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ABSTRACT

Differences in actual classroom behaviors in teaching with technology between novice and expert teachers were studied for six middle-school mathematics teachers from a large urban/suburban school district in a major metropolitan area. Teachers received inservice training in the use of calculators, and their students were issued calculators for the school year. Teachers were categorized as experts or novices based on their educational background and observations by a superior. Observations and interviews made the differences between experts and novices apparent. Experts were more than twice as likely as were novices to focus on content and process, to determine the difficulty of the task, restructure the task as necessary, redirect student thinking, and check individual work. Experts praised student behavior more and corrected student performance twice as much, while novices were more apt to correct student behavior and were more often seen at their own desks. Novice teachers initiated use of calculators less often than did experts and were less likely to use them in class and less likely to emphasize the importance of estimation in determining the reasonableness of a calculator answer. Implications for other areas of educational technology are discussed. Three tables present study data. (Contains 11 references.) (SLD)

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Statement of the Problem

Research studies have determined that effective teachers plan and behave differently from less effective teachers. Of more importance, it is believed that these differences can be identified and used to improve the teaching of novices. Although there are numerous studies on expertise, few have investigated the instructional differences between experts and novices when technology (i.e., calculators) is present. The purpose of this study was to initially categorize teachers into expert/novice groups and then examine actual classroom behaviors that occurred between the two groups. In particular this study sought to investigate differences between expert and novice teachers in the ways in which they instruct when technology (i.e. calculators) is being implemented, differences observed in student activities in classrooms when calculators are present, and differences between the amount of student calculator use in novice and expert classrooms.

Theoretical Framework

The study of effective teaching has identified several factors which differentiate expert teachers from novice teachers. Leinhardt and Greeno (1986) named planning as a major area of difference, noting that experts do not form detailed plans but adjust as they go in reaction to feedback received during the course of the lesson. They are able to diverge during "teachable moments" but return to their objectives (Institute for Research on Teaching, 1986). Novices may become tied to detailed plans which may result in their becoming flustered when students do not follow the planned sequence (Livingston & Borko, 1989).

Carter (1988) suggested several ways in which content knowledge problems along with pedagogical problems become tied to differences between novice and expert behaviors. Those weak in content knowledge often fail to emphasize the processes and interpretation, and thus focus is placed on the correct answer or fact (Clarridge, 1990).

Other effective teaching strategies include focusing attention, guidance, feedback, and managing. Experts use activities to draw students into overt involvement; novices often encourage passive learning by discouraging question and avoiding divergence from the lesson (Wittrock, 1986). According to Leinhardt and Greeno (1986) experts are more sensitive to cues and questions from students. Clarridge (1990) recognized that expert teachers anticipate problems and keep students on tasks through activities and monitoring.

Methods

The subjects in the present study were six middle-school mathematics teachers from a large, urban/suburban school district located in a major metropolitan city in the south central region of the US. The schools were a part of a nationally funded project involving the implementation of calculators. Teachers received a minimum of 12 hours of inservice training on the use of calculators, and math students were issued their own calculators for the year. Three teachers were selected as experts and three as novice based on experience, highest degree held, specialization in mathematics, number of college hours in mathematics and/or mathematics education, and observations by a certified supervisor and other observers. A strong effort was made to identify those teachers who particularly exhibited many expert and novice behaviors reported in educational literature.

Each teacher was observed twice during the spring school semester by trained classroom observers. There were a total of six unscheduled 45-minute observations for each group. During each of these periods there were 8 windows in which the teacher's behavior would be determined (48 total scans per group) and 48 periods per observation in which each of 6 randomly chosen students' behavior would be noted (288 total student scans per group). The Observation Rating Scale for Features of Adaptive Instruction (ORSFAI) (Waxman, Wang, Lindvall, & Anderson, 1983) was used to measure several major constructs: classroom instruction, instructional activities, classroom management, content focus, teacher questioning, emphasis on higher-level thinking, teacher feedback, student engaged time, and classroom environment. The Observation Rating Scale for Calculator Implementation (ORSCI) (Williams, Waxman, & Copley, 1991) was used to measure the amount of calculator use, to assess the quality of the calculator instruction, and to identify the kinds of student activities when calculators were present. Seventeen indicators measure the quantity and quality of calculator instruction and use.

