Proc. Natl. Sci. Counc. Repub. China,
Part D Math. sci. technol. educ.
Vol. 6, No. 1, 1996. pp. 9-15

Teaching Mathematics Methods Using Videodisc

Gary G. Bitter[†]

Technology Based Learning & Research
Arizona State University
Box 870111
Tempe, AZ 85287-0111, U.S.A.

(Recieved: August 27, 1994; Accepted: August 11, 1995)

ABSTRACT

An multimedia-based instructional system was developed and piloted with preservice elementary teachers. Four mathematics methods classes experienced either lecture supplemented with a new instructional multimedia system or lecture without such material. Subjects who received the system-enhanced instruction appeared more knowledgeable about teaching mathematics using manipulatives than those who received traditional instruction only. Results suggest that multimedia can have beneficial effects for preservice teacher training.

Keywords: Multimedia, Videodisc, Mathematics Methods, Manipulatives, Elementary, Preservice

I. Teaching Mathematics Methods Using Videodisc

Teaching mathematics is a complex process which requires a teacher to utilize many types of information (e.g., subject matter, pedagogy, instructional contexts, manipulatives, social-motivational factors) that are often not adequately addressed by teacher preparation programs (Goldman & Barron, 1990). Much frustration exists for both student-teachers and teacher educators because most prospective mathematics teachers are competent in subject matter and well-versed in instructional theory, yet they appear inept at applying this information when providing explanations for mathematical relations, concepts, or operations. (Commission on Standards for School Mathematics of NCTM, 1989). What is even more perplexing is that teachers who are aware of the discrepancy between their knowledge and their performance in the classroom seem unable to correct their performance (Berliner, 1986; Goldman & Barron, 1990).

Efforts to ameliorate this problem have traditionally centered on introducing additional concepts for prospective teachers to use in the classroom for a student's understanding of mathematics. One such concept is the use of mathematics manipulatives. Mathematics manipulatives are physical objects that teachers use to demonstrate a mathematical operation or concept and allow children to directly manipulate them in order to facilitate their understanding and skill of the operation or concept (Hatfield, Edwards & Bitter, 1993). Researchers (e.g., Akers, 1986) have indicated that using manipulatives to teach mathematics concepts augment elementary student performance and their attitude towards mathematics in general. Sowell (1989) recently reviewed 60 studies that examined mathematics manipulatives. She concluded that,

†Requests of reprints should be addressed to Gary G. Bitter, Technology Based Learning & Research, Educational Media and Computers, Arizona State University, Box 870111, Tempe, Arizona, 85287-0111, U.S.A.

indeed, these devices are useful for learning mathematics knowledge and skills when they are used to make learning an active process (i.e., allow children to actually use the manipulatives) and when children are allowed to manipulate physical objects as often as possible when studying mathematics. Moreover, manipulatives used in mathematics instruction seem to motivate students to work and learn, stimulate mathematical reasoning, and appear to be an informal introduction to higher reasoning in mathematics (Hatfield, Edwards & Bitter, 1993: Sowell, 1989).

More recently, educational researchers have attempted to incorporate "real life" scenarios in teacher training programs whereby prospective mathematics teachers observe actual classroom instruction. Research suggests that preservice teachers learn more and can transfer that knowledge to their craft of teaching when important instruction on pedagogy is experienced in context (e.g., anchored or situated instruction) (Bransford, Sherwood, Vye, & Rieser, 1986; Palincscar, 1989). Observations in elementary classrooms provide the preservice teacher with a sense of the reality of the instructional environment, but are often limited in allowing learning of teaching theory, mathematics instruction, or learning important aspects of exemplary instruction in general (Carter, Sabers, Cushing, Pinnegar, & Berliner, 1987; Goldman & Barron, 1990). The use of selected videotaped examples from actual classroom teaching lessons provides a non-obtrusive method of demonstrating good and bad mathematics teaching, but without some kind of focus, direction, interaction, or narration to point out specific attributes of good and bad instruction, novice teachers may not notice or may misinterpret fundamental points of quality teaching (Berliner, 1986; Carter, et al., 1987; Goldman & Barron, 1990; Lampert & Ball, 1990). For this reason, a hypermedia-based, instructional program for preservice teachers has been suggested to improve their training and, ultimately, the quality of elementary mathematics education (Copeland, 1989; Goldman & Barron, 1990; Harvard, 1990). Accordingly, the use of interactive technology would allow preservice teachers to develop their perceptual, interpretational, and decision-making skills as well as transfer their training in theory to classroom instruction (Copeland, 1989; Goldman & Barron, 1990).

