

Parent signature ______________________________

Semester Exam Options Handout, cont.

Computational:

1. Written exam – "traditional" test of mathematical ability
2. Computer exam – test of mathematical concepts and applications on a computer program in multiple choice form
3. Take-home exam – test requiring extensive knowledge of concepts and their applications. This option will include computation and written (narrative) explanation.

Global:

1. Read a mathematics content book from the approved list and write a review. Give an oral presentation of the book review.
2. Write a research paper about a mathematician and his/her contribution to mathematics personally and universally (MLA style).
3. Write a mathematical autobiography. Investigate issues of personal concern. This is to be an extensive study of your progression through the past eleven years of mathematical study. It is to include trouble areas and those areas that you find interesting or easy to understand. This paper is also to include teacher practices that lead to a deeper understanding for you and/or caused further confusion.
4. Write a research paper on mathematical test anxiety (MLA style). Give an oral presentation of the results. This option may be done in a small group.

Semester Exam Options Handout, cont.

5. Give an oral presentation on a mathematician and his/her life and contribution to the field using some form of dramatics or multimedia. This option may be done in a small group.
6. Interview a person from the field in which you are interested. Tape-record and transcribe the interview. Find out what level of mathematics was required from the trade school, college, or on the job training to get and keep this job. Determine what mathematical concepts are used daily, weekly, monthly, and/or annually on this job. Investigate how your current or future mathematical coursework would positively influence your chances of getting and keeping a job in this field.

Cumulative Test Option Handout

Fourth six week cumulative test option

Terri Teal Bucci
1998

You have the choice of taking a traditional cumulative test at the end of this six weeks or a power point presentation.

The traditional test will cover the following concepts.

- ❑ Function addition, subtraction, division, multiplication, and composition.
- ❑ Compound functions
- ❑ Determining domain and range
- ❑ Recursive functions
- ❑ Simplifying exponential expressions
- ❑ Simplifying root expressions
- ❑ Solving root and exponential equations

This option may be done in a small group of no more than three.
The power point presentations will be a choice of one of the following topics.

- ❑ Math anxiety
- ❑ Study strategies for mathematics
- ❑ Functions
- ❑ Simplifying exponential expressions
- ❑ Recursive functions
- ❑ Multiple intelligences
- ❑ Learning styles
- ❑ Approved optional topic
- ❑ Compound functions
- ❑ Domain and Range

One Computational Option, take-home exam

Semester One Exam: Algebra II

Terri Teal Bucci 1997/98

1. Write a brief description of the methods needed to solve a problem of the given type. Write this description using generalities. If there is more than one way to solve this type of problem, write briefly about each type. If you have a preferred method, state why you prefer that method. Do not solve a problem in this first part. A hint would be to write the description as if you were talking to a friend and explaining to him/her how to solve the problem.
2. Write an example problem and solve showing all work.
3. Each section should take approximately one to two pages and will be typed or done on a word processor. I have computers available if you do not have one at home.

Respond to the above questions for the following topics:

1. Solving linear equations.
2. Solving absolute value equations and inequalities.
3. Writing equations of lines.
   a. given 2 points
   b. given a line perpendicular and/or parallel and one point
4. Graphing equations of lines.
5. Graphing inequalities.
6. Solving systems of equations.
7. Solving systems of inequalities.
8. Matrix operations: +, -, x
9. Graphing quadratic equations.
10. Solving quadratic equations.
11. Simplifying complex expressions.

Problem Solving Models, Technology Education, and the Permanently and Temporarily Disabled

Phillip Cardon
The Ohio State University
cardon.1@osu.edu

The nature of technology education in our society is constantly changing, and with these changes come the problems and challenges of developing effective curricula and instruction. One technology education instructional strategy that has been effective for several decades is that of problem solving.

This paper presents a brief background of problem solving in technology education, followed by a discussion of how problem solving in technology education can assist teachers of students with disabilities and people working with permanent and temporarily disabled populations. Finally, some practical applications present how teachers can incorporate problem solving into an effective instructional approach for students with disabilities.

Background of Problem Solving

The background of problem solving includes research performed by Bosworth III and Savage (1994); Brown, Collins, and Duguid (1989); Cote (1984); Johnson (1988); Maley (1972); and Pedras and Braukmann (1990) among others.

Problem solving strategies have been presented by many professionals throughout the years. Dewey (1916) presented one view of the problem solving process. Maley (1969) incorporated Dewey's process in the Maryland Plan (1972). Pedras and Braukmann (1990) discuss the difference-reduction method while Johnson (1988) and Johnson and Thomas (1994) discuss problem solving theories. Finally, Bosworth III and Savage (1994) discuss the problem solving environment.

Application of Problem Solving Strategies to Students with Disabilities

Technology education offers a problem solving approach that can assist teachers in their quest to teach people who work with disabled populations. What follows is a teacher training model used at The Ohio State University.

A Teacher Training Model

One of the goals of The Ohio State University's Technology Education program is to help train prospective teachers and other professionals working with disabled populations to develop problem solving skills. The training of these college students is performed through a "practical application" approach. This approach focuses on helping the student to solve a specific problem related to disabled people through a problem solving approach.

There are two primary courses in the OSU Technology Education program that provide the education mentioned earlier; a graduate level problem-solving course for people working with disabled populations, and an undergraduate level course for occupational therapy students. The primary part of each course's curriculum is the problem solving approach, "Engineering for Success" (see figure 1), adapted from Gugerty, Roshal, Tradewell, and Anthony (1981).

The steps of the Engineering for Success problem solving design include: (1) identifying the design problem, (2) identifying the disabled condition to overcome, (3) listing all possible solutions, (4) selecting the best solution, (5) developing a prototype, (6) testing the prototype, (7) making modifications and retesting (optional), and (8) determining the degree of success.

Examples of the Engineering for Success design in action include products designed by both the teachers of special needs students and the occupational therapy students. The teachers of special needs students designed solutions to problems dealing with people who suffered from permanent disabilities, while the occupational therapy students designed solutions to recovery problems dealing with people who were injured or suffered a disabling illness.

Conclusion

The problem solving process has contributed greatly to the field of technology education, and can be used to assist those in the disabled population. One problem solving design that can help students and teachers working with disabled people is the Engineering for Success design. This design tries to group technology education students with teachers of special education students in order to teach them how to develop quality products through the incorporation of the knowledge from their respective fields and the Engineering for Success design. In addition, this design assists occupational therapy students to learn the problem solving skills they need to help temporarily disabled people recover from an injury or illness. As faculty and teaching associates at The Ohio State University, we have found this design to be successful, and recommend it to others interested in assisting disabled populations.

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A Framework for Analyzing Students' (Non)Problematic Experiences in Mathematics

Richard P. Connelly
The Ohio State University
connelly.1@osu.edu

In this paper the lens offered by learning-approach theory (Marton and Saljo, 1984; Biggs, 1985; Bessant 1995) is applied to understand the experiences of the learner as they are shaped by (mis)alignment of his or her preferred learning orientation with the orientations afforded and encouraged within a mathematics course. A general framework for analyzing the alignment of a course with different learning orientations is developed, based on empirical data including student interviews.

