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AUTHOR	Hofmeister, Alan M.; And Others
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ABSTRACT

A series of videodisc-based mathematics products have been developed by the cooperative effort of the University of Oregon, Utah State University, and various school districts. The products were designed to: (1) achieve educationally significant changes in student achievement and attitudes; (2) be consistent with group and individual classroom management practices most commonly used by effective public school teachers; (3) capture and model curriculum-specific practices identified in the research literature on effective teaching; (4) require modest investments in staff development and supervision for effective implementation and maintenance; and (5) be consistent with school budgets. During formative development, prototype versions of the product were field tested and revised until predetermined standards of student mastery were met. The product was then exposed to challenging instructional settings for stress testing. During the independent regional implementations and evaluation phase, school districts in different geographical areas reviewed, implemented, and evaluated product effectiveness. Comparative field test results and the rationale for the instructional design and use of videodisc technology are included in this report. The appendix describes different types of instructional videodisc programs in relation to needs and resources of public schools. (Author/MES)

The Development and Validation of an Instructional Videodisc Program

Alan M. Hofmeister

Utah State University

Logan, UT 84322

and

Siegfried Engelmann

Douglas Carnine

University of Oregon

Eugene, OR 97403

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The Development and Validation of an Instructional Videodisc Program

Introduction

This paper reports on the development and validation activities conducted to date on "Mastering Fractions," an instructional videodisc program. The information is organized around the following three phases.

Phase 1: Formative Development. In this phase, prototype versions of the product were field tested and revised until predetermined standards of student mastery were consistently achieved by members of the target population. The standard used called for 90 percent of the students to demonstrate mastery on all the instructional objectives.

Observations from the formative development and validation activities are reported in Part 1 of this paper.

Phase 2: Stress Testing. Realizing that many teachers are required to teach under conditions less than ideal, an instructional product should be "overbuilt." It should be robust enough to work in difficult settings. The product should help the teacher solve problems, not add to the teacher's problems. In stress testing, the product is purposefully exposed to challenging instructional settings. In such testing the product's effectiveness may be evaluated by comparison with some predetermined standard, or it may be compared with another instructional product designed to teach the same instructional objectives.

Results from the stress testing are reported in Part 2 of this document.

Phase 3: Independent Regional Implementations and Evaluation. In this phase school districts in different geographical areas review the product and implement it and evaluate its effectiveness. In these regional implementations the manufacturer may provide a discount of approximately 20 percent to encourage such evaluation. If issues of cost effectiveness are to be validly treated, the school's initial review should indicate that the product is worth expending school resources to purchase the versions under evaluation. This phase should provide data to verify earlier decisions on the appropriateness of the curriculum and the quality of instructional procedures.

Phase 3 is an ongoing activity, and a progress report is provided in Part 3 of this paper.

Additional information on videodisc technology. An appendix, describing interactive videodisc technology, is provided for readers unfamiliar with the more recent developments in this field.

Part 1: Formative Development

Observations from the Development and Field Testing of an Instructional Videodisc Program[1]

This paper reports on the observations made during the formative development of a series of interactive videodiscs for high school math and science. The series, entitled "Core Concepts in Math and Science," (1985) was being developed by Systems Impact Inc., a private corporation supported by faculty at several universities, and the administrators and teaching staff from a range of school districts from coast to coast.

In the development, a heavy emphasis was placed on designing the products to meet the needs of students with different skill levels. During field testing, particular consideration was given to the inclusion of students in need of remediation as well as to students progressing without difficulty.

Instructional Format

In designing a dual level interactive videodisc product, a decision had to be made regarding whether to emphasize Level 1 or Level 3 initially. (The reader unfamiliar with the terms "Level 1" and "Level 3" should refer to the article "Videodisc Technology: Providing the Teacher with Alternatives," in the appendix). It was decided to emphasize Level 1 procedures in the initial stages of development. The reason being that the Level 1

[1] This report has been adapted from the paper: "Designing Videodisc-based Courseware for the High School, Hofmeister, A. M, (Utah State University), Engelmann, S. & Carnine, D., (University of Oregon), which was presented at the American Educational Research Association Meeting, Chicago, 1985.

format, with its group presentation and its reduced facility for extensive branching, required very effective instructional sequences.

If the instructional hierarchies are not valid and the important prerequisite skills are not identified and mastered, then the Level 1 format will not be successful. In a Level 1 format, with its reduced capacity for individual remediation, failure experiences associated with the presentation of new material must be reduced. Rosenshine and Stevens (1986) have noted that

> New learning is easier when prior learning is readily accessible or automatic. In a large number of academic situations the student needs to apply and use the knowledge or skills that have been previously learned. (p. 378)

This constant attention to the mastery of prerequisite skills is one of the ways one assures success in group-based instruction.

The Level 3 format, although far more expensive to implement, is more tolerant of inadequate instructional sequences because of the increased facility for remedial branching and because of the potential to supplement inadequate videodisc content with microcomputer-delivered material. When the initial emphasis is placed on the Level 1 format, the quality of the Level 3 format is also enhanced through the use of better sequences and fewer failure experiences, with their associated remedial loops.