The promise of videodisc technology as an effective medium for teacher training is a function, in part, of its unique characteristics. A user can control the learning sequence, the subject matter, the form of a lesson's presentation, the speed at which a lesson is presented, and the pace at which a user progresses through the material (King, 1990; Litchfield, 1990). A user has access to a variety of visual and audio presentations and graphic displays. Because of a vast storage capacity (a completed videodisc contains 54,000 individual visual frames), videodisc systems provide multiple pathways for accessing information including realistic practice exercises, examples to perform and study, problems, and a host of instructional exhibits. A computer can be programmed to control the playback. This allows many different lessons to be developed from one videodisc and the order of playback is completely under the control of the user. Although schools have been slow in incorporating its use in their curricula, the benefits that have been reported from those that have are most encouraging. High achievement motivation, less instructional training time, and general increases in teaching performance have been notable outcomes of interactive videodisc instruction (Savenye, 1990). While the majority of educational videodiscs are used as ancillary instructional activities or for individual instructional modules, more and more whole courses in middle and high schools are being taught with routine videodisc sessions (Savenye, 1990).

The purpose of the present investigation was to explore the effectiveness of a multimedia-based videodisc instructional supplement that was developed for a teacher's use in an elementary mathematics education methods course. This undertaking, Teaching Mathematics Methods Using Videodisc (TMMUV), was an NSF funded pilot project, that addressed the need to train preservice teachers in the use of mathematics manipulative and the teaching standards advocated by the National Council of Teachers of Mathematics (NCTM). The objective of the present study was to explore the added instructional value that can be attributed to the TMMUV prototype classroom presentation mode for enhancing a regular lecture.

II. Method

1. Design and Subjects

The present study employed a "nonequivalent control group" design typically used in two-group quasi-experimental designs (Campbell & Stanley, 1966). Four elementary mathematics methods education classes that train pre-service teachers at Arizona State University were used to test the effectiveness of the TMMUV program. Two of the classes were taught by traditional lecture (non-TMMUV group). Two other classes received the identical lecture with the addition of the TMMUV program system (TMMUV group). Randomized assignment of subjects to each class/group was not possible. However, the inclusion of an extra group in each condition compensated, to some degree, for the lack of randomization by the use of "retrospective pretests" to compare differences between the two groups on the dependent measures (Campbell & Stanley, 1966). Examination of posttest scores for two classes in each condition increases confidence in the validity of differences found that are thought to be due to the independent manipulations.

Subjects were 99 undergraduate, elementary education majors enrolled in four preservice methods courses (TMMUV: n=33 & 17; non-TMMUV: n=28 & 21). Classes were assigned to groups so as to result in nearly equal numbers of subjects in each group. Data were to be collected by the TMMUV standalone system used in the laboratory, following the treatment. Bugs in the standalone mode, however, resulted in the loss of 28 subjects from the non-TMMUV group, and five subjects from the TMMUV group. Pencil-and-paper instruments were then substituted for all subsequent data collection. There were no significant age differences between the TMMUV and non-TMMUV groups (means=28.87 and 28.89, respectively). An analysis of the prior knowledge levels of subjects in each class revealed two important differences between the TMMUV and non-TMMUV groups prior to conducting the instruction. Subjects in the non-TMMUV groups had more previous experience using geoboards to teach mathematics as reflected in their reported information (means of 1.24 vs. 2.68 for the TMMUV and non-TMMUV groups, respectively). A significant proportion in the non-TMMUV group also reported having been taught with geoboards as elementary students themselves (means of 1.05 vs. 2.72). The non-TMMUV group scored higher on a measure of academic ability. By combining scholastic aptitude test or achievement test scores with previous grade point averages into inter-quartile categories, it was revealed that subjects in the non-TMMUV groups had higher estimated academic ability, on average, than those in the TMMUV classes (means of 3.17 vs. 2.80). Although this between group difference was not statistically significant, it may be worth noting when examining the effects of TMMUV-enhanced instruction on the attitudes and motivation for using manipulatives.