Learning-approach theory traces back to a monograph of British and Swedish empirical studies investigating both qualitative experiences and learning behaviors in a variety of settings (Marton, Hounsell, & Entwistle, 1984). The findings of these studies consistently support the notion that college students display two general approaches to learning, described as the deep and surface approaches. These terms are borrowed from Marton and Saljo (1984), who used them originally to describe approaches to learning from text. The motives and strategies which constitute deep and surface approaches are developed further by Biggs (1985), who in addition describes a third "achieving" approach pertaining to broad learning strategies rather than strategies applied to specific tasks. These general descriptions are the basis of learning-approach theory and are reproduced below, in a table from Biggs (1985, p. 186):

Table 1: Student Approaches to Learning

Approach	Motive	Strategy
SA: Surface	Surface motive(SM) is instrumental: main purpose is to gain a qualification with pass-only aspirations, and a corresponding fearoffailure	Surface strategy (SS) is reproductive: limit target to bare essentials and reproduce through rote learning.
DA: Deep	Deep motive (DM) is intrinsic: study to actualize interest and competence in particular academic subjects.	Deep strategy (DS) is meaningful: read widely, inter-relate with previous relevant knowledge.
AA: Achieving	Achieving motive (AM) is based on competition and ego-enhancement: obtain highest grades, whether or not material is interesting.	Achieving strategy (AS) is based on organizing: follow up all suggested readings, schedule time, behave as "model student."

The Deep and Surface approaches complement several conceptions of the nature of mathematical knowledge, but correspond most closely to the concept of learning with understanding as formulated by Hiebert and Carpenter (1992). Based on ideas from cognitive science including representation theory and a network metaphor for cognitive architecture, the authors operationalized the notion of mathematics being understood "if its mental representation is part of a network of representations. The degree of understanding is determined by the number and the strength of the connections" (p. 67). This basic idea ties closely to the deep strategy, as the inter-relating of knowledge is precisely what the connectedness of an internal representation is meant to convey. By contrast, the surface strategy of memorizing aims to reproduce information from the teacher or text without constructing connections to personally meaningful prior knowledge. The achieving strategy can be used in tandem with each of the other two because it is an over-arching strategy for achieving within a course rather than in relation to specific tasks.

The premise behind the framework is that alignment among four factors that are dichotomized (student learning orientation, view of mathematics, student role, and level of task(s), see Table 2 below) can account for the nature of course experiences from the student perspective. Specifically, nonproblematic student experiences are fostered by these factors being present within the context of a mathematics course (reading across horizontal rows in the table below): a deep orientation toward learning, a conceptual view of mathematics, an active/generating student role, and high-level tasks (DCAH alignment); or, a surface orientation toward learning, a procedural view of mathematics, a passive student role, and low-level tasks (SPPL alignment).

Table 2: Alignment of Factors Pertinent to Student Experience of Mathematics

Learning Strategy	*View of Mathematics*	*Student Role*	*Task Level*	*ALIGNMENT*
Deep, understanding	Conceptual, integrated	Active, generating	High, synthesizing	DCAH
Surface, memorizing	Procedural, isolated	Passive, receiving	Low, reproducing	SPPL

The DCAH alignment can be seen as embodied in recent recommendations for reform in mathematics education, most notably in the *Curriculum and Evaluation Standards* established by the NCTM (1989), which is also to suggest that even the nonproblematic student experience of an SPPL alignment is problematic from the wider perspective of mathematics educators. Indeed, much of the research on mathematics reform efforts can be interpreted as representing the problems and potentials encountered when teachers try to move students from a tradition of SPPL-aligned experiences to a new alignment of DCAH.

While the (SPPL) alignment may be problematic from an educator's perspective, the consistency of factors can lead to student experiences and beliefs that are not problematic unless viewed from a wider perspective of mathematics, one that is only rarely opened up to the student. An illustrative case is that of one inservice teacher reflecting on her past experiences while enrolled in the SummerMath for Teachers program at Mount Holyoke College:

> I was always very successful with math during high school and college--a straight A student. I am perplexed about how I could have done so well, truly understanding so little. I realize now that it was possible; I had mastered the mechanics, not the concepts. *And it wasn't like faking because I didn't realize that anything was missing* (Schifter, 1993, p. 279, emphasis added)

Contrasting this perspective are the experiences of a deep-oriented student enrolled in both traditional and *Standards*-based mathematics classes at the college level. Her experiences, similar to those of high-ability female secondary students reported by Boaler (1997), were difficult in a setting where factors seemed to mediate against understanding. In her own words,

> Some students are motivated by getting a grade, but for me there has to be...I have to feel something more for the class. If it's going to be difficult I need to know why and I need to understand the math if I'm going to put that much energy into it.

The varied experiences of this student will be used to illustrate the usefulness of the suggested framework.

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Cooperative Learning: Transitioning from a Traditional Classroom

Kelly M. Costner
The Ohio State University
costner.1@osu.edu

Geri Granger
Mifflin Alternative Middle School
The Ohio State University
granger.5@osu.edu

Cooperative learning is an approach that is endorsed and promoted by the national standards in both science and mathematics (NCTM, 1989; NRC, 1996). Although cooperative learning is frequently discussed, it seems to be a term that is too freely applied to any type of group work. The techniques employed in true cooperative learning activities are, however, very specific and can be daunting to those considering such an approach. This paper will present broad definitions of cooperative learning, a brief overview of research results, tips on how to form student groups and make them work, and ways to incorporate cooperative learning principles and techniques in traditional classroom settings.

Characteristics of Cooperative Learning

True cooperative learning activities have the following characteristics: (a) Members of the group perceive they are part of a team, all with a common goal; (b) Members realize they have a group task, and that success or failure of the group is shared; (c) All students must communicate to accomplish the goal; and, (d) Each member's work has a direct effect on success or failure of the group (Artzt & Newman, 1997).

Research Results: Achievement

Cooperative learning is a much-researched topic (Slavin, 1995). Research results on achievement, as reported in Slavin's review of the literature, show positive effects resulting from the combination of group goals/rewards and individual accountability. Most studies find equal benefits of cooperative learning for high, average, and low achievers (Slavin). Further, cooperative learning promotes critical thinking, higher-level thinking, and problem-solving skills (Artzt & Newman, 1997).

Research Results: Other Benefits

Research shows many other benefits from cooperative learning. These include the development of intergroup relations, acceptance of those with disabilities, improved self-esteem, generation of proacademic peer norms (that is, academic success becomes a positive goal among students), contribution to the internal locus of control, increased time on task, improved classroom behavior, positive attitudes toward class and school, general improved relations among students, overall cooperation and altruism, and development of the ability to take another's perspective (Slavin, 1995). Perhaps most importantly, cooperative learning tasks provide students the opportunity to engage in mathematical and scientific activity in much the same way as actual researchers do (Artzt & Newman, 1997).

Cooperative Group Formation

Achieving such outcomes requires strategic planning. Having students move their desks together in a group is not sufficient to engage them in true cooperative learning tasks. Successful cooperative learning groups are heterogeneous in terms of ability levels, working styles, race, gender, handicap, etc. Groups can stay together for a few weeks, a semester, or a full year, but at least need to remain a unit throughout a cohesive unit of work in order to develop true group skills. Groups should consist of only three to five students in order to avoid isolation or difficulty in coordination of efforts (Artzt & Newman, 1997).

Characteristics of Successful Cooperative Groups and Tasks

Successful groups are those in which there is mutual dependence among the members. Verbal action is essential and abundant, but controlled: criticism should be of ideas, but never of people. Interpersonal and group skills, including communication, trust, shared leadership, and conflict management, are essential, and must be specifically taught and modeled by the teacher. Individual accountability, along with responsibility to the group goals, must be built into the assignment. Rewards and/or competition among groups can be part of the necessary recognition of groups for their accomplishments (Artzt & Newman, 1997).

The Teacher's Role

The teacher has three main tasks in implementing cooperative learning activities. First, the teacher must influence group behaviors, both by direct instruction and through modeling. Second, the teacher must design tasks that require a single group product, but have built-in individual accountability. Finally, the teacher monitors groups to insure both academic and social success (Artzt & Newman, 1997).