Because of the heavier involvement of the teacher in the Level 1 format (see article "Videodisc Technology: Providing the Teacher with Alternatives," in the appendix), it is essential that the field testing is carefully monitored to ensure that success can be attributed to the product and not to unrecorded adaptions of individual field test teachers. Such careful monitoring also allows the observations and recommendations of the field-test teachers and observers to be added to those of the product developers and the content and design consultants.

Development and Validation Procedures

The major development and validation procedures included:

1. An analysis of school district curricular and textbook content. For each course, curricula from school districts in several geographically separated states and four or five widely used textbooks were used for the initial curriculum analysis.

2. An initial listing of possible core concepts. In selecting core concepts the intention was not to try and teach everything, but to select the most common and the most important foundation concepts, and teach them well.

3. A review of the initial listing by content consultants and the associated revision of the listing. Consultant input at this stage was primarily concerned with the selection of the most important concepts and their approximate instructional sequence.

4. The preparation of "track scripts" and their review by consultants. A track script is a preliminary draft of the videodisc script for a specific curriculum strand. Through the review process, consultants make input on sequence, terminology and instructional presentation issues. A course will contain several curriculum strands and their associated track scripts. The use of track scripts makes the underlying curriculum

structures visible to all and facilitates revision on a modular basis.

5. The development of prototype field-test lessons. Lesson scripts are prepared from the revised track scripts. Videotapes and additional print materials are used to approximate the videodisc presentations in the field testing.

6. The field testing and revision of prototype lessons. The process of field testing and revision is repeated until product effectiveness is consistently demonstrated. To date, courses have been through three to five revision cycles. In a typical field test, there will be two groups, approximately ten lessons apart, being field tested at the same time. As problems are encountered in the first group, alternative procedures are developed and tried on the group that is ten lessons behind. Such a procedure allows for extensive product improvement in a limited time period. The field test and revision cycle is repeated until a version is developed that is consistently effective. Field test and revision cycles were repeated until 90 percent of the group had mastered the objectives.

Decisions on the degree of product effectiveness are based on an analysis of individual pupil performance on daily in-class assignments, homework, criterion-referenced tests administered as a part of every fifth lesson, and comprehensive pre- and posttests. The daily worksheet analyses provide information on the effectiveness of the specific instructional procedures used in the daily lessons. The criterion-referenced tests provide information on the degree of mastery of the core concepts. The testing procedures also include previously mastered material to check on retention.

7. <u>The preparation of videodiscs and supporting print materials</u>. After the prototype videotape and print materials have been refined and their effectiveness demonstrated, the videodiscs and final versions of the instructor manual and the individual student workbook are developed. The prototype videotapes are low budget, half-inch tapes. After field testing with the prototype materials is completed, an investment is then made in the final one-inch, broadcast-quality, master videotapes with high quality graphics, high interest motion footage, and a quality, precisely paced narration. The final videodiscs are made from this one-inch master tape.

This two-stage video production process, with its dependence on success with the more primitive prototypes, is a very demanding development process. It does, however, ensure that the final product is both robust and effective and not highly dependent on the high interest video effects added in the second phase. Too much dependence on such high interest video material could result in novelty effects, disguising and overestimating the true long-term instructional value of the product.

Observations from the Field Testing

The intensive observation of the field test classrooms was a central strategy in the product development process. We were concerned with data that would guide the product improvement process. A knowledge of student outcomes, by itself, has limtied value. Outcome data must be paired with observational data on "teacher-child" interactions to help identify more successful instructional procedures for inclusion in revisions of the product. The following observations were made as a result of this product revision process.

1. Narration format and student interaction. In the early field testing, considerable attention was given to the identification of a narration format that was suited to both Level 1 and Level 3. Perhaps the most common narration format used with videotape instruction is the "illustrated lecture" approach. While such an approach has been used successfully with video programs such as the early "Nova" series, where extensive student interaction is not expected or programmed for, it would clearly reduce the possibility of extensive student interaction in either a Level 1 or a Level 3 approach.

Experiments were conducted with a tutorial approach to the narration. This approach was designed to emphasize the highly personalized, step-by-step, question-packed presentation of the expert tutor. While a tutorial approach was well suited to a Level 3 mode, where there was no limit to the system's ability to pose questions and supply feedback, there was some question as to whether it would be successful in the group-oriented Level 1 mode.

In the tutorial format, there were three basic types of student interactions. The most time-consuming interaction required the group to make individual written responses. The videodisc would stop automatically at a preprogrammed point, with the question posed on a "still frame." When the group was ready, the teacher would advance the videodisc to the next still frame, or series of still frames, that provided the solution to the problem. In some cases the solution would be presented using motion and narration rather than the more space-saving still frames. Motion sequences are necessary to present audio feedback. Motion presentations, however, use up still frames at the rate of 30 per second.

The second most time-consuming type of student interaction was similar to the one just described, except that an oral rather than a written response was required. The least time-consuming, and most common interaction, was one in which a question was posed by the narrator; a short pause was provided for an oral group response, and the disc moved on automatically and provided the feedback. The field testing demonstrated that it was possible to achieve a very high level of student interaction, even with full class groups, through the appropriate mix of these three types of interactions.