In addition to systematic classroom observations, field notes on the classroom environment and teaching strategies of each teacher were compiled. In an effort to obtain unobservable information and to acquire a more complete picture, each teacher was interviewed.

Results and/or Conclusions

From the interviews, differences between experts and novices were easy to identify. Experts' attitudes towards planning are summarized by such comments such as, "I use 'skeleton plans rather than detail plans", "plans have to be flexible", "some of the best plans are a result of a student's question", and "scripting turns out to be 'too canned'". In contrast, one novice teacher admitted to "almost continuous" planning. Her lesson plans were very detailed and sometimes included scripts. Although the other two novices denied using scripts or planning to the clock, they prepared detailed transparencies in advance and seldom varied from the plan outlined by the transparencies.

Classroom observations indicated that the experts were approximately twice as likely as the novices to focus on content, focus on process, determine the difficulty of the task, restructure specific learning tasks, redirect student thinking, and check individual work. Responding to student signals, showing interest in student work, and showing personal regard for students was observed approximately three to five times more in experts than in novices. Experts encouraged students to

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Place Table One here.

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succeed, extended student responses, and encouraged self-management an average of five to six times more than did the novices. Experts praised student performance and corrected student performance twice as much, while novices corrected student behavior eight times more: novices were seen at their desks 4 times more than experts. Experts, however, were seen at students' desks twice as much. While neither group was seen to discuss student progress often, experts had a slightly higher rate of frequency. Differences also were noted in the nature of interactions which teacher used. Listening, demonstrating, and modeling by experts was observed approximately twice as often. The expert group also commented and cued or prompted students about one third more than did the novice group.

The frequency of student behaviors instrument also reported differences in student behaviors of expert and novice teachers. Students of experts were more likely to be engaged in independent seatwork, to be taking quizzes or tests, or to be doing activities or games (though the frequency count here was depressingly low for the experts and nil for the novices). Expert teachers were not seen to interact personally with students as often as did the novices, but were seen to be in a student/teacher paired setting more often. The setting for these students of experts was more likely to be independent working on the same activities, and they were much more likely to be on

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Place Table Two here.

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task (273-expert, 204-novice). Other areas of management were also seen to be very different between the two groups. Students of novices were seen to be uninvolved 32 different times, while experts' students were uninvolved only twice. Distractions also occurred about four times as often in novice classrooms. Student interactions were noted in novice classrooms one third more often. There were 13 (novice classroom) disruptions to 1 (expert classrooms) recorded, and students of novices were seen in undertaking preparations was about 4 times more. These students were also over twice as likely to be engaged with the teacher in a managerial interaction. Novice students worked on written assignments and were involved in getting or returning materials about two thirds more than the expert groups. No activity or non-academic activity by students of novices was reported approximately eleven twelves more. However, novices' students were seen in small groups 10 times, while experts' students were only recorded once in this setting.

With regard to teaching with calculators, experts emphasized the importance of estimation in determining the reasonableness of a calculator answer and stressed the use of a calculator as a problem-solving tool eight times more than novices. High level questioning is used often, said one expert, to get students to realize that "they will use this, that they need it in real life." The novice teachers initiated use of calculators in the classroom less than half as often as the experts, while the experts stressed the use

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Place Table Three here.

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of calculators as a time-saving device 14 times as much as novices. Mrs. Day from the expert group enthusiastically supported these findings, saying, "It frees students up from alot of the tedious parts of math to really do alot of logical thinking. Besides, the kids like them! They're motivating." In every case where a student was using a calculator in the expert group, the student was on task. About half of these frequencies in the expert classrooms were recorded as use during testing. In the novice classrooms the data reported only 2 cases out of 40 in which students who were using calculators were off task (uninvolved with the lesson). This account of 87 out of 89 frequencies of on-task behavior seems to be significant and would warrant further investigation.

Almost twice as many students of the experts brought their calculators to class. These were used in expert classrooms 1.5 times more than in classes of novice teachers, as reported on the high inference instrument. The frequency counts of 6 randomly selected students per class reported that students in classes of experts were using them approximately one fifth more. Students of expert teachers used calculators twice as often as students of novice teachers for exploration and induction; eight times more in solving routine word problems; 3.5 times more for verifying answers; and 1.3 times more for computation. The gaps between means and frequencies still do not demonstrate a great amount of difference in actual usage between the experts and novices. The highest reported mean on the high inference scale even for the experts is at the 3.6 level, and many high inference calculator items show little or no difference between the groups. Perhaps, even though experts in teaching can be identified, their classroom behaviors may tend to be pulled more toward the novice level when introducing and integrating materials or concepts that are new to them.