Incorporating Cooperative Learning Techniques in Traditional Tasks

Many specific cooperative learning methods have been developed and tested by psychologists and educational researchers. These include Student Team Learning and Student Teams--Achievement Divisions (by Slavin), Teams--Games--Tournaments (by DeVries and Edwards), Jigsaw and Jigsaw II (by Aronson), Team Accelerated Instruction (by Slavin, Leavey, & Madden), Cooperative Integrated Reading and Composition (by Madden, Slavin, & Stevens), and Learning Together (by Johnson & Johnson) (Slavin, 1995; Artzt & Newman, 1997). The basic principles of these methods can, however, be incorporated in modifications of traditional classroom activities.

Artzt & Newman (1997) suggest the following ways to use cooperative learning techniques in traditional mathematics class activities:

1. *Homework Review*: Form groups and have students compare/discuss the previous night's homework, then prepare a common, agreed-upon set of solutions to be handed in (perhaps select portions of homework rather than entire assignment). Collect the single set of solutions from each group, then discuss them as a class. Collect individual papers and grade for completion only (individual accountability), not correctness, and give a grade for correctness from the single group set (group accountability).
2. *Homework Review*: After members have worked together to agree on homework solutions, as in (1), have one member of the group write up a solution on the board, and another member explain to the class. The teacher chooses each of these (and it can be done randomly), so that all members must

be prepared to do either job. During discussion, any member of the group may respond/defend the group's solution.

3. *Developmental Lesson*: The practice portion of a traditional lesson is done as described in (1), with a single set of solutions agreed upon by the group. Follow up with reflective, metacognitive questions, such as "What have we learned today that we didn't know before?" or "What would we like to know as a result of today's work?" or "How did we get to where we are today?"
4. *Review Lesson*: *Team Mathematics Bee*--Teams compete, with incorrect answers being challenged by other team(s). All teams have to work on the question in order to answer or to attempt when the first team is incorrect. Further, all team members have to be prepared to speak on behalf of the team, because any one of them can be called on as the spokesperson. *Challenge Mathematics Bee*--a variation in which the other team(s) get to challenge solution, rather than the teacher simply determining whether the answer is correct or not.
5. *Test Review*: A sample test is given as homework and students work in class the next day to agree on one set of solutions to turn in. The teacher then selects important questions and calls on groups to discuss--all group members must be prepared to speak for the group.
6. *Enrichment Possibilities*: Cooperative groups can investigate the historical development of a topic (divide tasks among group members and have them present a cohesive project). In statistics, have groups design, conduct, tally, study data, and display/present results--all on topics of interest to the class (examples include music, TV, school issues, etc.). For more recreational assignments, groups can work throughout the week on "problem(s) of the week."

These suggestions are equally applicable to the science classroom as well as other subject areas, and can serve as beginning steps to transition from a traditional classroom to a successful group-learning enterprise.

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Enhancing Mathematics Through Writing

Noraini Idris
The Ohio State University
idris.4@osu.edu

The *Curriculum and Evaluation Standards for School Mathematics* states, "opportunities to explain, conjecture, and defend one's ideas orally and in writing can stimulate deeper understandings of concepts and principles" (NCTM, 1989, p. 78). The use of writing as an instructional tool has been receiving a great deal of support among mathematics educators (Kober, 1991; Schwart, 1991; Secada, 1992). Writing can provide opportunities for students to construct their own knowledge of mathematics and helps students make sense of mathematics. Writing is a way to clarify students' thinking. It also encourages students to think more deeply about mathematical content and to see relationships between concepts. Achievement in mathematics in a given language seems to be related to the degree of proficiency in that language (Secada, 1992). Thus, appropriate teaching strategies and learning tools, such as writing, could improve achievement in mathematics.

Purpose

This study was designed to investigate the effect of writing on the achievement of sixth- and eighth-grade Asian mathematics students.

Research Design

The subjects of the study were six pupils in grades six and eight. They were one student from Indonesia, one student from Malaysia, one student from Vietnam, and three students from Korea. In this project, students need to interpret texts, organize, and explain, and to reflect through the use of writing, so that student's engaged in the learning process. They were first given a pretest. The independent variable was the writing and the dependent variable was achievement. Achievement was measured by a twenty-question, multiple-choice test. The students were given eight tasks across four weeks for them to complete by writing out the detail of the answer. The writings were graded according to their completeness, accuracy, and clarity. Based on total scores the students were divided into three subgroups: good writers, average writers, and poor writers. After four weeks, the students were given the posttest.

Results

Results of the study indicated that writing did improve mathematics achievement. Students identified as good writers showed higher achievement than poor writers. On the last day of lessons, I prepared feedback forms which were completed by the students. All students stated that they liked mathematics much more and they had improved their writing skills, too. Most of the students agreed that they understood mathematics in English better. Three of the students who were previously scared of mathematics because of their deficiency in English now look forward to their mathematics lessons.

Conclusions

The practical implication of this study is that asking students to write about mathematics can effectively increase students' achievement. Students will come to learn more of the mathematics they are studying if they are required to write about what the mathematics is, and how they believe it works. The researcher acknowledges that creating, explaining, and grading the writing tasks are very time-consuming activities. However, the practice is recommended for mathematics teachers because of the possible effect on achievement especially to students with limited English proficiency. The activities helped to motivate the students to write, and encouraged meaningful rather than rote learning.

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Mathematics Teachers' Beliefs about Instructional Features of Mathematics Education Software

Asli Koca
The Ohio State University
koca.1@osu.edu

As educators, we must prepare our students and ourselves for new and exciting forms of technology that take the best of what we have to offer as teachers and apply it our subject matter. *(Diem, 1992, p. 109)*

In the age of technology, we cannot deny that computers and educational software are crucial factors in the learning and teaching of mathematics. The National Council of Teachers of Mathematics (NCTM) makes strong statements on the use of technology in mathematics education. "Mathematics programs must take full advantage of the power of calculators and computers at all levels" (NCTM, 1980). "Changes in technology and the broadening of the areas in which mathematics is applied have resulted in growth and changes in the discipline of mathematics itself" (NCTM, 1989).

My focus will be on computer uses in mathematics education. My primary interest in this study is to determine the beliefs of teachers on instructional features of educational software used in the mathematics classroom. Thus, when I attended the NCTM Regional Meeting in Cleveland in 1997, I asked 69 respondents at the conference, of whom 64 were teachers, their opinions about mathematics educational software. I asked them to respond to my questionnaire (see appendix).

The number of respondents claiming that they were using educational software in their classrooms was 62.3%. Approximately 74% percent of the respondents believe in the importance of mathematics educational software with varying degrees from important to very important. Moreover, 58% of respondents mentioned that they are between comfortable and very comfortable with using software. The purposes for using mathematics educational software are varying but discovery and remediation are the primary purposes chosen by the respondents.

Respondents think all these items stated in the questionnaire are important for mathematics education software. The most important item is using real world situations (with a mean of 5.33), and being able to integrate assessment throughout the instructional aspects of the software is the least important item for the respondents. On the other hand, being able to present the same information in different forms (multiple representations) is the second most important attribute for educational mathematics software. These two items are the most substantial advantages of the computers or technology. Technology or software can bring real world environments or situations into classrooms that we cannot create physically.

When I asked the respondents to put a rank order on the three most important items in this list, results indicated that teachers believe that providing real-world situations in a computer environment is the most important feature of any mathematics education software. It is the item that has been placed in the three most important attributes, most frequently in the first place. Moreover, being able to accommodate different learning styles was ranked as the second most important attribute by 19 respondents. Addressing different learning styles has been a difficult issue for teachers. However, since computer environments are mostly individualized environments, it gives students the opportunity to adjust the environment to suit their needs.