Stodolsky (1984) has noted that "Pacing is a very central variable in the analysis of instruction." It was found possible to use a fast-paced, highly involved tutorial narration for the Level 1 group presentations. The critical variables were the appropriate mix of types of interactions and the quality of the instructional sequence and associated demonstrations. A poor sequence made even very slow pacing ineffective for ensuring adequate student engagement.

2. <u>The comparative value of the videodisc presentations.</u> While few would question the instructional value of videodisc presentations that capture laboratory demonstrations which would

be difficult or dangerous to conduct, the comparative value of the less spectacular presentations is often overlooked. Even with simple demonstrations, such as the application of the distributive law in algebra, the advantage over the standard teacher-delivered chalkboard presentation was substantial. With the videodisc the teacher was able to stand toward the back of the classroom and maintain full control of the class. The loss of class observation and time that occurs when the teacher has to write the problem on the chalkboard is removed. In demonstrating the distributive law, the presentation of the parallel actions of the external term on the terms inside the parentheses was possible with the videodisc. This presentation was made even more powerful when tied to the precisely timed narration. In summary then, even with relatively simple instructional presentations, the teacher, using the videodisc, was more in control, was able to present more demonstrations in less time, was able to give higher quality demonstrations, and was able to give more attention to individuals.

3. <u>Classroom management and mastery learning</u>. The development of an effective Level 1 delivery system requires that the teacher's behavior be given the same attention as the student's. Dynamic video and well-designed instructional sequences will not guarantee adequate learning by the full range of students found in secondary classrooms. Economical, practical, and effective instructional management procedures must be used for ensuring that individual needs are met when group-oriented instructional systems are used. After synthesizing the research literature on effective instruction, Rosenshine and

Stevens (1986) identified the following six "fundamental instructional functions."

1. Review, check previous day's work (and reteach, if necessary)
2. Present new content/skills
3. Guided student practice (and check understanding)
4. Feedback and correctives (and reteach, if necessary)
5. Independent student practice
6. Weekly and monthly reviews. (p. 379)

These six fundamental instructional functions formed the frame of reference for the classroom management practices. These practices were progressively refined during the different field test and revision cycles.

The following specific review, feedback, and correction management procedures were developed as a part of the field test and program revision procedures.

Each course has numerous checkpoints for evaluating student progress. At each checkpoint, the teacher decides whether enough of the students are performing acceptably. If class performance is satisfactory, the next instructional segment is presented. If performance is unsatisfactory, the teacher replays the appropriate earlier segment from a videodisc and then presents new practice problems using still frames. A sufficient number of alternate practice problems are provided on still frames to ensure that student success will be due to conceptual understanding rather than rote memory.

The following checkpoints and associated procedures were found to be effective:

a. After each new instructional segment from a lesson. These checks indicate how well initial learning is progressing.

b. Before the beginning of the next lesson. This brief quiz is a one-day delay check. The importance of beginning a lesson by checking on the material taught in the previous lesson is well supported by the research literature (Emmer, Sanford, & Clements, 1982; Good & Grouws, 1979).

c. After every fourth lesson. This mastery test is a one-week delay check.

d. At the end of each grading period. This exam is a multi-week delay check.

In classes with a wide ability range, this mastery-based system gave field-test teachers the feedback needed to decide how much additional explanation and practice was needed by the students.

4. Cost and time. Once a commitment is made to a cyclic process of "field test, revise, and field test," the product developer should be aware that development costs are related to the time and effort it takes to achieve the predetermined levels of student mastery. In the case of the videodisc programs just discussed (Systems Impact, Inc., 1985), one thinks in terms of years and hundreds of thousands of dollars, not months and tens of thousands of dollars.

However, once the commitment and investment are made, the return in student gains is massive. The value of a program that can be implemented at a modest cost, that can be used with a range of learners, and that can be consistently effective is incalculable.

Conclusion

The field testing of the Core Concepts Courses (Systems Impact, Inc., 1985) demonstrated that the combination of interactive videodisc technology, with well researched instructional design and mastery learning procedures, provided the teacher with a flexible and powerful resource. The "core concept" orientation allowed the teacher to provide effective instruction on the most important central concepts to all learners, including those in need of remedial instruction.

In the process of developing and validating a technologically based product, the primary resource should still be the research on the characteristics of effective instruction considered important in any instructional effort (Ragosta, 1983). Characteristics such as "review of previous learning, demonstrations of new materials, guided practice and checking for understanding, feedback and corrections, independent practice and periodic review" (Rosenshine & Stevens, 1986), will have to be present regardless of the technology used. The product development effort should not stress the characteristics of a specific technology at the expense of proven characteristics of effective instruction (Clark, 1983). Even a technology as flexible as videodisc-based instruction will only be as effective as the quality of the instructional content and associated classroom management practices will allow.

Part 2: The Stress Testing of "Mastering Fractions"

If a product developer seeks assurance that the product will be of the highest quality, the developer does not restrict testing to normal conditions. Indeed, the developer seeks very challenging environments. Two of the ways that an instructional product may be stressed are: (1) placement in a classroom with learners with less skills than the target population, and (2) the use of learners who have a documented history of failure with other products and procedures designed to teach the same instructional content. Both of these approaches were used in the stress testing of "Mastering Fractions."

