DOCUMENT RÉSUME

ED 377 894 JC 950 016

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TITLE It's a Wonderful Life: Using Public Domain Cinema Clips To Teach Affective Objectives and Illustrate Real-World Algebra Applications.
PUB DATE Oct 94
NOTE 28p.; Paper presented at the Annual Conference of the International Society for Exploring Teaching Alternatives (Salt Lake City, UT, October 12-14, 1994).
PUB TYPE Reports - Descriptive (141) -- Speeches/Conference Papers (150)

EDRS PRICE MF01/PC02 Plus Postage.
DESCRIPTORS *Algebra; Community Colleges; Computer Assisted Instruction; *Course Content; Course Evaluation; Courseware; Curriculum Development; Curriculum Enrichment; Educational Technology; *Mathematical Concepts; Mathematics Instruction; *Participant Satisfaction; *Student Attitudes; Teacher Attitudes; *Teaching Methods; Two Year Colleges

ABSTRACT

A basic algebra unit was developed at Utah Valley State College to emphasize applications of mathematical concepts in the work world, using video and computer-generated graphics to integrate textual material. The course was implemented in three introductory algebra sections involving 80 students and taught algebraic concepts using such areas as sports and games; reconstruction after disaster; nutrition; aviation; police investigation and forensics; and country music, radio, and rodeo. The purpose of the instructional organization used was to gain students' attention; make applications understandable, relevant, and applicable; inform learners of class objectives; stimulate recall of prerequisite learning; present stimulus material; provide learning guidance; elicit performance; provide feedback; assess performance; and enhance retention and transfer. Pre- and post-course surveys were conducted of students regarding introducing real-world concepts into the algebra classroom. Prior to the course, students rated the usefulness of algebra as 3.75 on a 5-point scale. After the course, students indicated that their attitudes toward the subject had positively changed, although a slightly lower usefulness rating was given. Students disagreed with the statement that real-world concepts should not be introduced into the classroom. Teachers interviewed also felt that development of the unit was worthwhile and that the visual materials aided learning. Student and teacher comments included. Contains 30 references. (KP)

It's a Wonderful Life: Using Public Domain Cinema Clips to Teach Affective Objectives and Illustrate Real-World Algebra Applications

ISETA Conference
October 1994
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Statement of the Problem

A Need for Real-World Algebra Applications

On Wednesday morning Rosemary went to the hardware store. After purchasing a new saw blade she put $1.85 in change into her pocket. She had one more dime than she had quarters. What percentage of interest was she charged for the purchase?

Obviously, this math question makes little sense, but to many students the math applications used in some textbooks seem to fall into this same category of bizarre, contrived word problems. Adults punctuate many of their assignments with statements like, "If I knew how much money the coins totaled, then I would take them out of my pocket and count the quarters and dimes. I wouldn't create a massive algebra problem." Or "I've been working for 10 years and I haven't had to factor one equation, let alone use the quadratic formula."

A similar refrain is found in community college math classes: "When am I ever going to use this stuff?" The truth is that most workers, professionals, and thinkers, seldom have to use the quadratic formula or FOIL two binomials in their offices or at home. Plumbers and ambulance drivers don't have to factor polynomials. (Burke, 1990) Standard algebra problems which deal with age, coins and distance have little to do with reality yet they are proliferated from one text to the next. Instead of analysis, these problems create anxiety and frustration. Instead of improved reasoning, we often see reticence and reaction.

Instructors should teach with applications which build bridges between algebraic concepts and students' experiences instead of erecting barriers to math education. Learning situations should be designed to allow students the opportunity "to solidly connect the new material with existing ideas in the learner's cognitive structure." Thus we should allow our students to "relate and reconcile" new information with what they already know and understand. (Joyce, 1986)

To allow students to focus their energies on the learning task and not on internal efforts to minimize the importance of the material, instructors should rethink their presentations to allow for an initial application which would direct students' attention to the material instead of a terminal word problem. (Gagne, 1992) This approach is sometimes contrary to the standard scientific approach of: rule, example, feedback and application. In many math textbooks, it appears that the purpose for the rule is often buried at the end of a chapter or section and stresses an approach which is atypical of students' experiences.