The most important implication of this study is that these results can be taken into account when designing educational software. Teachers are actual users and they experience educational software in their classrooms with their students. Thus, their beliefs play an important role in this issue and they should be considered.

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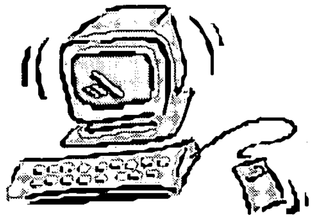

A SURVEY FOR EVALUATING MATHEMATICAL SOFTWARE

In educational literature we can find many software evaluation checklists or guidelines in order to evaluate educational software. Although there are some common important properties for educational software, I believe that some features are more valuable for specific discipline, which are different from those of other disciplines. My aim with this questionnaire to find these special instructional features of software used in mathematics education such as LOGO and Cabri Geometry.

First please tell me a little about yourself:

Teacher ( ) Student ( ) Faculty Member ( )

Age under 25 ( ), 25-29 ( ), 30-34 ( ), 35-39 ( ), 40-44 ( ), 45-49 ( ), 50-54 ( ), 55-59 ( ), over 60( ).

Do you use mathematics education software in your classroom? Yes ( ) No ( )

How many hours a week do you use software in your math classroom? ________

How comfortable are you with using mathematics education software in your classroom?

Not comfortable 1 2 3 4 5 6 Very comfortable

How do you feel about the importance of use of software in mathematics classrooms?

Not important 1 2 3 4 5 6 Very Important

For what purposes do you see or use mathematics education software being used? Please circle that apply.

1. Remediation 2. Discovery/Exploration 3. Reinforcement 4. Reward

5. Extension 6. Other(Please specify)________________________________

What grade level(s) are you using mathematics education software? Please circle the grade level(s)? K 1 2 3 4 5 6 7 8 9 10 11 12 13+

Which mathematics education software have you used in your classroom and what do you think about their interaction level by students such as Drill and Practice, Tutorial, Game, Problem Solving, Open ended (microworlds)?(e.g. LOGO Open-ended)

Please list names of mathematics education software you would like to use

Would you please the answer following questions to share how important you believe each of the items are for mathematics educational software. This can be done by circling the appropriate response. KEY; 1=not important—6=very important

1. Having a path from concrete situations to abstract situations.	1 2 3 4 5 6
2. Presenting problems in real-world situations.	1 2 3 4 5 6
3. Integrating the concepts with other disciplines.(e.g. Science, English)	1 2 3 4 5 6
4. Being able to accommodate different learning styles (visual, audio, etc).	1 2 3 4 5 6
5. Encouraging students to communicate.	1 2 3 4 5 6
6. Being able to present the same information in different forms. (Multiple Representation)	1 2 3 4 5 6
7. Integrating assessment throughout the instructional aspects of the software.	1 2 3 4 5 6
8. Providing intelligent feedback to the student needs.(e.g. feedback analyzes student misconceptions and difficulties)	1 2 3 4 5 6
9. Being able to assess previous knowledge of a student and adjust the problems according to it.	1 2 3 4 5 6
10. Level of interaction by students with the software:	1 2 3 4 5 6

Please rank, in order of importance 1 -5, the level of interaction. (1 is the most important)

__Drill and practice __Tutorial __Game

__Problem Solving __ Open ended (microworlds)

Each question 1-10 contains an attribute of software that some people may think is important. For these questions, list

- the most important attribute ____
- second most important attribute ____
- third most important attribute ____

Other comments:

THANKS FOR YOUR TIME

A Comparison of the Teacher Preparation Programs of Colleges and Universities

John R. Mascazine
The Ohio State University
mascazine.1@osu.edu

Several colleges and universities have adopted the fifth year (or graduate year) program for the certification of teachers following completion of their undergraduate degrees. Many programs have also had the time and opportunities to evaluate aspects of their programs. This paper has grown out of a meeting held at Winston-Salem, North Carolina, in spring 1998, where representatives of 18 institutions discussed their programs of teacher education. The conference was hosted by Brown University and Wake Forest University.

In addition to presentations, participants answered specific questions about their programs and disseminated these to others in attendance. The data presented in this report was gathered from notes taken at the conference, documents and papers collected there, and from formal and informal discussions between participants. The components of each program that were discussed by representatives included the following:

- Students (Admission and Recruitment, Composition of Intern Groups)
- Academic Program Components
- Internship Experiences
- Research Experiences of Interns
- Induction or Entry into the Teaching Profession

Both similarities and differences among these program components were discussed at length. Some of the more dramatic findings involved the number of students admitted to teacher preparation programs, their field experience arrangements, the length of MEd or MAT programs, support mechanisms (both financial and educational) for both interns and their mentors, and the length of the student teaching experience. Follow-up support and retention of new teachers following their first few years of teaching was also emphasized as a critical issue in many of the discussions. These majors point will be discussed further in the sections that follow.

Number of Students Admitted to Teacher Preparation Programs

The numbers of students enrolled in MAT or MEd programs varies greatly from institution to institution, from as few as 10 per year at universities such as Rice University and the University of Richmond, to as many as 85-120 at universities such as Furman University, Harvard University, and the University of North Carolina. The Ohio State University usually enrolls approximately 300 students in such programs within the College of Education.

Most Common Certification Program (Content) Areas Offered by Universities

The most common teacher preparation areas were those in English Education, Math Education, and Social Studies Education. Most limited certification programs were those offered in Foreign Language Education. Other content areas were represented adequately between these two extremes. The Ohio State University, because of its scope and size, is able to offer the greatest range of teacher certification programs for secondary education.

Field Experiences of Interns

Many programs include a component referred to as either preteaching fieldwork or prestudent teaching field experience. Some programs include this as part of their student teaching (Duke University and University of North Carolina). Other programs offered field experiences ranging from four to six hours duration (Cornell University) to 40 hours (Wake Forest University) to 65 hours or an equivalent of 3 hours per day for 4.5 weeks. The longest periods of pre-student teaching field experiences are those found in the programs at Harvard, which are 75 hours or an equivalent of 3 hours per day for 5 weeks. Ohio State's program consists of two quarters of field experience prior to student teaching and is equivalent to approximately 3 hours per day for 16 weeks, or a total of approximately 190 hours. This is the most field experience any program reported.

Some colleges include field experiences at sites where interns will complete their student teaching and do not differentiate between early field experiences and student teaching. This is done in programs at the University of Maryland, the University of Richmond, and at Lewis and Clark College.

Length of MAT and MEd Programs

The length of the fifth year programs range from 9.5 months (Harvard University) to one full year (Duke University, Brown University, and University of Maryland, and University of North Carolina), to two years (University of New Hampshire, University of Virginia, and Vanderbilt University). Ohio State's program lasts five quarters, or just over one year.

Support Mechanisms for Interns and Mentor Teachers

One topic of lively discussion was that of support for interns and mentor teachers. The most common financial support (for interns) reported was in the form of scholarships and loans (University of New Hampshire, Wake Forest University, and The Ohio State University). Limited awards were reportedly available for interns at many other institutions (Duke University, Furman University, Harvard University, and University of North Carolina). A few universities offered graduate assistantships to interns as part of their support (The Ohio State University, Vanderbilt University, University of Richmond, and University of New Hampshire).

Financial support or compensation for mentor teachers was limited or nonexistent in many programs. Only a few institutions like Harvard University and University of Maryland offer financial compensation to mentor teachers.