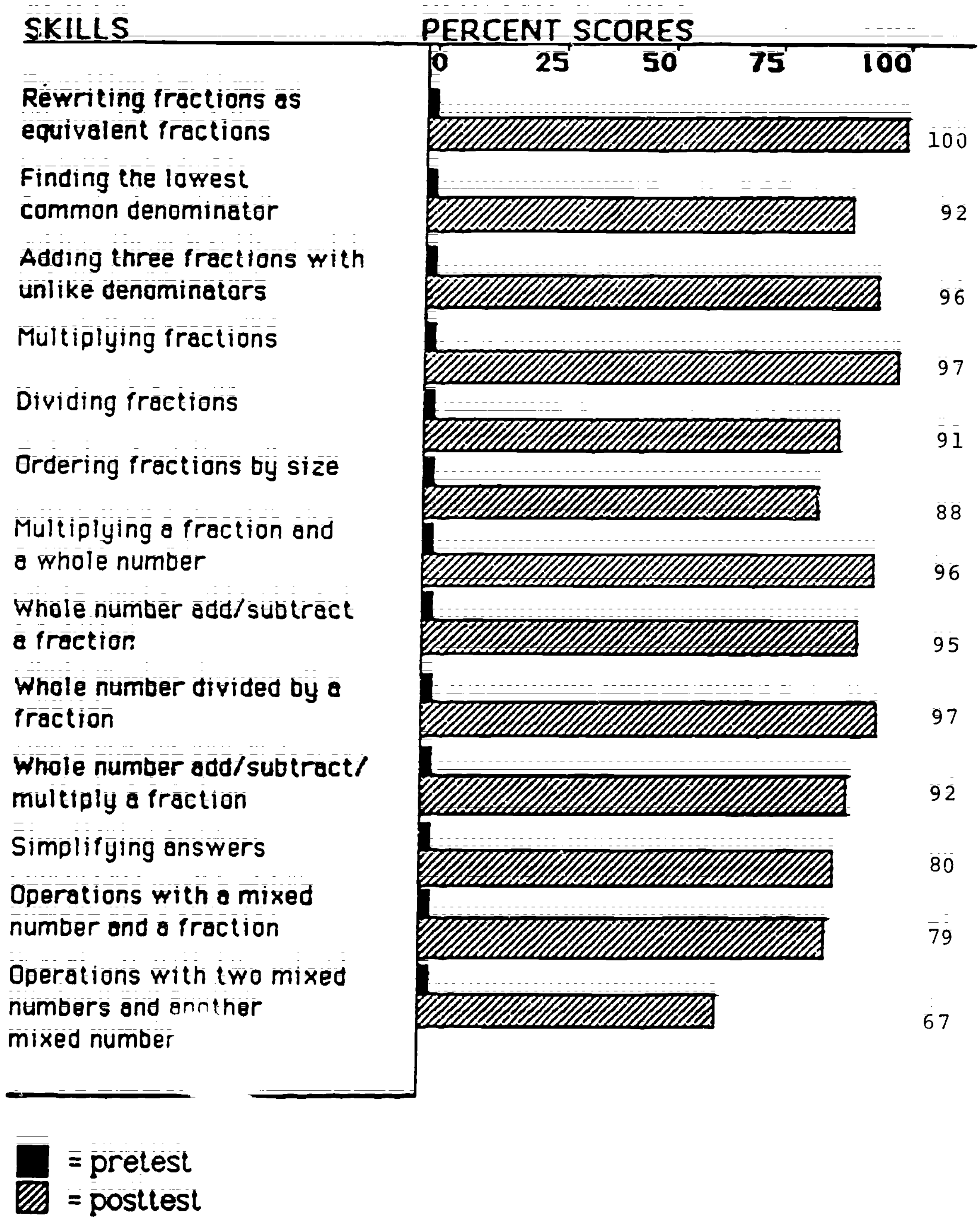
Stress Testing by Using Younger Students

Every instructional product assumes some entry skills on the part of the student. The more students lack these entry skills, the higher the probability the product will fail. In the case of "Mastering Fractions," the total curriculum is usually completed by the end of grade 8. However, substantial portions of the curriculum are often introduced in grades 5 and 6.

To ensure that a challenging test was arranged, grade 4 students were selected as a part of the stress testing. To ensure that students were not exposed to unnecessary failure experiences, the implementation was carefully monitored, and the final few instructional objectives were not taught to mastery. The students were taught the objectives typically required for grades 5 and 6.

Figure 1 depicts the results of the field test. The

Figure 1


SKILLS
PERCENT SCORES
0
25
50
75
100
Rewriting fractions as equivalent fractions
100
Finding the lowest common denominator
92
Adding three fractions with unlike denominators
96
Multiplying fractions
97
Dividing fractions
91
Ordering fractions by size
88
Multiplying a fraction and a whole number
96
Whole number add/subtract a fraction
95
Whole number divided by a fraction
97
Whole number add/subtract/multiply a fraction
92
Simplifying answers
80
Operations with a mixed number and a fraction
79
Operations with two mixed numbers and another mixed number
67
= pretest
= posttest

students were twelve fourth-grade students in an urban elementary school. The students were pretested to ensure that the assumption of limited entry skills was accurate. The average number of students mastering each objective was 90 percent. The skills normally required for grades 5 and 6 were mastered at well above 90 percent.