The instruments, though excellent for recording behaviors systematically, do not allow analysis of quality in many areas. This was especially noted in calculator areas where field notes proved invaluable but difficult to obtain. Further research may be needed to extend the instrument to aid in more precise description of areas regarding calculator activity. In addition, a larger sample of experts and novices could be first determined using the established expert/novice criteria, then examined much more closely for significant differences in calculator areas.

Limitations

1. The choice of the sample was fairly subjective, indicating a danger of experimenter bias. Also, some teachers grouped as experts due to training and experience were seen by certain observers to exhibit novice behaviors. To avoid these problems other observers were consulted. Experimenter bias may also be a problem in scoring the instruments. Several observers were used during the semester who where checked for interrater reliability.
2. The sample size was small. The teachers, however, were chosen from five schools within the district.
3. There is some danger of the Hawthorne Effect as well as novelty and disruption effects since much of the information was gleaned from observers in the classroom. However, this was the second year of the ABC Calculator Project, so many of the students and teachers were accustomed to having observers in their rooms. Teachers chosen for this particular research were not aware of their inclusion.
4. There may also be questions of validity in applying certain behaviors of teachers to judgments of expertise. There has been an effort to strengthen this through inclusion of many sources in the review of prior studies.

Educational Importance of Study

A major objective of many educational studies is to identify ways to improve classroom performance of inservice teachers. Technology has added to the complexity of teaching. Calculators have been available to both schools and individual students for many years. However, the objective of this project was designed to integrate them into the math curriculum--to make the jump from simple use, checking answers, etc., to actually teaching problem solving with technology and having each student become "calculator literate" past the basic facts. Because of the differences between calculators and other technology, it is important to examine this process closely. At this level computers are often not available to many children except on a once-a-week basis in special labs. Due to their low cost, calculators can be made available to practically every student, thus giving the student a feeling of ownership ability. Often the computer programs are preset so there is immediate feedback for skills or knowledge but little in areas of thinking. The calculator, in this project, is to be integrated as a "means" or a tool to advance students' higher levels of thinking, thus the teacher has a dual role--to teach the processes of the calculator as well as to obtain an operational repertoire of activities which will give students opportunities. Teachers must specifically learn how and where to use them in this capacity on a day-to-day basis. As in the progress of any integration in education, it is natural to examine those who are designated as experts to see if they are able to apply new concepts with higher rates of success. Thus, by identifying specific differences between novice and expert teachers and relating those differences to instruction with calculators, teacher educators may be better able to formulate programs to inform teachers of effective behaviors for teaching with technology (specifically calculators) and encourage them to incorporate those behaviors into their own schema.

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Table 1

TEACHER OBSERVATION SCHEDULE
Total Frequency Counts

	Experts	Novices
2. Setting		
A. Teacher's Desk	0	4
B. Student's Desk	8	3
3. Purpose of the Interaction		
A. Focuses on the task's content	21	13
C. Focuses on the task's process	35	18
F. Determines the difficulty of the task	16	8
G. Restructures specific learning task	22	12
H. Redirects student's thinking	8	4
I. Discusses student's work plans/progress	4	0
K. Checks student's work	30	16
L. Responds to student signal	16	6
M. Shows interest in student's work	10	2
N. Shows personal regard for student	6	1
P. Encourages students to succeed	19	3
Q. Encourages extended student responses	14	3
R. Encourages self-management	7	0
T. Praises student performance	8	3
U. Corrects student behavior	1	9
V. Corrects student performance	8	3
4. Nature of Interaction		
C. Commenting	45	34
D. Listening	37	18
E. Cueing or prompting	31	21
F. Demonstrating (Visual aids/and or psychomotor)	32	19
G. Modeling (verbalization of processes)	33	19

There were eight 15-second "sweeps" approximately 5 minutes apart during each observation at which time an observer coded one or more indicators under each heading. There were a total of 6 observations for each group. Therefore there was a total of 48 sweeps for each group of when teacher behaviors under each heading would be observed and noted. Further research may need to examine the small (or large) frequencies in some areas of both novice and expert behaviors*.