While teachers are urged to teach from concrete experience to abstraction (Lee, 1992), most math textbooks begin with theories, properties, and rules after which exercises are presented. The problem which this presents is clear: When abstract rules and concepts are taught first, removed from real-world connections, students have no way to ground the concepts.

AMATYC, the association for math teachers at community and other two year colleges have formalized this dilemma in a draft of pedagogical reform:

"The developmental curriculum must develop mathematical intuition along with a relevant base of knowledge, challenge our students even as it builds their confidence, and provide experiences which bridge the gap between classroom learning and real-world applications. People should emerge from this curriculum with the ability and confidence to use mathematics effectively in their multiple roles as students, workers, citizens and consumers." (AMATYC, 1993) Emphasis added.

A course designed for mature students should include applications of the content appropriate to the work place so adult students' perspectives about the relevance of algebra can be strengthened and expanded.

Statement of the Purpose

A basic algebra unit covering the concept of roots and radicals was developed which:

(1) emphasized applications of algebraic concepts in the work-world.

(2) used the technology of video and computer generated graphical overheads to integrate textual material and appropriate visual representations during the presentation of material. These

teaching aids were adaptable to individual teacher's needs through a simple editing procedure.

Audience for the Instruction

The developmental math program at Utah Valley State College (UVSC) is designed to teach basic concepts to students with minimal math background.

The particular course for which this unit will be designed is introductory algebra, MAT 099. It serves as a prerequisite for intermediate algebra and is a requirement for some vocational and technical degree and certificate programs. Students in this class have been initially identified by the mandatory ASSET test (a placement exam for community colleges) as being deficient in their knowledge of algebraic concepts but sufficiently proficient in basic mathematics to benefit from the material.

Students who register for this course generally fall into one of three categories: (1) students directly out of high school who have not succeeded in their math courses or did not choose to continue beyond basic math; (2) students who have been out of school for one or two years who succeeded in math and only wish to brush up on their skills; and (3) mature students who have been away from an educational setting for a number of years and have returned to expand their job skills.

Eighty students took part in this study. They were enrolled in three separate sections of the course. Two sections were taught by the author of this project and a third section was taught by a cooperating instructor. The students represented a good cross section of junior college enrollees as described in the statement of the problem.

Literature Review

Instructional Theory Review

The role of technology in the classroom has begun to expand. With the advent of classroom computers during the 1980's many instructors tried to integrate technology into their classroom instruction. This limited use of technology was usually in the form of drill and practice multiplication problems.

A new emphasis in the use of technology toward multi-media presentations is taking place initiated with software programs which allow instructors to adapt more traditional class discussions to media formats. This technology combines calculators, computer generated graphics to amplify the instructor's ability to introduce materials which draw upon many learning styles (Laughbaum, 1991). Additionally these presentations may incorporate "virtual world" demonstrations which illustrate the laws of algebra (Winn, 1992).

The goal of teaching in community colleges must now be a reconceptualization of mathematics instruction to integrate technology into instruction in a way which encourages conceptual

understanding and not rote memorization of procedures (Jonson, 1989).

The review of the literature suggested that good instructional design must be included with instruction using technology. Proven methods of increasing knowledge must not be ignored in the design of multimedia approaches. (Litchfield, 1993) A recent study indicated that much of the material which has been produced as educational software would be much better if thoughtful instructional design would be employed to "repurpose" the instructional material. Unless instructional design is consistent and thorough, the addition of multimedia formats may do little to enhance effectiveness. (Tessmer, 1993).

From this instructional theory literature review, a decision was made by this author to use computer generated graphics and video presentations, but be less concerned with flashes, bells and whistles in a multimedia presentation and more concerned with concrete, proven principles of instructional design.