Stress Testing by Using Remedial Students[1]

The students selected for this aspect of the product testing were 28 students, approximately half of whom were classified as "remedial" students by the school; the other half of the students were special education students classified as "learning disabled." In this study the product was compared with a more traditional basal program. In order to ensure that the comparative process was indeed a challenging test, the researchers identified a highly regarded comparison product. They then took other measures to ensure that the comparison product was implemented in as appropriate a manner as possible.

The final results confirmed that the comparison product did perform in a very credible manner; however, the "Mastering Fractions" program was clearly superior, and the difference in performance was significant by all accepted measures of statistical or practical significance. The following is a summary of the major aspects of this study.

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[1]These resesarch findings have been abstracted from material provided by the principal investigator for the comparative study: Bernadette Kelly, Division of Teacher Education, University of Oregon, Eugene, OR 97403.

Experimental Results

The study compared two ten-lesson programs for teaching basic fractions skills. The programs consisted of lessons from the interactive videodisc course "Mastering Fractions" (Systems Impact, 1985) and lessons from Mathematics Today (Harcourt, Brace, Jovanovich, 1985). The skills were writing a fraction from a picture, multiplying fractions, multiplying a fraction and a whole number, identifying fractions equal to one, and adding and subtracting fractions with like denominators. Each program also taught additional skills, which were measured for secondary analyses.

The two treatments were the same in that (1) the two teachers switched half-way through the study, so that each teacher taught half the students for half of the study, and other students for the other half of the study; (2) the total instructional time was the same each day, and the amount of time spent on concept development was comparable each day; (3) the same major skills were the focus of both treatments; (4) the same reinforcement system was used with both treatments.

The program differed in two major ways: the delivery medium (videodisc versus textbook) and the instructional design. The videodisc has capability for dynamic video and audio, automatic stops, still frames, and branching. The relevant instructional design features were: explicitness of strategies, degree to which explanations focused on "whys" versus "hows," usefulness of explanations, presence of discrimination exercises, frequency of review, incorporation of the components of a mastery learning system, and the structure of the lessons.

Students were given pre, post and maintenance tests on basic fractions skills. The post and maintenance tests had a reliability of over .9. The results are summarized in Table 1. The differences between treatments on the posttest and maintenance tests were significant. Students were also given a pre- post- attitude questionnaire. Three questions dealt with their perceived competence; three dealt with the feeling about the relevance of fractions. The scores could range from -1, very negative, to +1, very positive. The results are summarized in Table 2. Data were also collected on the percent of six-second intervals, during which, students were on task. The results, averaged across five sessions, were 96 percent on-task for the interactive videodisc group, and 84 percent on-task for the basal group. The level of implementation of the basal group is informally reflected in one of the teacher's remarks. He indicated that the basal classroom was about the best traditional program he had ever used with handicapped students.

Table 1: Pre, Post and Maintenance Scores for Interactive Videodisc and Basal Treatments

TREATMENT	MEASURES								
	Pre Test[a]			Post Test[b]			Maintenance[b]		
	%	Num	Sd	%	Num	Sd	%	Num	Sd
Interactive Videodisc	42	2.5	.92	95	11.4	1.0	94	11.3	1.1
Basal Textbook	34	2.1	.98	77	9.2	2.3	72	8.6	2.0

a six items

b twelve items

Table 2: Mean Positive Responses on Pre and Post Attitude Measures Concerning Student Competence In and Relevance of Fractions

TREATMENT	MEASURES		
	Pre Test	Post Test	Gain
Interactive Videodisc			
Competence	.08	.81	.73
Relevance	.08	.57	.49
Basal Textbook			
Competence	-.20	.58	.78
Relevance	.16	.31	.16

Part 3: Independent Regional Implementation and Evaluations

The following is a listing of school districts presently implementing and evaluating "Mastering Fractions." Other school districts have implemented the pr ́duct since it became available in December 1985. Only school districts with known formal evaluation components have been included in the following listing.

Rochester, New York. This school district is assessing the product in the regular grades.

Houston, Texas. An evaluation of student and teacher reaction is presently being conducted.

Knoxville, Tennessee. The school district has completed a review and has implemented "Mastering Fractions" district-wide in all middle schools.

Lincoln County, Wyoming. This is a district-wide implementation in regular classrooms, remedial programs, and special education programs. The implementation is being evaluated under a grant from the Wyoming SEA.

Logan City, Utah. The district is using the product in JTPA programs.

Davis County, Utah. Both adult education and special education programs are involved.

Jordan Valley, Utah. This district is using the product in high school special education programs and in corrections programs.

Carbon County, Wyoming. The product is being used in homebound programs.

Mukilteo, Washington. The majority of use is in regular grades in the middle school.

Olympia, Washington. The product is being used in remedial and special education programs.

