Strategies and Techniques Using Graphing Calculators to Enhance the Learning of Mathematics Applications in the Gifted Classroom: A Collaborative Group Action Research Approach

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INTRODUCTION

An emerging research tool used in recent years to better understand and improve teacher thinking has been the use of collaboration and collaborative action research (Saurino, Saurino, Blankenhagen, Graziano, & Raymond, 2006; Pate, 1997; Elliott, 1990; Noffke & Zeichner, 1987; Carr & Kemmis, 1983). In our study, we were interested in whether gifted teachers could enhance the learning of mathematics through the use of teaching techniques and strategies involving graphing calculators. It is worthy of note that when we refer to action research by any name in this study, we are actually referring to a subset of action research called collaborative action research. More specifically, we are further referring to a subset of collaborative action research that we will define as collaborative group action research.

Figure 1: Relationship of collaborative group action research to collaborative action research and action research

The overall concept of "action research," as illustrated in Figure 1, has its foundation in the work of Kurt Lewin (1947). Lewin is most often cited as the "founder" of this form of research, which he called "action research," because he combined interventive actions and group research. Lewin took an existing group, introducing a change or action to it through a group facilitator, and observing the impact of such change or action. Lewin used a cylindrical process involving a recursive, nonlinear pattern of planning, acting, observing, and reflecting on changes in social situations observed by the facilitator. For the purposes of our study, we are using Lewin's definition of action research as the basis of our definition of collaborative group action research.

The addition of the word "collaborative" to action research, illustrated as a subset of action research in Figure 1, implies that two or more researchers are working together. These researchers are
actively exchanging ideas and expertise and are continually interacting as they conduct action research in an effort to be more productive than if they worked alone. The collaborators meet together regularly to plan, conduct, reflect, and write about the action research they are conducting. There are different forms of collaboration and the setting for our collaborative efforts was a collaborative group of pre-service, in-service, and university educators. The use of the word "group," illustrated by the smallest subset of action research in Figure 1, emphasizes the true value of this approach to research because the research is done by a group of teachers, graduate students, and university researchers all involved in classroom-based research. The group setting allowed for regular interaction among the researchers and a place for discussion, brainstorming, reflection, accountability, and organization of the process of conducting the research.

In summary, we define collaborative group action research for the purpose of this study as a group of pre-service and in-service teachers actively working together with a university researcher to ask questions of interest, in an attempt to find answers that might help improve their practice. The ultimate beneficiaries of the process are the students, yet the teachers and university researcher also benefit from the new and relevant knowledge gained by experiencing the process. In addition, we see collaborative group action research as a methodology, a process of conducting research using a particular sequence of research strategies and theoretical perspectives (Saurino, Saurino, Blankenhagen, Graziano, & Raymond, 2006; Saurino, Saurino, & Crawford, 2005; Saurino, 1998; Saurino & Saurino, 1996). The varieties of collaborative action research are as numerous as the potential topics that can be addressed. However, collaborative action research is generally qualitative in nature, aimed at developing new insights into schooling, education, teaching, learning, and/or finding new approaches to solving problems in education, industry, community development, and the military (Noffke, 1995). This type of research also involves reflection, which provides the researcher an avenue to better understand what was learned from the research process and to better understand the implications of the findings. The research continues by repeating the process again, and begins with either a completely new question or a refinement of the initial question based on what was learned during the first research sequence. Therefore, collaborative action research can be an ongoing recursive sequence; each completed series of research steps often referred to as a "cycle" of research. The term cycle is a little misleading, however, since the research never begins at the same point as the term "cycle" implies (Saurino, 1998).

**Our Cycle of Collaborative Group Action Research**

The research group in our study consisted of two in-service gifted mathematics teachers, two graduate pre-service mathematics students, and a university collaborator. Meetings with various members of the group were scheduled regularly throughout the study, and an informal atmosphere was maintained. The group meetings provided a place where plans were made, questions were asked and answered, problems were discussed, and reflections were expressed. The group setting also provided an avenue to brainstorm for new ideas, strategies, and techniques used to initiate actions, direct the research, solve problems, and ultimately answer the research question.

The research process completed by our study involved four chronological phases and a planning phase for future cycles. The four chronological phases were based on the recursive collaborative group action research cycle outlined below and illustrated in Figure 2.

Phase 1 through 4 comprise the first research sequence of "Cycle 1" 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 complete cycle, as was conducted during our study, consists of the phases outlined in Figure 2:
Phase 1: August  
Planning phase of the project and Cycle 1
Phase 2: September  
Baseline data collection for Cycle 1
Phase 3: October-November  
Intervention strategies/Modification of interventions
Phase 4: December  
Repeat baseline data/Reflection for Cycle 1
Phase 5: January  
Return to Planning phase for future cycles

Phase 1 (Planning Phase in Figure 2) began in August with an initial meeting of the pre-service teachers and the university researcher. The students had volunteered to do the research after being contacted by the university researcher, but did not know any particulars about the process of conducting this type of 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. The students had a variety of questions and concerns that were expressed and discussed. Their most arduous concern dealt with the amount of time required to complete this project. The university researcher emphasized the fact that the process was flexible and the time line could be adjusted. During the project, meetings were audio-taped and field notes created from observations and interviews with administrators, parents, students, and other teachers. In addition, everyone in the group kept a personal journal. These data were the source for this written report. The in-service teachers were included after they returned to work in early September. At that point we finalized the research question for the cycle. The finalized research question is as follows:

What strategies and techniques using graphing calculators might we utilize to enhance the learning of our gifted mathematics students?
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 fourth and fifth grade gifted class for our study was located in a suburban area one hour west of a large mid-Atlantic metropolitan city. The group consisted of three out of four classroom centers for an all-day pullout gifted and talented program. The teachers in each of the four centers shared ideas and wrote curriculum together. The curriculum was written by the teachers, supervised and reviewed by their two supervisors, and also looked over by various experts in education and gifted education. A particular model was used to develop the program, which cycled every two years. Since students met with their gifted and talented teachers weekly, total involvement in their gifted program for the year was approximately 33 days. The differentiated curriculum was extremely hands-on and was designed to present content so that it related to broad based issues, themes, and problems through open-ended tasks that helped develop research skills and methods of scientific research. During the first-year cycle of the program, students studied “Structures;” the second year was “Systems.”