Instructional Content Review

Recently a restructuring of the mathematics curriculum was initiated as a result of the standards proposed by (1) National Council of Teachers of Mathematics (NCTM, 1989), (2) Office of Educational Research and Improvements national report, "Goals for 2000 and Beyond in Mathematics Education," and (3) the American Mathematical Association of Two-Year Colleges' "Standards for

Curriculum and Pedagogical Reform in Two-Year college and Lower Division Mathematics" circulating draft (AMATYC, 1993). Recommendations were made to diminish memorization and procedural skills such as factoring, simplification of radical expressions, and routine calculations of the quadratic formula.

Math curriculum is now in such a period of transition that it was extremely important, in terms of this research, to limit references to materials which have been written in the last five years. This time period appeared to frame the questions regarding the new mathematical standards posed by many instructors and possible solutions tried by educators in the field.

The three benchmark documents which initiated the current mathematical reform movement seem to have a broad base of support (Kullman, 1991). Unlike the "new math" of the 1960s, which floundered and died, the new standards are couched in a world of technological reform which enriches the curriculum.

Even though the support is strong, the approaches to the transition ran a continuum from those who wish to change everything to those who resist any change. Reformers viewed the curriculum as outdated and gasping for breath. (AMATYC, 1993; Burke, 1990; Hansen, 1991; NAS-NRC, 1990; NCTM, 1991) Other educators, especially those who had been through the 1960s mission, reacted pessimistically toward the curriculum shift and voiced concerns that poor student math performance would be increased with the new "standards". (Ralston, 1990)

Fortunately, there were some authors who stood among struggling students yet saw possible moves which they hoped would not jeopardize students and still shift curriculum emphasis away from rote-memory toward conceptual understanding. (Kysh, 1991; Schmitt, 1993)

For the purpose of this project, this last, more pragmatic approach was followed. The concept of essential math skills was extended beyond low-level skills toward involvement by students and enriched applications.

Development of Instructional Material

Algebra Material

The unit was developed in association with the instructors in the math department of the Learning Enrichment Center (LEC) at UVSC. Objectives, course material, and reference sources were organized. A single unit was tested initially with three MAT 099 classes at UVSC where two instructors incorporated the materials into their teaching.

These resources, along with class outlines and reference material, were organized so to be accessed by UVSC contract and adjunct instructors.

The themes for each proposed chapter, around which applications and study strategies will be woven, will be:

Basic Concepts: Sports and games

Linear Equalities and Inequalities: Reconstruction after disaster

Graphing and Linear Systems: Environmental issues

Exponents and Polynomials: Study Topics

Factoring: Nutrition

Rational Expressions: Aviation

Roots and Radicals: Police investigation and forensics

Quadratic Equations: Country music, radio and rodeo

Format

The events of instruction were organized using the following format:

Gain Attention:

Illustration of an algebraic topic in a work-world setting was shown using previously filmed video clips of guest interviews. These interviews were taped as part of a telecourse developed by the author. Currently, the interviews had not been available for classroom use and were cut and edited to be placed in an easily accessed form.

A shift to meaningful applications was sought in designing the algebra unit. Formulae from the work-world were used to introduce math topics and give meaning to adult students. Applications selected for the course had two characteristics:

(1) Understandable. This did not mean simple or contrived. Broad rules focused on examples from many fields.

(2) Relevant and applicable. (Burke, 1990)

Care was taken to include female and minority guests to promote a goal of increased diverse representation in mathematics and mathematics-related disciplines.

Inform Learner of Objective:

Following a discussion of the application, new algebraic knowledge was embedded in the illustration.

Computer-generated overheads were developed to present the objective to the students. The objective was written to frame the algebraic concept to be introduced during the class instruction. The authoring program, "Powerpoint" was used to develop the visuals.

Stimulate Recall of Prerequisite Learning:

The instructor elicited student interaction at the board to bring back into students' memory the concepts which would serve as a foundation for the topic presented.