Tennessee Valley Authority. The TVA initiated implementations in four states. The product was selected because of the importance of the math skills in industry. The TVA has contracted with Vanderbilt University to monitor and evaluate the implementation.

Las Cruces, New Mexico. This implementation is in a bilingual setting. The implementaion is being monitored by staff from the New Mexico State University Center for Rural Education.

University of Florida. The discs are being used in in-service training programs to develop excellence in math instruction.

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Appendix

Videodisc Technology:

Providing the Teacher with an Alternative

Videodisc Technology:

Providing the Teacher with Alternatives[1]

Alan M. Hofmeister

Utah State University

Siegfried Engelmann

Douglas Carnine

University of Oregon

January 1986

[1]This Appendix has been adapted from the paper: "Designing Videodisc-based Courseware for the High School," which was presented at the American Educational Research Association Meeting, Chicago, 1985.

Abstract

As educators search for effective and flexible instructional alternatives, consideration must be given to videodisc programs built on the characteristics of effective instruction. The different types of instructional videodisc programs are described and discussed in relation to the needs and resources of the public school. In discussing needs, both staff development and student achievement goals are considered.

Videodisc Technology: Providing the Teacher with Alternatives

An Overview of Videodisc Hardware

The phrase "technological applications in education" usually evokes the image of a computer. In reality the underlying phenomenon is the information age, with the computer serving as a major tool. One indication of educators' growing awareness of the breadth and pervasiveness of this underlying phenomenon is the growing use of the term "technological literacy" in place of the term "computer literacy." The influences of other technologies such as videotape, videodisc, fiber optics, and satellite communications are beginning to be recognized as the schools prepare the present school age population for a place in an information-oriented society.

One of the most promising of the new information age technologies is laser videodisc technology. The technology is challenging the LP record in the form of the compact audiodisc; archival use of the computer's magnetic "hard disc" is being replaced by optically read digital discs; microfilm and microfiche storage and retrieval technologies are also being replaced by videodisc-based recording and retrieval systems, and videotape players are being challenged by laser videodisc players.

A Brief Description of Laser Videodisc Technology

A standard laser videodisc looks like a shiny white metallic LP record. The disc stores the same type of information as videotape, but the disc is a random access medium, and each of the 54,000 high-quality, individual frames on one side of the disc can be accessed in a second or two. There is no reduction in the quality of the video image when one moves from motion to still on a videodisc. In the laser reflective format, a low-power laser beam in the player is directed onto the disc surface, where it either strikes a tiny pit or the more reflective surface between the billions of pits etched in the surface. The laser light is then reflected off the surface to a sensor, which detects these variations in intensity of the reflected light. The variations in light intensity, detected by the sensor, are transformed into a signal that is fed to a television receiver. The pits are protected by clear plastic, and only the laser light contacts the disc, resulting in a very robust storage medium and player system.

Instructional Potential

While few have questioned the potential of interactive videodisc instruction to make a major contribution in health, defense, and industrial training, the potential of videodisc-based instruction for the public school has been questioned. Some of the concerns have included the resistance of public educators to technology, the group teaching practices of teachers, the cost of hardware, and the lack of enough quality courseware to support investments in the hardware. The rush by educators to embrace microcomputer technology has demonstrated that educators can and will invest in technology on a large scale. Despite this demonstration of interest in technology, the nature of the public school is such that widescale adoption of videodisc technology may not occur until videodisc-based instructional products are specifically designed to meet the needs, restrictions, and strengths of public school instruction.

In this paper the authors discuss the rationale used to develop videodisc-based instruction in high school mathematics. The videodisc-based products were designed to provide for instruction with a wide range of learners in a variety of instructional settings, including group instruction and individual instruction.

Classifying Types of Instructional Videodisc Configurations

A widely adopted classification system was proposed by the Nebraska Videodisc Design and Production Group in 1979 (Daynes, 1984). The classification system is based on the "intelligence" levels of different systems. The initial classification scheme included Levels "Ø" through "3," and that classification has recently been augmented by a Level "4." The different levels are as follows.

Level Ø

This system consists of a linear player. Such systems are primarily designed for home entertainment, have limited interactive functions, and many of the same instructional applications as video tape players and movie projectors.

Level 1

The Level 1 players also include quick frame access, freeze frame and scanning functions, two user selectable audio channels, chapter and picture stops.

A Brief Description of Level 1 Functions

Quick frame access. There are 54,000 individually addressable frames on each side of a videodisc. A frame can be selected and found using the player's remote control panel. When moving from one frame to another that is a few hundred frames apirt, the search time is not perceptible. If the frames are thousands of frames apart, most players will make the change within three seconds at the most. The facility to allow a teacher to branch quickly to any frame from any location in the classroom is a very practical feature.

Chapter stop. The branching may be done by frame or chapter. To access a frame the teacher enters a 5-digit frame address or a 2-digit "chapter" address. Approximately 70 encoded chapter stops can be placed on one side of a disc. The chapter stop increases the speed and practicality of branching.

