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ABSTRACT

This study evaluates the use of graphing calculators in the science classroom within the context of a collaborative action research approach. A class of diversified middle-class students (n=650) defined by teachers and administrators as "above average" were studied. Initially, information was gathered on current classroom management techniques as well as feelings regarding graphing calculators and classroom management. The equipment used included Texas Instruments TI-83 graphing calculators with hand-held computer-based laboratory interfaces (CBL), a computer lab with 15 Macintosh Power PCs, and the teacher's own computer. Results indicate that effective classroom management depends on early planning, revision, and final implementation of the course for action with considerable thought given to possible contingencies and their resolutions when using graphing calculators and computer based-labs in the science classroom. Graphing calculators also enabled students to complete higher level work with understanding, enjoy the use of technology in the science classroom, and increased students' independence and self-confidence in completing the lab. (Contains 15 references.) (CCM)

Science Classroom Management Techniques Using Graphing Calculator Technology:

A Collaborative Team Action Research Approach

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Running Head: CLASSROOM MANAGEMENT TECHNIQUES

Classroom management has long been at the forefront of new teacher's thinking. One attempt to better understand and improve teacher thinking in recent years has been the use of collaboration and collaborative action research (Saurino, 1998; Pate, 1997; Elliott, 1990; Noffke & Zeichner, 1987; Carr & Kemmis, 1983), and we were interested in how its use by educational groups might help middle grades teachers answer questions related to their practice. It is important to note that when we refer to collaborative action research, we most often refer to a subset defined as collaborative team action research. In this study, we made use of collaborative team action research to answer our research question concerning classroom management techniques that utilize graphing calculators in the science classroom.

Defining Collaborative Team Action Research

The research process used in our study is described as cyclical, involving a recursive, nonlinear pattern of planning, acting, observing, and reflecting on changes in educational situations observed by the researchers. For the purposes of our study, we are using Lewin's (1947) definition of "action research" as the basis of our definition for collaborative team action research from his study of group dynamics. In Lewin's work, an attempt to solve a problem existing in the group was introduced by the group facilitator and the impact of the change was noted. Lewin's work began a trend influencing others over the next 50 years who emphasized issues of greater productivity and efficiency in many areas including education.

The addition of the word "collaborative" to action research implies that two or more researchers are working together, exchanging ideas and expertise, interacting as they conduct action research in an effort to be more productive than if they worked alone. The collaborators met together regularly to plan, conduct, reflect, and write about the research they are conducting. The collaborative team action research in our study involved a team of educators and researchers conducting classroom-based inquiries to answer a question of interest to the team.

The word "team" emphasizes an important area of development in middle schools. "Interdisciplinary teaming" (Gallagher-Polite, 1997; McEwin, 1997; Wraga, 1997) combines the concept of teaching in teams of content-area teachers with the concept of teaching an integrated curriculum (Beane, 1993; Gatewood, 1998). The team concept has been one of several attempts to meet the needs of students in transition between the self-contained classroom atmosphere of the elementary grades and the departmentalized classroom structure of high schools. In our study, we expanded the concept of teaming to include the benefits of working in a group, especially the interactions of the group to brainstorm new ideas and reflect on actions taken, to answer questions and solve problems.

Finally, the ultimate beneficiaries of the research process are the students, yet the teachers and university researchers benefit from new knowledge gained through the collaborative process. In addition, we see collaborative team action research as a methodology, a process of conducting research using a particular sequence of research strategies and theoretical perspectives (Saurino & Saurino, 1996). Collaborative action research is a recursive sequence, each completed series of research steps often referred to as a "cycle" of research. The term cycle is misleading, however, since the researcher never begins again at the same starting point (Saurino, 1998).

<u>Our Study</u>

Our expansion of collaborative action research was to utilize a group, or teacher team setting, and to adapt the research process accordingly. The research question did not involve the topic of teams or teaming in the middle grades, yet the research was conducted with middle school team teachers, and was found to be an appropriate tool to help answer questions relative to middle grades teaching team school structures. An interesting byproduct of the study was to discover that the research process did have beneficial effects on the teaming process and the working relationships among the team teachers, and we recommend more research on the benefits of conducting collaborative research as a teaching team.