Length of Intern's Student Teaching Experience

The length of student teaching experience varies, but the number of observations of interns during this time does not vary much. Many universities have a student teaching experience lasting 10-13 weeks, while a few have the experience lasting as long as 28 weeks (Duke University), 36 weeks (Lewis & Clark College), to 8 months (Trinity

University). The program at Trinity is a full year long a single site. At Rice University, students complete their student teaching as part of a summer school program lasting six weeks. Ohio State's program includes one quarter of student teaching which is on the lower end of time spent assuming full responsibilities of teaching.

How Often are Student Teachers Observed and by Whom?

Many programs do observe interns at regular intervals of approximately one time per week (Duke University, Furman University, University of Maryland, University of North Carolina, Vanderbilt University, and Wake Forest University). A surprising number of programs observe their interns less frequently, from as few as 5-6 times per 10-13 week terms (Agnes Scott College, Brown University) to as many as 8 times per 13 week term (Harvard University). The Ohio State University requires minimum observations of interns at least one time per week of the 10 week quarter, with many supervisors in some program areas visiting interns two times per week.

Another area of much discussion was who does the supervision of interns. In about half the universities represented in this group, interns were supervised by faculty (full-time professors). In a third of the programs interns were supervised by clinical professors associated or hired by the university for such purposes. For the remaining portion, about one-sixth of the programs represented, interns were supervised primarily by graduate students and occasionally by faculty.

Induction, Support, and Retention of Novice Teachers

This was perhaps one of the areas in which many institutions agreed that there was much need for improvement. Many colleges and universities recognized the need to follow up their graduates' careers and offer supportive reunions or postgraduation programs.

Comments of Novice Teachers of Two Representative Institutions

A highlight of the two day conference was the evening two novice teacher, recent graduates of Harvard University and Wake Forest University, shared their experiences. Both had only been on the job for six months, yet their reflections and comments were invaluable. They both commented on the constant struggle to keep up with the demands of time and energy that teaching require. Both reflected upon experiences from which they benefited by being pushed in their programs to excel and how such experiences actually gave them high expectations of themselves.

Both teachers also shared their first year teaching schedule, which was beyond what many professors had anticipated or could have prepared them to face. It was obvious that there is very little consideration given to the needs and pressures of first-year teachers when they are given their teaching schedules and duties. Likewise, there are not usually many support mechanisms in place for new teachers either. Both expressed a desire to have more regular peer and university support following graduation from their respective schools, even though it is difficult when interns often accept jobs great distances from their alma maters.

Gleanings and Conclusions

Ohio State's MEd program for teacher preparation fairs well when compared to many other major universities and small colleges, and many of the challenges and issues of concern are similar. Among the most commonly reported concerns were:

- Finding the balance between adequate theoretical and academic/pedagogical courses and field experience courses at school sites
- Finding, using, and developing realistic partnerships with local schools and districts, along with master teachers willing to serve as excellent mentors
- Supporting interns not only while they complete their programs, but after they graduate and teach their first few years
- Having faculty and programs continue to be viable and comprehensive enough to meet the needs of students, mentors, and the interns.

What is Technology Education, Really?

Chris Merrill
The Ohio State University
merrill.22@osu.edu

The need for a technology education for our students and the development of a technologically literate society has never been more important than today. Technology is a word that almost everyone in our society talks about and uses on a daily basis, but for the most part does not understand the educational role it plays. There are many reasons for this lack of understanding of technology education in our schools: (1) Technology education is, for the most part, a new education program without secured standards and a set definition; (2) Most schools and states do not require or even recognize in some cases, technology education as a core requirement for graduation, nor incorporate technology education as a part of proficiency exams; and (3) Our professional organization has not concretely secured what position technology education should take, e.g., as a discipline or a general education program. This paper will explain what technology education is, how it fits in the classroom, and will demystify the relationships between technology education and instructional and educational technology.

Definitions

Savage and Sterry (1990) defined technology as "a body of knowledge and the systematic application of resources to produce outcomes in response to human needs and wants" (p. 7). In the mid-1990s, with support from the National Science Foundation (NSF), the International Technology Education Association (ITEA) initiated the Technology for All Americans Project. Through the work of these professionals, the definitions of technology and technological literacy have taken on new meaning. This project has created a rationale and structure for technology education and is currently working on the standards by which technology education programs across the United States should be operated.

Technology in the simplest terms is "human innovation in action. It involves the generation of knowledge and processes to develop systems that solve problems and extend human capabilities" (TAA, 1996, p. 16). Technological literacy, therefore, can be defined as "the ability to use, manage, and understand technology" (TAA, 1996, p. 6). While these two definitions of technology are different in rhetoric, the common themes of knowledge, application, problem solving, and human needs and wants are constant.

Technology education is a hands-on, minds-on, integrative discipline engaging learners and developing literacy in the study of technology and society with the use of problem solving and critical thinking skills; implementing a broad spectrum of action-based delivery systems, which readily facilitate integration among other learning disciplines across the curriculum; fostering safety, design, manipulative skills and techniques, awareness of technological careers and providing a vehicle for understanding historical and future technological developments (Merrill, 1997, pp. 4-5).

Educational and instructional technology are designed to provide the knowledge and skills needed to use technology to enhance student learning. The focus is not on teaching students about technology in general, but how teachers can use technology to teach subject matter (Post, personal communication, May 5, 1998).

The Core of Technology Education

The core of technology education is comprised of four technological systems: construction, manufacturing, communication, and transportation technology. These systems do not act independently from one another, but rather as a cohesive system. For example, to teach students the knowledge and application (theory into practice) of manufacturing technology, the technology education teacher would rely on technical drawings and designs (communication technology), how the product or products are to move from point *a* to point *b* (transportation technology), and in some cases whether or not these products are to be installed on the job (construction technology).

With these systems in place, let us turn to the formal meanings of each one. Construction technology has been defined as "the efficient practice of using productive and management processes to transform materials and to assemble components into buildings and heavy engineering structures built on site" (Henak, 1995, p. 372). Manufacturing technology "includes the systems that transform materials into products in a central location" (Wright, 1990, p.25). Communication technology as defined by Brusic (1990) refers to "the tools, techniques, knowledge, choices, and decisions associated with sending and receiving information" (p. 8). Transportation technology is a "technical adaptive system designed by people to efficiently utilize resources to obtain time and place utility and to attain and maintain direct physical contact and exchange among individuals and societal units through the movement of materials/goods and people" (Snyder & Hales, 1981, p. 36).

Technology Education in the Classroom

Today, our students need to know more than how to turn on a table saw or weld two pieces of steel together. They need to know how to use, manage, and understand the advances within our society. To achieve these goals, the student needs to be taught the theory of technological systems, but more importantly, the practice or hands-on skills needed to turn theory into reality. The technology education classrooms and laboratories are in place to provide the hands-on, minds-on teaching and learning that students need most. Moreover, these labs are where subject matter comes to life!

The traditional career and traditional skills of yesterday are being replaced by more advanced skills needed to produce, communicate, and transport products and people. The mission of technology education, therefore, should be to provide students, and ultimately the society, with the tools, processes, and knowledge necessary to use, manage, understand, and evaluate technological choices. Through this mission, the vision of a truly democratic and just society in which all members are technologically literate can become a reality. This goal, however, has a time limit. We can no longer accept the fact that our society is not educated enough to make rational decisions about technology. McCade and Weymer (1996) stated that "technology---like language, ritual, values, commerce and the arts---is an intrinsic part of a cultural system and it both shapes and reflects the systems values" (p. 41). If this is true, why is our society, for the most part technologically illiterate? We must make technology education a core area of learning starting at the pre-kindergarten level and continuing through college. As a profession, it is our duty to use all forms of media, support, and facilities to guarantee every individual the right to obtain technological literacy.