Picture stop. A picture stop is a point or frame at which the player will stop automatically. For example, if students are to work a problem in their workbooks after a demonstration, a picture stop will cause the player to stop automatically with the problem showing on the screen. The teacher can then signal the player to advance when the students have completed the assignment. This very practical function allows the teacher more time to monitor pupils rather than be detracted by the operation of the player.

Selectable audio channels. While the entertainment industry typically uses the two audio channels for high quality stereo, the educator can remotely select both or either channel. This is often used when different audio tracks are used for the same visual display, for example, watching the same display in two different languages or presenting a display while posing a problem and then replaying, giving the solution on the second audio track.

Level 2

The Level 2 player adds the intelligence of an internal microprocessor to the Level 1 functions. The computer code to control the various functions can be placed in an audio track on a disc. Complex combinations of functions can then be conducted automatically or triggered by input through the player's control panel.

Level 3

Systems at this level consist of a Level 1 or 2 player linked to a microcomputer. Such a system will allow both computer and videodisc-generated material to be shown on the screen. In Level 3, the added intelligence and "read" and "write" functions of the microcomputer are added to the wide range of video functions of the videodisc player.

Level 4

A Level 4 system is distinguished from a Level 3 system by the additional power of the microcomputer software. If some type of artificial intelligence software is used, it is usually classified as a Level 4 system.

The Educational Implications of the Different Levels

Of the different levels, Level 1 and Level 3 appear to have the most instructional value at present. Level 3 has received the most attention in industrial and military training efforts. A Level 3 emphasis implies that the instructional institution emphasizes the individual learning station as a major instructional delivery system and that there are resources to support the installation and maintenance of individual learning stations. Some public school districts have the interest and resources to support the extensive use of Level 3 learning stations. However, a large number of school districts are heavily committed to group instruction, with the teacher as the primary instructional agent and technological aids in a range of support roles.

There is a tendency for many in instructional technology to assume that the individual learning station is the most powerful instructional delivery system and that the acceptance of anything less occurs because of a lack of resources. The widespread acceptance of this assumption suggests that there is a wealth of research to support the clear, comparative advantage of the individual learning station over other instructional delivery systems. Such is not the case. In their comprehensive review of the research literature on individualized systems of instruction in secondary schools, Bangert, Kulik, and Kulik (1983) reported that group-paced systems "appeared to produce stronger effects" than self-paced systems. The findings do not suggest that computer-assisted instruction and other types of self-paced systems are not effective. Indeed, the findings supported the effectiveness of computer-assisted instruction. The point is that other instructional delivery systems that monitor the individual's progress, including group-paced and systems such as peer tutoring, have been shown to be just as effective as some self-paced systems. Thus, the technologically based individual learning station must not be viewed as the ultimate delivery system for the public school.

The individual learning station is an effective tool that can make an important contribution, depending on the need and resources present in a specific instructional setting (Friedman & Hofmeister, 1984). There may be specific situations where the technologically based learning station may be clearly the best alternative. The rationale for the development of the MECC (Minnesota Educational Computer Consortium) high school videodisc-based economics course was the unavailability of teachers trained in the subject (Glenn, Kozen, & Pollak, 1984). This Level 3 videodisc project was the only available delivery system for some high school students.

The Level 1 videodisc system adds both a massive storage capacity and fast random access facility to the combined instructional functions of the videotape players and film and slide projectors. For this reason, this omnibus medium needs little promotion if we accept the instructional potential of any one of the media that videodisc technology can emulate. In analyzing the different instructional presentation functions possible with different media and media combinations, the combination of a Level 1 videodisc system and individual pupil workbooks results in a very flexible and comprehensive instructional delivery system (Walker & Butler, 1984). For the purposes of this article, a typical Level 1 system will include the integrated use of individual workbook material and videodisc presentations to large or small groups and individuals. In a typical Level 1 system the teacher would spend a large amount of time moving around the classroom checking on individual workbook activities, guiding discussion, and controlling the videodisc player with the aid of a remote control panel. Classroom management and attention to individuals is enhanced when the teacher is not confined to the front of the class.

Because of its considerable flexibility, decisions to implement Level 1 videodisc technology are not tied to the nature of the medium, but to such issues as hardware cost and availability of quality courseware. We have seen a recent decrease in price and size and an increase in the reliability of videodisc players. Quality videodisc players are now available for approximately $500. The availability of a range of quality courseware is, then, clearly, the most important issue. The development of the Core Concepts series (Systems Impact, 1985) has significantly increased the available alternatives. These videodiscs in math and science have been extensively field tested with a range of high school learners.