Other indicators which showed little or no difference in frequencies are:
(experts will be listed first)
(a). Interaction: none (0, 1), interactions with other adults, (0, 0) interactions with students, instructional (38, 33), interactions with students, managerial (10, 14), interactions with students, personal (0, 0), and other interactions (0, 0);
(b) Setting: small group settings (0, 2), whole class settings (37, 38), traveling settings (3, 1), and other settings (0, 0);
(c) Purpose of interactions: focusing on the task's product (17, 19)***, communicating the task's procedures/directions, (17, 14), communicating the task's criteria for success (9, 7), helping students complete work on time (3, 0), encouraging students to help each other (0, 0)***, praising student behavior (1, 0)***, and other purposes of interaction (1, 1);
(d) Nature of interaction: questioning (23, 21) explaining (47, 41), other (0,1)

Table 2

STUDENT OBSERVATION SCHEDULE
Total Frequency Counts

	Experts	Novices
1. Interaction		
A. None, independent seatwork	72	46
C. With Teacher Managerial	10	25
K. With student(s) Personal	4	14
3. Activities		
A. Working on written assignments	53	125
B. Taking Quizzes/Tests	34	0
C. Interacting	20	30
F. Getting/returning materials	3	10
G. Doing Activities/Learning Games	14***	0
L. No activity	4	39
		+12
		51*
4. Setting		
C. Independent, same activities	60	47
D. Paired -Student/Teacher	4	1
H. Small group	0***	10
5. Technology Use		
Using calculator	49	40
No technology	239	248
6. Behavior Manner		
A. On task	273	204
B. Preparation (getting materials, etc.)	2	9
D. Distracted	6	25
E. Disruptive	1	13
F. Uninvolved (daydreaming, sleeping)	2	36

* An additional 12 "no activities" were added here. When "other activities" were examined for the novice group, it was seen that 12 out of 13 of these activities were non-academic (brushing hair, rummaging through a purse, etc.) The decision was thus made to include these with the "no activity" behaviors. The "other activities" for the expert group was divided between students who had left class and those working with a protractor.

**There were eight 15-second "sweeps" approximately 5 minutes apart during each observation at which time an observer coded one or more indicators under each heading. There were a total of 6 observations for each group. Within each class, 6 students were monitored. Further research may need to examine the small and/or large frequencies in some areas of both novice and expert behaviors.

Other indicators which showed little or no difference in frequencies are:
(experts will be listed first)

(a) Interactions: with teacher, instructional (194, 195), with teacher/social personal (1, 0)
of any kind with support staff (0, 0), with students, instructional (5, 7)***, with students, managerial (0, 0), with other (2, 1);

(b) Activity Type: prescriptive (287, 288), exploratory (1, 0)***;

(c) Activities: watching or listening (155, 159), reading (0, 0), drawing (4, 3), working with manipulatives (0, 1)***, presenting/acting (0, 0)***, tutoring peers (0, 0)***, other (19, 13);

(d) Setting: whole group (220, 229), independent with different activities (2, 0)***, paired/student -to-student (0, 0)***, Paired/ student-to-other adult (2, 0), small group of 3-5 with different activities (0, 0)***, medium groups of 6-12 different or same activities (0, 0)***, other (0, 1)

(d) Behavior manner: waiting (1, 0), other (0, 1)

Table 3

CLASSROOM OBSERVATION SCHEDULE

Differences in mean scores must equal .6 or greater to have been reported in this table.