While writing the yearly curriculum for Systems during the summer, one of the teachers suggested that graphing calculators could be used to “diversify the use of technology, study data in various formats, and increase the integration of math in the curriculum.” Another teacher felt that the use of graphing calculators would be above the ability level of beginning fourth and fifth grade gifted students. The gifted coordinator for the county commented that the use of graphing calculators could enhance the learning opportunities for gifted students, and proceeded to find out what might be available in the county.

By the end of August, Casio CFX-9850G Color Graphing Calculators were made available to the teachers. Each of the four centers was issued 25 calculators plus a demonstrator model that had a video attachment for television demonstration. Three in-service classes were scheduled in September. We initially gathered information on what was currently being suggested during curriculum planning, as well as plans that were already in place, and the feelings teachers had about graphing calculators and their use in the curriculum. The information constituted our baseline data and would be used for comparative reflection at the end of the cycle. The biggest hurdle in making the color graphing calculators available to students was for the teachers to feel comfortable operating them the calculators. The teachers expressed concern during the in-service. Typical comments included (pseudonyms are used):

Ann: “I don’t understand how the data is being interpreted. How is this information relevant to what we our teaching.”
Bob: “I used TI-83’s during another workshop, and I liked the format of those calculators better, but these have other attributes.
Alice: “This is hard, but my students would like having a new toy.”
Bob assisted the instructor with the video attachment. He and Alice were most enthusiastic. They also taught at the same center which would give them a greater ability to share ideas together. The students in our study had not used graphing calculators in the past and were not familiar with their operation or application.

Interventions and Adjustments

Interventive actions included the actions we took to answer our question, reflections about our actions, and adjustments of our interventions. It began in September, as soon as our inservice was competed. The teachers at this point were either determined to practice with the graphing calculators to prepare future lessons, or they let it go.
The first intervention was an experiment by Elaine in her class on tracking the trajectory a spacecraft travels in its route from the Earth to Mars. She began the class with a video demonstration of an Earth to Mars takeoff that clearly demonstrated the route of the spacecraft. This was followed by a demonstration using a visual of a football being hurled through the air toward the goal line. The students then tracked the trajectory of a spacecraft flight from Earth to Mars using a compass, paper, and pencil. The students found this task to be tedious. Bob questioned, “Would astronauts really figure out how to get to Mars by doing this?” which led to a very natural extension. Elaine continued the class by demonstrating trajectory using the graphing calculator with the video. The large numbers and decimals awed the students. Even though the students did not fully understand the formulas, they were intrigued with the accuracy and speed in which it calculated trajectory. Warren said, “This is cool. What else can this do?” After class was over, several students were questioned about the lesson format using graphing calculators. Mary said, “It was fun to work with big numbers.” William commented, “This is like being a real astronaut.”

Alice waited to use her graphing calculators until she found a lesson that was specifically suited for them. In her lesson, students calculated how much time it took for a message to get to Earth from the nine different planets. The calculators were used to take advantage of the large numbers that they could calculate. She began the lesson by teaching the students just a few simple actions such as what the execute button was for and how to work the arrows. The simple introduction helped both the teacher and students feel more comfortable with the equipment. Throughout the lesson, the calculators were used to enhance and demonstrate the concepts being taught. When asked about the success of her lesson, Alice said, “My students loved having the ability to use large numbers, they enjoyed using something different, and they liked having all the answers on the same screen. The screen of the calculator is more like a computer monitor.” Even though her lesson was successful, she still had difficulty with the thought of developing future lessons around the graphing calculators, or in using the calculators in different modes, because, “On a scale of 1 – 5, my comfort level is still a 2! I would only feel comfortable using the calculators in the graph mode if someone handed me a lesson and then showed me just what to do. I don’t know if I will ever feel comfortable with it.”

Repeating Baseline Data and Reflections
The first part of phase four began in December when the teachers were preparing for the following semester. Alice and Elaine became the primary users of the graphing calculators. They exchanged lesson ideas and encouraged each other to try new ideas and different types of lessons. Some of the others within the group reduced their use of the calculators because of the added work in preparing lessons and their inability to feel comfortable using the calculators. Elaine and Alice’s students expressed interest in the lessons that used the calculators and wanted to use them over and over again. Ann was asked if she might ever choose to incorporate the calculators, and she said, “No, I need two more months just to cover what I haven’t had a chance to cover this year. We will use graphing calculators in the future if the lesson warrants it, but we’ll need advanced preparation time, and that is time we don’t currently have.”

Conclusions
As with other forms of technology, time for the teachers to become more proficient with graphing calculators might make the equipment for assessable to the students. The three-day in-service was not enough to raise the comfort levels of the majority of our teachers to the point which would allow them to use them on a regular basis. Longer, or ongoing in-service training may have allowed more time for
practice without the stress of first-time teaching anxiety looming in the teachers’ minds. The activities that the teachers utilized were well received and suggested that graphing calculators could be an effective tool for the enhancement of teaching mathematics to gifted students, but more study is needed to assess the full effectiveness of this form of technology and its use by teachers.

REFERENCES

Note: An earlier version of this paper presented at the annual meeting of the American Educational Research Association, New Orleans.