<u>Staff Development and Student Achievement</u>

In terms of external appearance, the Level 3 videodisc system and a computer-assisted instruction (CAI) system appear very similar. In reality there are some subtle, yet important, differences between Level 3 and CAI systems. Perhaps the most important difference is in the degree to which the two systems can emulate the instructional presentations of effective teachers. In the past CAI has not tried to model the classroom presentation practices of the effective teacher. The cost and complexity of generating the graphic visual displays and the associated audio have limited the ability of CAI to emulate the dynamic instructional procedures of the teacher. CAI has, instead, relied on the instructional presentation practices of programmed learning. Programmed learning's extensive use of the single-frame, immediate feedback, and the extensive use of text to communicate is much more suited to the capacities of microcomputers presently being used in the schools. These programmed learning approaches being used in some CAI programs have clearly been effective in meeting their primary purpose of instructing students (Hartley, 1977; Bangert, Kulik & Kulik, 1983; Fisher, 1983). The problems of instruction in some high school subjects are not limited to the need to teach students. Ewell (1983) reported as follows:

> Math teacher scarcity is so great that even when compared with the 'traditional shortage' of physics teachers, it ranked higher.
>
> The roots of the problem go even deeper. A study by the NCMT indicates that last year 25 percent of math teaching positions were filled by uncertified instructors or those holding only temporary certificates. According to Max

Sobel, president of the 45,000-member teacher's organization, this rate approached 50 percent in some areas of the country! (p. 36)

If an instructional delivery system can both instruct students and model the presentation practices of effective instructors, then its cost effectiveness will increase significantly in subject areas where staff development and student achievement are both important. Of the technological alternatives presently available, interactive videodisc instruction appears to be the one best suited for modeling effective teaching presentations and increasing student achievement.

Dual Level Videodisc Courseware

It is possible to design videodisc-based courseware that can be used in both Level 1 and Level 3 systems (Jonassen, 1984). Kessinger (1984-85), in his in-depth review of MECC's videodisc-based economics course, reported as follows:

> MECC originally designed Introduction to Economics for those smaller high schools unable to offer economics as a regular class. One could simply set it up in a media center and allow students to work through the course at their own pace. Yet it is quite likely that this MECC package will be of interest to teachers in larger schools. These materials can be used with the whole class in a discussion format to introduce topics with precise control and immediate feedback under teacher direction. I have used a similar approach with middle school students. It worked smoothly, and the

level of discussion from first period in the morning to the last period of a teaching day was high. And it was fun. In most cases, Introduction to Economics will work with individual students, small groups and entire classes. (p.37)

Effective Instruction and the High School Learner

The point has been made quite forcefully by Clark (1983) that the medium serves as a vehicle for instruction and that the instructional methodology will be the important variable in determining the effectiveness of the instructional product. The components of an effective instructional methodology were summarized by Ragosta (1983). In reporting on a successful longitudinal study of a CAI project, Ragosta stated,

> The success of CAI in this study may be related to the successful practices identified in other effectiveness studies: mastery learning, high academic learning time, direct instruction, adaptability and consistency of instruction, an orderly atmosphere with the expectation of success in basic skills, the use of drill, and equal opportunity for responses from all students with a high probability of success in responding. (p. 124)

In addition to the above listed components of an effective instructional methodology, consideration must be given to the specific characteristics of the high school learner. In mathematics in particular, a significant percentage of high school students will display a range of inappropriate learning strategies. The observant high school teacher is very much aware that the teacher must not only plan instruction to teach new material, but also counter the attitudes and learning habits resulting from past unsuccessful experiences with the subject.

There are two main types of inappropriate learning behaviors that instruction must counter. The first is an unwillingness to follow directions in lieu of alternative student-generated procedures, which could range from using their own "short cuts" to copying the answers from their peers. The second is the emphasis on single-case problem solving at the expense of developing general problem-solving strategies. Too often the unsuccessful student fails to recognize a problem as a member of a class of problems. A student cannot hope to achieve conceptual depth in a subject area, such as mathematics, if the basic problem types are not recognized and the problem-solving rule or rules for the problem class are brought to bear on the problem.

If instructional procedures are to counter these two main types of inappropriate learning behaviors present in many high school learners, then the teacher must first restore the student's confidence in instructional directions. As Rosenshine and Berliner (1978) and Ragosta (1983) have noted, a "direct" instructional approach is needed. Clear specific directions, which make the problems and the problem-solving steps explicit, are essential. Long-winded "interest building" introductions that disguise the problem and leave the problem solving to student trial and error may have some value for the successful student with well-developed problem-solving skills. Such procedures will, however, compound the problems of the unsuccessful students, who will need explicit problem-solving strategies and numerous consistent demonstrations of success before they will consider instructional directions worth their attention.

Developing generalizable problem-solving strategies, instead of the rote learning of individual examples, requires carefully managed instructional sequences in which problem classes and their associated rules are carefully introduced, practiced to mastery, and reviewed. The Level 1 and the Level 3 interactive videodisc systems are ideal vehicles for ensuring the careful control of the instructional sequence, while at the same time ensuring that there is flexibility to allow faster learners to move through only the material they need to cover.

Conclusion

In summary, the range of resources and instructional needs present in public high schools suggests that the Level 3 learning station approach, so popular in other areas such as industrial training, may be too narrow a delivery system. Videodisc-based courseware can be designed to work effectively as Level 1 and Level 3 delivery systems. This dual level approach to videodisc-based courseware development appears consistent with the range of resources and instructional needs present in public high schools. The dual level approach appears particularly well suited to math and science instruction, where both student achievement and staff development are of major concern.

The flexibility of interactive videodisc technology can allow the instructor to adapt instruction to the needs of a wide range of learners. The potential exists, even with Level 1 systems using individual pupil workbooks, to provide both very structured learning sequences for the slower learner and still meet the needs of the more successful student.

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