All the steps we took in the process can be considered the actions of collaborative team action research; they were the ongoing practice of the teachers, the actions we took to answer the research question, and include changes in practice, or new actions resulting from participation in the collaborative group. There has been very little research published about the use of collaborative action research in a middle grades (grades 6-8 in this case) setting, and even less about the process of conducting collaborative action research in a group or team of more than two researchers. With the increase in the use of teaching teams in middle schools, we were interested in how collaborative action research might be utilized with educational teams.

We believe the documentation of the process of adapting collaborative action research to teaching teams is an important first step in the use of the research process in other areas of education. The unique fit of collaborative team action research to the teaming process found in many of today's middle schools could allow the process to become an important teaming tool, allowing teachers to learn more about their practice and providing a forum in which to try new strategies, receive feedback, and reflect on what is learned in the process. In addition, the process allows university researchers to conduct meaningful research in the classroom environment and learn more about what theoretical strategies have practical application in practice.

Our Cycle of Collaborative Team Action Research

The research team in our study consisted of a science content area pre-service graduate student teacher, two cooperating in-service science teachers, and a university researcher. Meetings for the team were scheduled regularly throughout the study, and an informal atmosphere was maintained. The team meetings were where plans could be made, questions asked and answered, problems discussed, and reflections expressed. It was the opportunity for discussion and flow of ideas between members of the team that proved most valuable in moving the research forward. The group setting was conducive to the generation of new ideas, strategies, and techniques used to initiate action, direct the research, solve problems, and ultimately find answers to the research question. Through the process of self-conscious scrutiny we could theorize our practices, revise our theories in light of reflective interaction, and adjust our practice through reflectively informed changes in our behavior (Carr & Kemmis, 1983). An important goal of the reflection was to develop a rational understanding of our practice of how it applied to the transfer of information to our students. This increase in understanding was achieved through systematic reflection on both the unconscious and deliberate acts which constituted the research process (Oberg, 1986). Another goal of the process was for the participants to understand this form of team inquiry, that is, how the reflective process increased awareness of our practice and eventually our capacity to direct it more fruitfully.

For convenience in the discussion, we have divided the overall research process into four chronological phases, based on the recursive collaborative team action research cycle in the study, and a planning phase for future cycles:

1. August 1998	Planning phase of the project and Cycle 1
2. September 1998	Baseline data collection for Cycle 1
3. October - November 1998	Intervention strategies/ Modification of interventions
4. December 1998	Repeat baseline data / reflection for Cycle 1
5. January 1999	Return to Planning phase for future Cycles

Phases 1 through 4 comprise the first research sequence or "Cycle" and Phase 5 and any following phases might repeat the cycle to gain more information. After the first cycle, research questions could be modified or replaced, based on what was learned to date. A single cycle consists of the steps in the phases outlined in Figure 1 below, as was conducted during our study.

Planning

Phase 1 (Planning Phase in Figure 1) began in August of 1997 with an initial meeting of the team members. The group volunteered to conduct the research after being contacted by the