	Expert Mean	Novice Mean
INSTRUCTIONAL MATERIALS		
23. Teacher uses appropriate instructional that intensely cover the subject area of this class.	3.8	2.5
25. Teacher uses a variety of different materials during the class.	2.8	2.1
TEACHER'S INSTRUCTIONAL ACTIVITIES		
29. Adjusts lesson when appropriate.	4.5	3.1
30. Provides guided practice for students.	3.1	1.6
35. The work in the class is at the right level of difficulty for students.	4.3	2.5
CLASSROOM MANAGEMENT		
37. The class is well-organized and efficient.	4.6	3.3
39. Classroom procedures/rules are clearly communicated to students.	4.6	3.5
41. Work of the class is interrupted by the behavior of other students.	1.1	2.0
SET INDUCTION		
49. Focuses student attention on the lesson.	3.5	2.5
50. Creates an organizational framework for the information that follows.	4.3	3.3
52. Stimulates student interest and involvement in the lesson.	3.1	1.6
TEACHER QUESTIONING		
60. Gives a clue or rephrases a question to enable students to answer.	3.0	2.1
62. Allows appropriate wait time (depending on ques. level).	2.3	1.6
63. Distributes questions equally among students in class.	3.3	4.0
64. Asks questions that encourage extended student responses.	3.5	2.0
65. Asks questions that cause students to reason through to a conclusion or to explain something at length.	2.3	1.5
69. Asks students to clarify and justify their responses	2.3	1.5
70. Probes "I don't know" responses.	2.8	1.1
71. Uses "if/then language.	2.3	1.5
72. Poses "what if" or "suppose that" questions.	2.3	1.3
74. Encourages students to raise and pursue questions.	2.6	1.6

EMPHASIS ON HIGHER-LEVEL THINKING		
75. Models processes involved in obtaining answers/ solving problems (i.e. thinks out loud).	4.1	2.8
76. Requires students to explain their thinking processes when solving problems or answering questions.	2.1	1.5
77. Encourages students to evaluate their own thinking.	2.3	1.5
80. Gives students the opportunity to practice critical thinking and/or problem solving	2.1	1.1
82. Uses clear examples to facilitate logical thought.	4.8	3.6
85. Withholds "correct" responses; encourages.	2.0	1.1
87. Students analyze sources of information for reliability relevance.	2.8	2.0
TEACHER FEEDBACK		
89. Monitors student learning (checks for understanding).	4.0	3.3
92. Checks carefully all student work.	4.1	3.1
STUDENT ENGAGED TIME		
104. Get started on work with little delay.	4.5	3.5
105. Complete their work with few interruptions.	4.6	3.3
CLASSROOM ENVIRONMENT/STUDENT SATISFACTION		
124. Students appear motivated to learn.	3.5	2.3
125. Students have positive attitudes toward learning.	3.5	2.6
126. Students appear interested in class activities.	3.5	2.6
TEACHER CALCULATOR INSTRUCTION		
136. Allows students to determine appropriate use of calculator.	3.5	2.5
138. Explains relationship between calculator and paper-and pencil algorithm.	1.0	.16
141. Demonstrates use of calculator.	8.0	.16
143. Student initiated use of calculators	3.6	2.5
151. Percentage of students who have calculators at their desks.	40.5	36.8
152. Amount of time students (who have calculators) use them.	14.00	19.00

The following items were examined in order to compare expert/novice behaviors. However, there was barely any difference seen in a comparison of their mean scores.

27. Materials are derived from real-life situations.
28. Selects and organizes appropriate information.
31. Provides independent practice for students.
53. Relates the experiences of the students to the objective of the lesson.
56. Analysis/Synthesis
57. Evaluation
58. Problem Solving-Inductive
59. Problem Solving-Deductive
61. Asks questions about complex issues which does not have clear-cut responses.
66. Asks low-level questions.

67. Asks higher-level questions.
68. Asks open-ended questions with multiple answers.
73. Encourages students to answer other student's questions.
78. Encourages students to evaluate the thinking of others.
79. Teaches problem solving or critical thinking strategies directly.
81. Allows time for reflection.
83. Uses nonexamples to help students understand concept.
84. Poses problematic situations.
86. Encourages transfer at the end of lesson with comments like, "This will help you in your every day life in this way.."
88. Provides immediate feedback to students.
93. Lets students know how well they do in class.
96. Involves giving correct or incorrect answer only.
99. Is informative regarding the reasons for correct/incorrect answers.
115. Shifting interaction (i.e. teacher-student to student-student).
118. Shifting sense (i.e., from seeing to hearing).
137. Emphasizes importance of estimation to determine reasonableness of calculator answer.
139. Stresses use of calculator as a "time-saver".
140. Stresses use of calculator as a "problem-solving tool".
142. Students use calculators during teacher demonstration.
144. Teacher initiated use of calculator.
145. Students use calculators for computation.
146. Students use calculators for exploration/induction.
147. Students use calculators for solving routine word problems.
148. Students use calculators for solving non-routine word problems.
149. Students use calculators for self-checking/verifying answers.
150. Students use calculators for games.