2. Materials and Instruments

A multifaceted, video database and instructional system (TMMUV) was created that combined full-motion video, digitized audio, text, and graphics to give preservice teachers multiple views of exemplary classroom instruction using teaching methods with manipulative materials that were proposed by the NCTM. Three instructional modes of the system are possible: (a) classroom presentations given in a traditional manner where the instructor displays the program to the students; (b) a standalone tutorial mode which allows students to work through the program at their own pace; and, (c) a video database whereby the student is afforded an opportunity to interactively explore video illustrating the application of specific NCTM teaching standards. For this study, the TMMUV video was projected, in a linear fashion, on a screen.

The TMMUV system is based on the IBM PS/2 microcomputer with M/Motion Video and M/Audio Adapters, and an attached videodisc player. A 32 bit operating system/2, version 2 (OS/2) was used for TMMUV (a 386, 486, or higher family microprocessor is necessary for the system's implementation). The overall structure for the software consisted of (a) multimedia database that included a video and audio library, a three dimensional animation and graphics library, a lesson template library, and a Structured Query Language (SQL) index; (b) interactive graphical interface; (c) authoring shell program; (d) classroom presentation program; (e) laboratory tutorial program; and, (f) an on-line user's guide.

Multiple views of exemplary classroom instruction using teaching methods with manipulative materials proposed by NCTM were used in the present investigation. Types of manipulatives and their content that can be used with TMMUV are shown in Table 1. Two 30-minute videodiscs of elementary mathematics instruction using the manipulatives were developed for use in the prototype. One videodisc contained 189 clips of instruction with geoboards and another disc contained 84

Table 1. Mathematics Manipulatives and Associated Content

Manipulative	Content
Geoboards	Arrays
Greenies	Congruency
Posterboard Shapes	Coordinate Geometry
Shapes	Flips
	Geometric Shapes/Figures
	Properties of Shape
	Reflections
	Right Angles
	Rotation
	Similarity
	Symmetry
	Unit of Measure
	Visualization Skills

clips of instruction with base 10 (numeration) blocks. The geoboard is a manipulative used to build logical thinking and problem solving skills as students investigate shape, symmetry, conguence, angles, areas, perimeters, square roots and functions. Numeration blocks are used to model ones, tens, hundreds and thousands and to build mental, images and understanding of the numeration system. The video clips on each disc ranged in length from 1-second still images to 120-second segments of instruction. In this particular study, selected clips from both videodiscs were used.

3. Measures

There were two measures of the effectiveness of the TMMUV prototype system. It was hoped that such materials would increase a preservice teacher's knowledge of quality instruction. This was termed *cognitive gain.* Six "retrospective pretest-posttest items" were used to assess changes in perceived knowledge and competence to teach with geoboards. Retrospective pretest-posttest items have been suggested as a means of investigating knowledge gain in content areas where subjects have no prior knowledge (Campbell & Stanley, 1966; Rockwell & Stevens, 1992). Five of the items were specific-knowledge referents (e.g., perceived competence to convey ideas of "estimation," knowledge of how to help students feel comfortable in the classroom) and the sixth was more general; i.e., "knowledge of what it is like in the elementary classroom." Items were measured on a 7-point, semantic-differential scale with endpoints labeled 0% and 100%. The subjects were to place a "B" on the scale to indicate where they felt they were before the classroom instruction. They were to write an "N" on the space that they felt they were *now*, after receiving the instruction.

Cognitive gain was further measured using three (3) open-ended questions that required subjects to give their opinions concerning the teacher in the video segments. The questions were: (a) "How did the teacher indicate to the students that it was all right for them to give an answer that was something other than the correct answer?;" (b) "What important teaching strategy did the teacher use to teach the concept of area?;" and, (c) "What did the teacher do that shows a way of making young children comfortable in the classroom?"

Test-retest reliability for the questionnaire was assessed by correlations of the same single-item scale given twice (attitude toward classroom instruction: r=.78; p<.01). Alpha reliability coefficients were obtained from multi-item scales of attitudes toward mathematics and attitude towards the classroom instruction; .83 and .88, respectively. Face validity was assessed by correlating "knowledge to teach with geoboards after classroom instruction" and "preparedness to teach with geoboards after classroom instructions:" r=.61, p<.01. A comparison between attitude towards mathematics and attitude toward classroom instruction using geoboards revealed satisfactory

Table 2. Study Design

Group	Intended *n*	Obtained *n*	Treatment
Non-TMMUV	49	21	lecture only
Class #1 (n=28)			
Class #2 (n=21)			
TMMUV	50	45	lecture & TMMUV
Class #3 (n=33)			
Class #4 (n=17)			

convergent validity as evidenced by the correlation of different measures of the same trait: attitude toward instruction (r=.56, p<.01) and attitude toward mathematics (r=.68, p<.01).