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Using Peer Coaching in Teacher Education Programs

Michelle K. Reed
The Ohio State University
reed.253@osu.edu

Clinical supervision (Cogan, 1973), developed as an alternative to traditional supervisory methods, focuses on the nonevaluative use of classroom observation data to improve teaching. The process of clinical supervision includes: (1) the pre-observation conference, at which the supervisor and the teacher make decisions about what aspects of teaching will be observed and how data will be collected; (2) the observation; and (3) the postobservation conference, at which the supervisor and teacher analyze the teaching and learning processes in the classroom and plan for future teaching and observations.

Peer Coaching

Peer coaching, an innovative outgrowth of clinical supervision, places the responsibility of supervision in the hands of teachers themselves. As a type of developmental collaboration, peer coaching is a process in which two or more teachers meet regularly for problem solving using planning, observation, feedback, and creative thinking for the development of a specific skill (Joyce & Showers, 1980).

The purposes of peer coaching vary according to the needs of the teachers (Garmston, 1987). *Technical coaching* asks peers to focus on helping each other transfer a new teaching skill. *Collegial coaching* focuses on the refinement of teaching practices. *Challenge coaching* resolves a problematic situation in instruction and begins with the identification of a persistent problem. Regardless of the purpose of peer coaching, the process is the same and follows the stages of the clinical supervision cycle. However, emphasis is placed on the pre-observation conference, where peers collaboratively decide which skills or methods will be the focus of the observation and postconference.

The peer coach has two primary functions within the clinical supervision cycle (Neubert, 1988). The first is to provide *feedback* to the coached (observed) teacher on her attempts to adapt the new or revised classroom skills. Also, because making a change in teaching may cause anxiety, the coach provides *support* for the coached teacher during this adjustment period.

Peer Coaching as Professional Development

With its beginnings as a staff development technique, peer coaching has most often been applied at the inservice level. Too often inservice workshops ignore the individual needs of teacher participants and do not provide follow-up assistance to teachers in the classroom. As a result, only 5-10% of what is learned in a one-shot workshop is transferred to the classroom (Joyce & Showers, 1980; Batesky, 1991). However, teachers who have been involved in peer coaching programs have been found to practice the new strategies more frequently, use them more effectively and skillfully, retain knowledge of the skills for a longer time, and exhibit a better understanding of the skills in terms of their lesson objectives (Showers, 1985).

In addition to enhancing the effectiveness of teachers, peer coaching provides them with many benefits, such as increased companionship and collegiality (Showers, 1985), learning of teaching skills within the context of a familiar classroom (Smylie & Conyers, 1991), and fostering of reflective thinking about teaching processes (Garmston, Linder, & Whitaker, 1993). The successful use of peer coaching at the inservice level has caused many educators involved in preservice teacher education to question current supervision methods.

Peer Coaching with Preservice Teachers

Several conditions exist within traditional supervision practices that impede effective supervision of preservice teachers. University supervisors are often either graduate students with demanding schedules, or are professors who are busy teaching and/or designing courses and who also need to produce scholarly work (Pierce & Miller, 1994). Also, the roles of each member of the supervisory triad (preservice teacher, cooperating teacher, and university supervisor) are at times poorly defined, and individual responsibilities are often unclear (Hoover, O'Shea, & Carroll, 1988). Unfortunately, training for the role of cooperating teacher is an uncommon practice (Lewis, 1990), and cooperating teachers are thus unprepared for their roles as teacher educators.

Caruso (1977) categorizes student teacher development based on student teachers' feelings and attitudes. Six stages compose this model, and it is only at stage five, labeled "more confidence/greater inadequacy," that survival is no longer a concern for student teachers. Student teachers at this stage finally realize that they have the abilities to complete the internship and only then can they make progress toward analysis of their teaching. Unfortunately, many student teachers do not reach these later stages of development because their earlier concerns are not taken seriously and sufficiently addressed.

Clearly, it behooves teacher educators to apply techniques to provide the developmental support that preservice teachers need to enter student teaching at a higher stage of development, thus making the teacher education process more efficient. Peer coaching is a technique that enables university supervisors and cooperating teachers to become more effective teacher educators. Peer coaching has been found to improve preservice teacher education by providing: (1) ongoing practice in the use of observation skills (Majhanovich & Gray, 1992), (2) opportunities to transfer strategies and techniques presented in methodology courses (Neubert & Stover, 1994; Peterson & Hudson, 1989; Wynn, 1988), and (3) participation in a community of learners to study teaching and learning together (Arends & Winitzky, 1996).

Designing a Preservice Peer Coaching Program

Implementation of peer coaching in an existing preservice teacher education program calls for teacher educators to make careful and deliberate decisions regarding the particular form of peer coaching that will be used in the program (Hudson, Miller, Salzberg, & Morgan, 1994). First, a cooperating teacher or another preservice teacher must be chosen as a coach for each preservice teacher. Next, the extent of grading and observation responsibilities of the coach must be decided upon. Third, the amount of training provided to coaches must be considered. Finally, the teaching behaviors the coach will focus on and how data will be collected should be decided.

Once these decisions are made, the teacher educator must remain closely involved with the evolving peer coaching program, ensuring that the process is helpful for the prospective teachers by supervising the process of teacher collaboration and assisting the prospective teachers in their discussions and analyses of their teaching (Benedetti, 1997). For instance, teacher educators should advise participants to collect materials to aid observation and feedback processes, such as notebooks/log books and video- and audiotapes. Videotaping the lesson may help coaches who become overwhelmed by the amount of activity during observations or who may not be able to view the lesson firsthand. Also, weekly peer coaching seminars can be conducted as Mello (1984) outlines: peers propose discussion topics, group members ask clarification questions, members share their experiences or brainstorm new ideas, the nominator of the topic chooses what she thinks will work best in her situation, and during the next meeting, the group member informs the group about how she applied the advice the group generated. By following these guidelines, and improvising when necessary, a preservice peer coaching program can be established to provide extra support, communication, and opportunities for beginning teachers.

Conclusion

The process of becoming a teacher is complicated. Apart from the academic and practical aspects of teacher education, there is a very personal component to becoming a teacher. If teacher educators are going to attend to this personal component, they must appreciate and understand that one's learning proceeds best when it is situated in a context, constructed from personal knowledge, and takes place in a social setting (Borko & Putnam, 1996). With its many successes with inservice teachers, and similar results in preservice teacher education, peer coaching has been shown to provide opportunities for this kind of learning, and is a powerful technique for effecting change and reform in today's classrooms.

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Overcoming Publication Anxiety: Ways to a Healthier Vita

Michelle K. Reed
The Ohio State University
reed.253@osu.edu

Kelly M. Costner
The Ohio State University
costner.1@osu.edu

Doctoral students are preparing for faculty positions in which they will be expected to teach, do research, and serve the academic community. Learning how to publish both research and practitioner papers is therefore an essential part of our preparation. This paper will present various avenues for publication, provide writing and editing suggestions, and describe the submission and review process for professional journals.

Avenues for Publication

Students are in a position to publish in several different arenas. Research journals may be the highest priority for vita-building purposes, but other possibilities are teacher/practitioner journals, ERIC documents, and various other routes.

Major research journals for mathematics, science, and technology educators include: *Journal for Research in Mathematics Education*, *The Journal of Mathematics Teacher Education*, *Science Education*, *The Journal for Research in Science Teaching*, and *The Journal of Technology Studies*. Other more general research journals, such as *Review of Educational Research* and *American Educational Research Journal*, should also be considered.