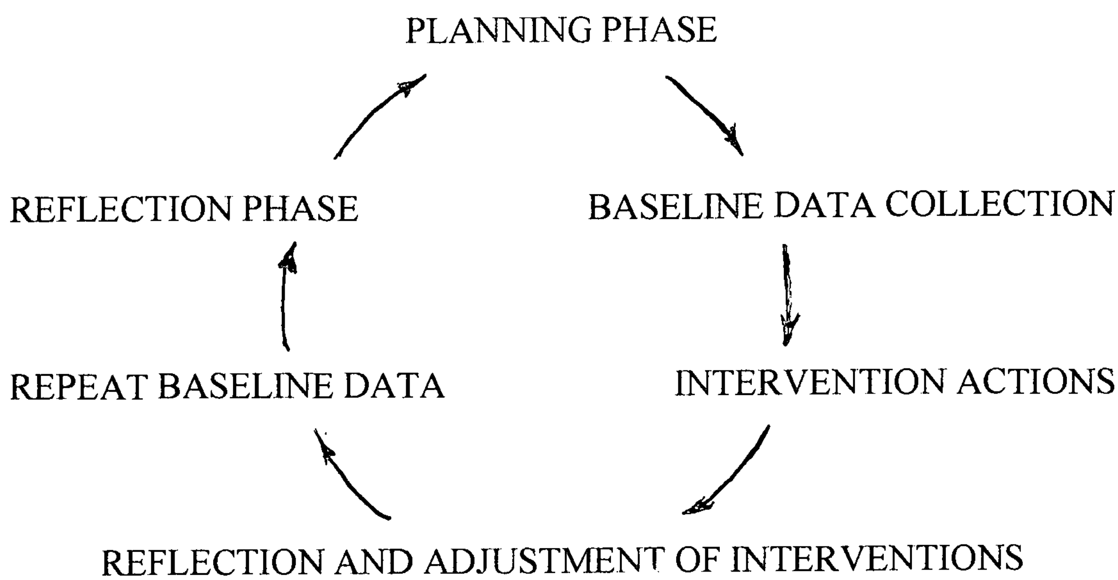

Figure 1. Illustration of one recursive sequence of collaborative team action research, often referred to as a "cycle."

university researcher, but did not know any particulars about the process of conducting the research. The general plan of creating research questions, taking actions, collecting data, and reflecting was discussed and a basic time-line for the cycle of research was established during this meeting. The participants had a variety of questions and concerns that were expressed and discussed, the most notably concern was about the amount of work required to complete the project in regard to the process of data collection. We emphasized the flexibility of our planning and of our time-line. During the project, we audio taped all meetings of the participants, including individual and group meetings. In addition, we made field notes of observations, kept personal journals from our individual points of view, and gathered data concerning the research question from administrators and other teachers. These data were the source for this report.

We met during pre-planning in August and finalized the research question for the cycle. As a group, we decided to develop one group question, rather than individual research questions. Decisions about research procedures concerning the group question were made by the group. In fact, we decided that we all had to be in agreement in order for an idea to be accepted. We were concerned initially whether unanimity might be a problem when trying to move forward in the research process, but were pleasantly surprised that conflict and work toward its resolution kept all members of the group involved, allowed opinions to be aired and discussed, and generally united the group by insuring that everyone had input before a decision was made. After discussion and reflection on our research interests, the group decided on the following research question:

What classroom management techniques might utilize graphing calculator technology?

Baseline Data

Phase 2 (Baseline Data Collection in Figure 1) began with what we refer to as "baseline data." Baseline data answers the question, "What is the current situation in regard to our research question?" The middle school for our study was located in a semi-urban area just west of a large mid-Atlantic metropolitan city. It consisted of about 650 diversified middle-class students defined by teachers and administrators as "above-average." Initially we gathered information on what was currently being utilized in classroom management plans, what plans were already in place, as well as the feelings teachers had about graphing calculators and classroom management. This information constituted our baseline data and would be used for comparative reflection at the end of the cycle.

The middle school science department had class sets of Texas Instrument TI-83 graphing calculators with hand-held computer based laboratories (CBL), a regular computer lab containing fifteen Macintosh Power PCs, and each science teacher had his or her own computer in the classroom. With a total of eight science teachers, four teaching life science to seventh graders and four teaching physical science to eighth graders, the availability and the functionality of the technology resources was often difficult to rely upon in the regular computer lab room. Due to the initiation of SOL (Standards of Learning) testing, the county where the study middle school was located developed a required POS (Program of Studies) for science teachers at the eighth grade level. The created curriculum left little room for deviation from its prescribed path, and included "teacher notes" of the expected topics to be covered as well as the manner in which they were to be covered. The teacher notes also referenced available resources dealing with each unit, lesson, and lab. The prescribed science curriculum was a very "hands-on" experience for students including a lab manual containing the required labs for each unit. For a person new to the teaching profession, it was extremely helpful, but experienced teachers might resent having to conform to the county's packaged curriculum. An informal interview process was used to collect baseline data from science teachers, math teachers, and students, in addition to the science department head who had been instrumental in the development of the eighth grade science curriculum.