4. Procedure

To determine the additive effect of TMMUV on conventional instruction, four intact elementary mathematics methods classes were assigned to two groups, so as to achieve groups of nearly equal size, as reported in Table 2. One group received the TMMUV-enhanced instruction and one group received only conventional instruction on the same material. There were no significant pre-existing differences among the classes according to available data (e.g., age, sex, academic achievement).

To assure similarity in instruction, an outside instructor taught the same geoboards lesson to all four classes, each of which lasted 110 minutes. The TMMUV system was used to supplement the instruction of the TMMUV group classes. The video included a selection of appropriate videoclips needed for the posttest in both groups. These posttest clips had to be conceptually related to, but distinctly different in all other respects from, the clips shown in the TMMUV group during instruction. Following the instruction, these different clips were shown to subjects in both groups and the instrument was administered.

III. Results and Discussion

The subject's responses to the retrospective pretest-posttest items were averaged across groups and response categories were compared using the independent t-test for statistical significance. The scoring criterion for the open-ended questions utilized subject's responses in the form of sentences reflecting their perceptions and beliefs for the contrived situations. A seven-(7) point scale was constructed where by each question was graded according to clarity of expression indicating a "good-bad" range or exact sense of the correct answer (a score of 7) versus no idea what the solution would be (a score of 0). Two independent judges scored the questions. When a conflict arose in scoring, a solution was decided in consultation. There were two general categories of results. An analysis of the pre-instructional differences was conducted in order to determine if there were any variables that could have influenced the post-treatment effects.

Both groups showed gains on pretest-posttest knowledge and performance gain items. The TMMUV-enhanced groups indicated higher overall gain, but only one between-group difference was significant.

Subjects who were exposed to the TMMUV instructional system demonstrated a higher degree of observational power than the subjects in the non-TMMUV groups, as illustrated in Figure 1. When the results of the three open-ended questions were combined, the TMMUV and non-TMMUV groups had means of 5.54 and 4.27, respectively, $t(1.66)$=5.36, p<.01. Subjects were asked to indicate their gain in knowledge of the reality of the elementary classroom. Those in the TMMUV group indicated higher cognitive gain than those in the non-TMMUV group [means of 1.95 vs..92, $t(1, 64)$=2.05; p<.05].

In the present study, a new technology-based method for teaching preservice, elementary teachers to use mathematics manipulatives in the classroom was piloted. Given the prototypical nature of the TMMUV system and its relatively brief use in the class instructional sequence, it is not surprising that between-group differences for motivation to teach with geoboards and feelings of preparedness to teach with geoboards were not significant. Despite the problems encountered in this study, evidence was found for the utility of the system. Even though there appeared to be significant learning disadvantages for the subjects in the TMMUV group, who had less experience with geoboards (and manipulatives in general), these subjects outscored the non-TMMUV group on the measures of cognitive gain and overall performance.

The subjects in the TMMUV group viewed

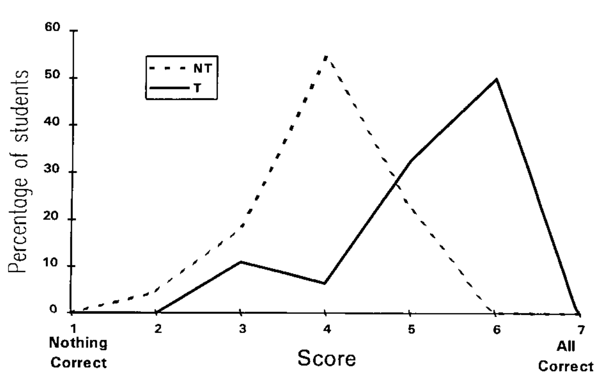

Fig. 1. Comparison of TMMUV and non-TMMUV mean scores on the combined objective performance tests.

geoboards as important devices for effective teaching of geometric area and felt that the system increased their knowledge of using geoboards. There was a general feeling among the TMMUV subjects that, by learning mathematics methods using the TMMUV-enhanced instruction, they could gain keen observational skills that they might not acquire with traditional instruction only. In addition, subjects reported that they acquired a very "real" notion of the elementary classroom from the TMMUV system programs. This is an important finding since a major problem of teacher training is said to be adequately preparing a teacher for the "real classroom" world. Overall, the subjects in the present study indicated that the TMMUV system made important contributions to their learning of mathematics methods, using manipulatives, and teacher training. The results of using the system indicate a future for interactive multimedia in teacher training that is worthy of closer scrutiny and effort in devising better systems for teachers and students.