Practitioner journals are a good starting point for the beginning graduate student, especially those entering with teaching experience. Course projects developed with the classroom teacher in mind can be converted into manuscripts for such journals in our field. These include *Mathematics Teacher, Mathematics Teaching in the Middle School, Teaching Children Mathematics, Science Teacher, Biology Teacher,* and *The Technology Teacher.* Other practitioner journals, such as *Teaching PreK-8* or *Educational Leadership,* are less content oriented on the whole, but often are in need of content-specific manuscripts.

Another publication outlet is the Educational Resources Information Center (ERIC) Clearinghouses. Although unrefereed, items submitted to ERIC are disseminated to libraries and resource centers across the nation. Basically, two types of documents can be submitted to ERIC. Resources in Education (RIE) documents can be papers from courses or conference presentations submitted in their original form and can be made available to the public with your permission. ERIC Digests are two-page overviews, each addressing one specific topic in education. Most digests summarize research results to bring theory and practice together for the classroom teacher (Reed, 1997).

Other avenues for publication include conference proceedings, newsletters and journals of state education organizations, book reviews for various journals, and regular features in journals.

Writing and Editing Suggestions

As you think about writing for publication, be sure to follow guidelines that will make the job easier and more efficient as well as increase the chances of acceptance of your manuscript. First, be sure to focus on only one idea in any paper. You should write on topics you know well, not on something that is completely new to you. Further, a manuscript must be targeted to a particular audience and directed to a specific journal. For instance, you might choose to write for a department or feature in a practitioner journal. If so, you should be familiar with the topics and format that usually appear in that section (Editorial Panels, 1998). Reading journals regularly is useful for this purpose, but you might also consider becoming a manuscript reviewer for one or two journals in your field to better familiarize yourself with the journals and their procedures.

Writing for publication does not have to start from scratch. Class projects or conference presentations and papers can be modified to become the beginnings of publishable manuscripts. Although it is not ethical to submit the same paper to more than one journal, one project or idea can become several manuscripts, because the basic idea can be rewritten and refocused for numerous target audiences.

A manuscript should only be submitted when it is truly ready for publication. To get to that point, the revision process is essential. You should make sure that there is only one point made in each paragraph, that transition sentences lead from one paragraph to the next, and that headings and subheadings are used appropriately. Once you have a paper to the point that you think it is in its best shape, take a break from it. Have several colleagues review the manuscript for content, accuracy, grammar, and style. Then, revise, revise, and revise again. Above all, avoid these common writing pitfalls: verbosity, ambiguity, and lack of evidence (Epstein, 1997). Verbosity is the opposite of brevity, and it is always preferable to get your point across succinctly. Ambiguity is a lack of clarity resulting from "evasive, vacuous sentences" (Becker, 1986, p. 53). Lack of evidence is one of the most common reasons for rejection because it is the most serious of these three problems (Epstein, 1997).

Journal Submission and Review Process

Preparing your manuscript for submission requires a final check to see that all journal guidelines (for margins, style, etc.) have been followed. Your submission must be accompanied by a cover letter in which you state that your manuscript has not been published or submitted elsewhere, and, for research journals, that your idea is original. You might also make the case for your work to appear in that specific journal--describe why you think your idea "fits" with the current interests of the journal's readership. Finally, be sure to mail the correct number of hard copies and/or the correct electronic format called for in the guidelines for authors.

After submitting your manuscript, prepare to wait--up to six months or a year in some cases. This timeframe allows for the blind review process, where your paper is sent without revealing your identity to three to five experts in your field. After receiving their comments, the editor decides whether to accept your paper, then notifies you of its status. Generally, there are three possibilities: accept, reject, and accept with revisions. While the first outcome would be preferable, most published articles actually go through many revisions. If your manuscript is accepted with revisions, follow the reviewer and/or editor suggestions accordingly. When you resubmit, it is suggested that in your cover letter, you "enumerate the requested changes and exactly how you dealt with each one" (Thompson, 1995, p. 344). Also, if you disagree with any of the suggested changes, explain your reasons for doing so in the cover letter.

Proper focusing and persistence are the keys to success in publishing. The many avenues and guidelines for publication offered here should provide numerous outlets for your work, and will enable you to begin a successful career in academia.

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Bridging Research to Classroom Practice

Parisa Vafai
The Ohio State University
vafai.2@osu.edu

What follows is the story of a collaborative effort between three sixth-grade teachers and a PhD student to create appropriate practices the teachers' classrooms. This project was an attempt to engage in action research in the classroom in order to allow teachers to be active participants in adapting curriculum appropriate for the needs of their students. The question we were trying to answer was: How can we get students motivated to learn.

As a researcher, a mother, and an idealistic inexperienced teacher, I was very much interested to hear what the students had to say about the dynamics of their learning environment. I wanted to know what was holding them back; why were they unmotivated to learn, and what did they think could change their attitudes. The teachers were very skeptical about my motive for the interviews.

But as the questions emerged for the interview, they let their guards down and helped me refine questions, and even created a couple of questions themselves. I felt very proud to earn the teachers' blessings.

When the teachers suggested I interview homogeneous groups of five according to ability, I jumped at the opportunity. It just sounded so right. The lower-ability kids would not be inhibited by having to answer questions in front of the gifted children. The trouble-makers would not be seen as such by their own peers, and would not be on the defensive.

I was given 3 groups of children labeled by the teachers as follows:

- *Gifted*: These were the students with 4.00 grade point averages.
- *Trouble-makers*: These students were identified as trouble makers because they created distractions during teacher's instructions, and did not follow the class rules.

- *Academically challenged*: According to the teachers these children had lower IQs, "...and it does not matter how much time we spend on them. They never learn."

Through this selection process, I found teachers had great insights in assessing student's ability because the groups were very homogenous and the students conversed comfortably amongst themselves. Through reading the transcriptions of the interviews, I found many commonalities between the three different groups' interests. For example, all 15 students agreed that the integrated project on Egypt was their most fun unit this year; they all wanted more such projects, with different themes. They all wanted to have more field trips, and hands-on activities. They all wanted the teachers to stop, "yelling at us all the time for no reason." I also found many differences between the children in the three different ability groups.

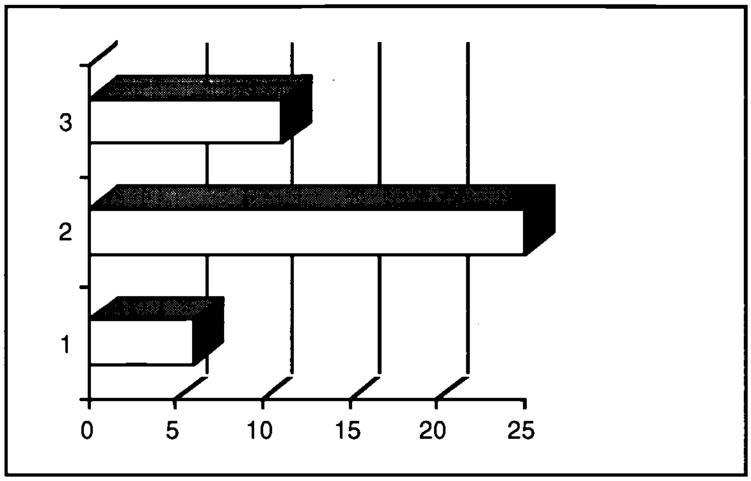
For example, I noted in my observation journal the students' attention to details in their environment:

> Each group acted differently toward my recording equipment. The trouble-makers manhandled the equipment. I had to ask them to stop a couple of times. After the interview I found out they had figured out how to turn off the microphone and parts of our conversation were not taped. The gifted children asked a few questions about the equipment, how it works and where I got it from. The academically challenged group did not pay any attention to the equipment.