The math teachers interviewed for the study also taught our science students and were engaged with attempts at integrating the math and science curriculum using the graphing calculators as a common instructional tool. Several challenges with integrating the math and science curriculum were being addressed during the time the study was conducted. First, since both the science and math departments were required to teach a prescribed curriculum it was difficult to coordinate the two curriculums. Second, the science students performed at very different math skill levels, as well as different levels of understanding in science. In addition, the science students from any one science class were not in the same math class so more than two classes (and often as many as four) had to be involved in any one integration project. One math teacher commented, "I used to start with graphing and line plots [so I could coordinate with science labs] at the beginning of the year, but with the SOLs and curriculum changes over the last few years, that has become unfeasible." Both the current math and science curriculums are relatively new to this middle school, and the process of coordinating ways to facilitate the integration of the science and math curriculums to allow for tandem use of the graphing calculator were still being developed.

As part of the baseline data collection phase, four purposely varied science students were interviewed regarding the use of graphing calculator technology. All four students were either currently enrolled in a math class that used the graphing calculator or had been enrolled in such a class the previous year. Two of the four students owned their own TI-83 calculators, whereas the other two students used the TI-83s provided by the middle school. It was interesting to note that not one of the four students had been exposed to the graphing calculator in their science classes, yet all four students had used a graphing calculator in their math classrooms. Kim (all names except the authors have been changed) stated, "Last year we used graphing calculators in math. They were pretty neat...." Sara commented, "We are using the graphing calculators this year in math. They have a lot of buttons and a lot of functions. I am really excited about using them." The students enjoyed using the graphing calculators in their math classes, and had also loaded a number of games onto them. David said, "One of my teachers caught me playing a game [on my graphing calculator] in class, and I had to wait a whole day before it was returned. [My teacher] threatened to clear all my memory if I did it again. Needless to say, I was more careful about playing games in class." Except to do their math homework, the students did not see any real life applications for their graphing calculators. All four students understood how to link two calculators together, find and load programs onto their calculators, and in general use their graphing calculators for math and gaming purposes.

The four science students in the study were also asked about using the CBL (computer based lab). Kim responded, "What is a CBL?" Sara asked, "What does CBL stand for?" John said, "Guess not since I have never heard of it." The four students had never been exposed to or used a CBL in science or math classes.

<u>Interventions and Adjustments</u>

Phase 3 (Intervention Actions and Reflection And Adjustment Of Actions in Figure 1), included the interventive actions we took to answer our question, reflections about our actions, and adjustments of our interventions. It began in October (1998) as the student

teacher(Brenda) started her four-week period of full-time student teaching. The cooperating in-service teacher taught Brenda to use a scripted curriculum for science, with all teaching based on an extensive "hands on" lab experiences. These student-centered lab periods were when classroom management problems were arising with both our student teachers and some in-service teachers that were interviewed, especially those new to the profession. Our hope was that the graphing calculators could be used as a classroom management tool due to the discipline-preventive aspect of increased interest and motivation they might add to the labs, and perhaps as "real life" extensions of the mathematics curriculum through integration, also adding to interest and motivation. Each intervention was reflected upon and adjustments were made to try to improve the affect on classroom management. As this was our first series of interventions, we did not note significant differences in our adjustments of interventions. We expect that after completing a full cycle of research we would be better equipped to suggest other forms of intervention.