Acknowledgements

This project was supported, in part, from a grant by the National Science Foundation (Award #TPE-8950317) and Internatioal Business Machines.

References

Akers, J. (1986). *California curriculum commission report of mathematics materials*. California: California Curriculum Commission.

Berliner, D. C. (1986). In pursuit of the expert pedagogue. *Educational Researcher*, *15*, 5-13.

Bransford, J. D., Sherwood, R., Vye, N. J., & Rieser, J. (1986). Teaching thinking and problem solving: Research foundations. *American Psychologist*, *41*, 1078-1089.

Campbell, D. T., & Stanley, J. C. (1966). *Experimental and quasi-experimental designs for research*. Boston, MA: Houghton Mifflin.

Carter, K., Sabers, D., Cushing, K., Pinnegar, S., & Berliner, D. C. (1987). Processing and using information about students: A study of expert, novice, and postulant teachers. *Teaching and Teacher Education*, *3*, 147-157.

Commission on Standards for School Mathematics of the National Council of Teachers of Mathematics. (1990). *Curriculum and evaluation standards for school mathematics*. Reston, VA: National Council of Teachers of Mathematics.

Copeland, W. (1989). Technology-mediated laboratory experiences and the development of clinical reasoning in novice teachers. *Journal of Teacher Education*, *40*, 10-18.

Goldman, E. S., & Barron, L. C. (1990). Using hypermedia to improve the preparation of elementary teachers. *Journal of Teacher Education*, *41*, 21-31.

Harvard, G. (1990). Some exploratory uses of interactive video in teacher education: Designing and presenting interactive video sequences to primary student teachers. *Journal of Aett, Educational & Training Technology International*, *24*, 155-173.

Hatfield, M. M., Edwards, N. T. & Bitter, G. G. (1993). *Mathematics methods for the elementary and middle school*. Boston: Allyn & Bacon, Inc.

King, J. M. (1990). Optical disc technology: Education trend of the future? *Technology-Teacher*, *49*, 25-29.

Lampert, M., & Ball, D. L. (1990). *Using hypermedia technology to support a new pedagogy of teacher education* (Issue Paper 90-5). East Lansing, MI: Michigan State University, National Center for Research on Teacher Education.

Litchfield, B. C. (1990). Criteria for evaluating videodisc interactivity. *Performance and Instruction*, *29*, 23-26.

Palincscar, A. S. (1989). Less charted waters. *Educational Researcher*, *18*, 5-7.

Rockwell, S. K., & Stevens, G. (1992). *How accurate are pretest self-report measures of adults' knowledge and behavior*? Paper presented at the American Evaluation Association, Seattle, WA.

Savenye, W. C. (1990). Instructional interactive video - what works: A review of the research and development literature. *Young Professors Program Monograph Series*, Washington, DC: National Society for Performance and Instruction.

Sowell, E. J. (1989). Effects of manipulative materials in mathematics instruction. *Journal of Research in Mathematics Instruction*, *20*, 498-505.

Teaching Mathematics Methods Using Videodisc

使用影碟數學教學法

Gary G. Bitter

美國亞利桑那州立大學學習與研究之科技

摘　要

一個以多媒體爲基礎的交談式教學系統已發展出來並在一些職前訓練的小學教師身上測試過。四個上數學教學法班級的學生當中，兩班除了接受演講式的教法之外，還接受新的交談式多媒體教學系統輔助。另外兩班則只接受傳統的演講式教法而已。那些有接受輔助教學系統的學生覺得他們自己準備更充分且更有動機去使用操作物。此外，這些接受多媒體教學系統的學生對於使用操作物表現出來得比那些僅接受傳統的演講式教法的學生懂得更多。這個研究的結果認爲交談式多媒體教學系統對於職前教師的師資培育有所助益。