The sense of self-efficacy was different among different groups; the gifted students had very high aspirations, whereas the academically challenged did not have a clue why they were in school and what they wanted to do in the future. The trouble makers had goals but they only aspired to jobs their parents had. For instance, one said " well, my dad has this job that he has to clean up people's basement and he makes a lot of money. That's what I want to do."

Most of these variables had a direct relation to children's skills and abilities, except one. While reading and coding the transcripts for the interview with the trouble-maker group, I found out that they related all the questions I asked to their teachers. A comparison between this group and the other groups resulted in the following chart:

Frequency Chart



Ability Group Coding:

1	Low Ability Group
2	Trouble Makers Group
3	Gifted Group

I decided to go through the transcriptions again to see what prompted the trouble-makers to be more vocal about their teachers than the other two groups. One obvious reason was that they probably routinely get dismissed from the class and go through a debate with the teachers about it, and therefore view teachers more negatively. But as I understood, the same was true about the academically-challenged group, and according to my count, they did not complain half as much. Another reason could be that the trouble-makers were more outspoken. But so were the gifted children. Specifically, when I asked a girl from the 'gifted' group to elaborate on the remarks she made on one of the teachers, she became very quiet. Upon my persistence with the question, she rolled her eyes and said, "I really don't care about my class; I have a tutor at home. That's who I learn from." And that was the end of our discussion on teachers.

Some direct quotations from the transcriptions follow.

I started the interview by asking the following question:

I: OK. Is everyone ready? What is your favorite subject at school?
S1: Gym.
S2: Gym.
S3: Gym.
S4: Gym.
I: Everyone gym?
S1: Cause you are not gonna learn nothing.
I: So you don't like learning?
S1: No. I just don't like the teachers.
S2: Yeah. I know.
I: But suppose I am asking this question regardless of who your teachers are: What is your favorite subject in school?
S3: I like Mr. X. He is cool......
I: (Trying to be firm but very friendly, smiling) We are not talking about teachers. We are talking about subjects.
S3: OK.
S4: Math.
S3: Math
S1: Don't have any.
S2: Gym.

I felt I had designed my questions in order to minimize discussions about the teachers. It worked very well with the first two groups, but this third group connected every little thing to the teachers. S1 was almost clinching his teeth while talking about the teachers. He was very animated and very open. Every so often he asked me whether the teachers were going to listen to the tape I was recording. Some more excerpts from the transcription that warrant this assertion follow:

I: OK. What would you change about your math class?
S1: My teacher.
I: What don't you like about your teacher?
S1: Today, this kid walked up to me and said shut up; and I was like "No!" and she put me on the card. she got me in trouble for that....
S2: GEEEEEs!

No matter what I asked and how I asked it, they related it to teachers. In this excerpt, I followed up on S1's response, and asked him what it was about his teacher he didn't like. He got a lot of sympathy from his group when he answered my question, and more stories follow.

I: What else? What else you don't like about your math class?
S3: ....she is stubborn.
I: You guys are not going to stop talking about your teachers; are you?
S3: One time our class got her to cry a little bit.
I: What?
S3: One time she couldn't take our acting up anymore. And she cried a little bit.

I was very frustrated at this point in the interview, and my frustration showed up in my outburst. They didn't even acknowledge my comment and went on with their stories. I decided to turn the interview in another direction:

I: How about your science class. What do you like about your science class?
S2: Our teacher is nice.
S5: She is our nicest teacher. (another muffled conversation is going on at this point.)

Although the science teacher got a good review, and some of the frustrations disappeared from the children's faces at this point, we were still talking about teachers in response to my question. I had asked the same questions from the other two groups and this certainly was not a pattern with them.

I: Do you like the books you read in your [language & art] class?
S5: Yeah. (S4 accompanies him by giving a narrative of one of the books they have read for the class)
S2: ...One time when we got in our home room before the bell rings and I go talk to my friends, she yells at me and stuff. So, I say school hasn't even started yet. We still have five minutes and she yells at me and stuff.

Some more stories about the language and art teacher followed. I ended my interview with two questions about what they liked and disliked about their school and the following are the responses that I got:

I: What don't you like about your school?
S3: I hate it when teachers yell at you.

I: What do you like about school?
S1: I like to play with my friends...
S2: I like to learn...
S5: I like Ms. Y.

S5 was still going on strong!

The tape recorder was already off when I thought of a question that in no way could be related to the teachers. So, I asked them, "What is your favorite movie?" They started telling me about their favorite movie's name, and some began to explain what the movie was about, and suddenly out of nowhere S2 starts with, "....another thing about teachers..." and they went on again!

One way to look at this group's frustration was through the lens of misplaced anger. In my observation journals I noted:

> When Scott asks a question, Ms. X, answers very shortly and moves on. Scott rephrases his question and repeats. This is a very good question. I could have answered this question by relating it to the previous material they had learned and start a discussion with the whole class. But Ms. X is not interested, and accuses Scott of disrupting the class.

Now, Ms. X might have had very good reasons for not addressing Scott's question. Perhaps she was in a hurry to cover some material they needed for a test; maybe she knew Scott was just showing off because a new face was in the class and Scott was trying to be impressive. But to Scott, this was an insult in front of his peers and this stranger (me). So, it was no surprise when he started to talk and laugh with his neighbor, and stopped paying attention to Ms. X. Meanwhile, Ms. X got upset and frustrated with him and after a few warnings she gave him a detention. Eccles and Wigfield (1993) argue this incident could have been avoided if Ms. X paid some attention to Scott's need for showing off. Adolescents want to be valued and respected by the adults in their environment. If the adults don't recognize this need and do not address it, perhaps it will come back to haunt them in the form of insubordination and protest.

Eccles and Wigfield's (1993) study is a very quantitative approach to this issue, and not surprisingly it is generalized to all seventh-grade teachers. They make claims about developmentally appropriate practices that they have tested by applying sophisticated statistical methods to survey questionnaires of all kinds. Our study so far has been very qualitative. It would be interesting to try some type of quantitative methods on our data and find out if our results match their findings.

Looking from motivation theory perspective, these children were all motivated extrinsically. Extrinsic motivation places the reason for learning on an outside factor. Woolfolk (1998) describes extrinsic motivation as "when we do something in order to earn a grade or reward, avoid punishment, please the teacher, or for some other reason that has very little to do with the task itself, we experience extrinsic motivation." In our case, the students saw teachers as the reason why they liked or disliked a subject or school, and as the reason for their lack of motivation. The children in the gifted group who had the same teachers did not feel their success depended on their teachers. They were intrinsically motivated. Our data then could make the case for teaching skills to children to move the locus of causality from outside factors to inside factors, such as interest and curiosity. Pintrich and Schunk (1996) claim that such skills could be taught. For example, if we help students generate knowledge instead of lecturing to them, we can help children's sense of self-efficacy, and consequently the level of their intrinsic motivation. Some other strategies they propose include:

- Provide students with options to choose from and have them consider the consequences of each choice [This strategy overlaps with the developmentally appropriate practices discussed earlier.];
- Foster internal attributions by not allowing students to blame others for their failures, or attribute success to luck; and
- Have students set goals, periodically evaluate their progress, and decide if a change in strategy is necessary (p. 269).

These strategies could help our sixth-grade teachers in rethinking some of their current practices. At the same time, it will allow us to continue our action research to see how these changes affect students' motivation.

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