The first intervention was an experiment Brenda taught in her eighth grade physical science classroom which used a line plot based on the length of a student's foot. The students were required to trace their feet on construction paper, measure the length of the drawn foot in centimeters, and hang their feet on a clothes-line style string with centimeter increments attached. The lab required the students to manually create a line plot in centimeters from their data on a piece of paper. As an extension, the student teacher had the students enter the data into the graphing calculator to provide a means of comparison. For the calculator portion, the student teacher placed the students in small groups where the students who had experience with the calculators helped and instructed students who did not have experience.

When asked about using the graphing calculator in science class, Kim stated, "I guess I kind of knew all along that the calculators had uses [other] than just helping me do my homework and class work in math and to provide an interesting game or two. This made it [the graphing calculator] seem more realistic to me." Sara expressed, "Since I am just learning to use my calculator, this gave me more practice in how to use it." John said, "I think it was kind of neat to see that there are places in real life that these calculators can be used and not just in made-up problems. I also think it was interesting looking at different types of graphs using the same data."

The students were asked whether the calculator experience was a worthwhile use of class time, or should the class have stopped once the line plot had been created on paper. Kim stated,

"I think it was worthwhile in that we could see the same data presented in three different ways." Sara said, "I think it was interesting to see how you could change the type of graph on the calculator." John expressed, "I think it made even more sense to me by seeing it on paper before using the calculator." David said, "I already knew what was going to happen. Why did I even have to put it down on paper before I used the calculator?"

As another intervention, the science students performed a lab experiment using the CBL and a temperature probe where the students plotted their data manually. For these labs, the student teacher paired students into groups of two. After completing the lab, the student teacher asked the students in her study sample about using the CBL with a temperature probe versus using a standard thermometer. Kim stated, "It took a few minutes to get the hang of it." Sara felt that the CBL was easier to read than a thermometer. John thought there might have been something wrong with his CBL because he had a beaker in ice water, and the CBL showed a -5°C reading. David stated, "I guess they are OK; not very exciting to just watch the numbers go up or down for the change in temperature, but I guess they do their job." The student teacher instructed that the increments on the CBL were correct, and had the students work on calibration.

Another intervention involved connecting the CBL to the graphing calculator so the students could view the resulting graphs. Students were placed in groups of three this time as another variety of student-centered grouping. Each group performed an experiment to study endothermic and exothermic chemical reactions. The middle school holds an annual parent day where parents are encouraged to accompany their child to school. The endothermic-exothermic chemical reaction lab occurred during parent day. Parents were interviewed and seemed to enjoy a chance to participate and were impressed with the CBL and graphing calculator combination. One parent remarked, "This is a lot better than when I took chemistry in high school, and we had to record each of those temperatures [by hand]. I wish we had the ability to link calculators and CBLs at that time. All we had were slide rules."

The students in the study sample were asked about their reactions to linking the CBL to the graphing calculator, and were very receptive. Kim stated, "I could better understand the decrease in temperature of an endothermic reaction by having [the CBL] linked to the [graphing calculator] combination. I just wish I could have done both of the experiments instead of having to share results." Sara said, "I thought it was fascinating watching the calculator screen as each temperature was taken by the CBL, then seeing the full graph at the end of the experiment." John stated, "The calculator screen is so small that it was a little difficult seeing the highest and lowest temperatures from the experiment, but that was definitely easier than taking all of those temperatures every five seconds." David responded, "It was certainly easier to let the CBL collect the data, and the calculator record the data."

The students were also asked about the usefulness of linking the CBL to the graphing calculator. Kim explained, "I thought it was quite useful to have the two linked. It provided an immediate way of looking at the experiment." Sara said, "I sort of see how linking the two could be useful to collect other data. I hope we will be using the linked setup in future experiments. It is pretty awesome that I am using the calculators both in math and science." John stated, "I appreciated not having to hunt for all of those little block coordinates on graph paper." David responded, "I know that having the linked calculator and CBL did save me a lot of time."

Repeating Baseline Data and Reflections

The first part of Phase 4 (Repeat Baseline Data in Figure 1) began in December of 1998 when Brenda had completed her full-time student teaching. We basically repeated the data collection for the Baseline Data at the beginning of the study so that we could directly compare the situation then with the situation at the end of the cycle. Because this was our first cycle of research, the final baseline data paralleled the interventions initiated in the study. What was different was the use of more interesting and motivating techniques used for student-centered work, especially the use of graphing calculators, CBLs, probes, software, and integrating the mathematics curriculum, as described above. In the next cycle of research, we might start at this point and try more strategies and techniques to see if we could increase the level of interest and motivation, and perhaps better define the effectiveness of each technique.

The other part of Phase 4 (Reflection Phase in Figure 1) began after all the data had been collected. We examined the data and made direct comparisons between the initial and final baseline data. Then we reflected on the other data collected, what we had learned as a result of experiencing the process of conducting the research, and the research as ongoing cycles. We reflected that we had highlighted a few effective techniques that might improve graphing calculators as a teaching tool if implemented consistently over a long period of time. We also believe that other techniques and strategies might be found to be effective if we continued the research question through more cycles. We agreed that experiencing the research process made us more aware of the needs of our students, and that by becoming proficient with the research process itself, we could continue to grow professionally through other projects.

Conclusions

In summary, we believe that effective classroom management depends on the early planning, revision, and final implementation of the course for action with considerable thought given to possible contingencies and their resolution when dealing with TI 83's and CBLs in the science classroom. By that we mean that when facilitating student performance on a higher plane, the prior planning based upon the applicability of the tools to the task, and student proficiency in the use of those tools is essential. Good planning and student proficiency with the equipment help prevent loss of classroom control and student frustration. As the plan emerges, revisions need to be developed based upon the availability of resources and of the allotted classroom time factor. Student frustration if there is not enough time to complete the activity, or student boredom if there is too much time given for an activity, both result in an increase in classroom management problems. Prior to implementation, the teacher needs to perform the activity and test the equipment for possible problems that can be handled before students become involved. We routinely make sure that the units have charged batteries installed, that the linking cables actually work at the proper junction, and that the program to be used is correctly installed. The preliminary time spent on these basics pays off in the classroom as middle school students enjoy the success of performing activities without technical problems. The bottom line is that students who are actively and productively engaged in a TI/CBL activity involved in learning and the classroom management takes care of itself.

Specific ways in which the use of graphing calculators improved classroom management include the following:

- Students were able to complete higher level work with understanding and without the frustration through the use of the linked TI 83/CBLs.
- Students enjoyed the use of technology in the science classroom, which made classroom management easier. At the end of her student teaching, Brenda had students fill out an evaluation which included references to the TI-83 and CBL. In answering the question, "Which labs did you find most valuable?" a majority of the students listed the labs

involving the CBLs and especially the lab which used both.

- Planning, trial and error, and using the TI-83 with a new regimented curriculum necessitated a plan for program implementation. Students really enjoyed using the calculators and CBL technology when explicit and detailed instructions were given to them through a set of guided instructions, verbally in a step by step approach, and kinesthetically with the process modeled by the teacher.
- The use of an overhead projector TI-83 view screen, which shows the screen of the connected calculator on the overhead projector, was very helpful and made instruction easier, but it is not absolutely essential. The view screen helped keep the class focused in the performance of the learning activity, again reducing the number of unacceptable behaviors in the classroom.
- The exposure of students to each component independently before linking the CBL to the calculator increased student self confidence. By becoming familiar with each component, students were able to achieve almost immediate success in the performance of the lab.
- The CBL and TI-83's smaller size, easier portability, and lower cost than comparable computer arrangements made the systems more accessible to students and teachers while providing the convenience of remaining in the regular classroom where students were accustomed to a certain standard of behavior.

Finally, we were satisfied with the positive effect our few techniques had on classroom management and think more research is needed along the lines of strategies to enable students to take greater control over their learning through the use of technology like the TI-83s and CBLs, so teachers can spend more time in the role of a facilitator than in the role of a disciplinarian. And the real beneficiaries will be our students.

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