Present Stimulus Material:

Computer generated "slides" were projected onto a "nuview" screen. Teacher and students worked through several examples and non-examples of the algebraic topic.

Provide Learning Guidance:

Pairs of students were given problems to work as the instructor circulated through classroom. The specific instructions for paired learning during each class varied to enhance interest, but all such activities were built on an approach which stimulated verbalization and communication of ideas. Feedback between

students provided learning guidance. Pairs were instructed to seek instructor insights when needed.

Elicit Performance:

Assignments were made using an algebra workbook written by Charles McKeague. The text was appropriate for adult learners and presented many reference problems which assisted students who needed to have a tightly structured set of tasks.

Provide Feedback:

Assignments were self-corrected with appropriate answers provided at the back of the text. The first five to ten minutes of the following class period were for student questions and insights which might have arisen as a result of the assignment.

Assess Performance:

Performance was assessed with intermittent quizzes during the unit and a unit test taken in the testing center in an untimed manner. An exam was created using unencountered problems. Students originated correct solutions using appropriate unspecified rules.

Enhance Retention and Transfer:

Students were given the opportunity to apply each concept to a "work" world application. This was accomplished by reaching closure with the initial problem posed by the guest. Students were asked to perform such tasks as calculating the speed of a vehicle before impact at a vehicular homicide or calculating the height of a victim using only the femur bone found at an death site.

Following the format described above, teacher lesson plans were designed which consisted of the following:

(a) A statement of the objectives of the lesson;

(b) A detailed description of the instructional events to be employed.

c) A list of the media, materials, and activities by which each event was to be accomplished.

(d) A description of any advance preparation required.

(e) Prescriptions for instruction.

(f) Masters for any required handouts and related material.

(g) Print-out of computer graphics of the multi-media presentation.

(h) Computer disk containing media presentation.

(k) Video containing film clips and interviews.

Technology Aids

Several authoring packages[1] have been recently developed to aid teachers in integrating concepts, applications, and visuals into a single presentation which is easily edited and stored. Topics such as linear and quadratic graphing, translations,

[1]Software packages such as WordPerfects's *Presentations* and Microsoft's *Powerpoint* are easily learned and can access equation-writing software. *Derive* and *Mathematica* are two of the most commonly used software programs used for both presentation and student investigation of mathematical concepts.

dilations and functions are easily demonstrated on a computer screen. Such visual representations can give students an intuitive sense of the material which has been heretofore limited to symbolic notation. To really be effective, software must be developed in the context of on-going cognitive research, must address teacher support needs, and must be accompanied by materials and activities that effectively draw upon the pedagogical principles of the tool. (Harvey, 1991)

Computer generated multi-dimensional, inclusive environments such as "virtual reality" may also be integrated into presentations. Such software systems overcome the abstract algebraic notation and use a more intuitive approach to curriculum presentation. Virtual reality objects behave in concrete ways. Still experimental, the use of virtual reality in algebra classrooms has the potential of making a significant improvement in the way students learn mathematics because virtual worlds are totally engaging while immersing the student cognitively and affectively in the environment. (Winn, 1992)

Assessment Instruments

A concept pre-test was administered to the students at the beginning of the semester which measured their ability to manipulate and solve root and radical expressions and equations.

The test itself measured overall algebraic ability but had three questions which were taken from the root and radical chapter.

The concept post test consisted of a 33-item multiple choice exam which was instructor written. Care was made to include appropriate, valid distractors. The option of "none of the above" was included to allow students who made calculation errors an appropriate choice.

Pre and Post Questionnaire

A single item instrument was used to measure students' views of the need or "usefulness" for the study of algebra previous to the delivery of the unit. The Lickert-style question was passed to students with no introduction at the beginning of the unit. Students were asked to read the statement and respond. The item and directions were as follows:

This is a survey of your feelings toward the usefulness of your study of algebra as it applies to your future goals.

Circle the response which best responds to the sentence below:

Algebra is used in occupations(s) I'm considering:

Not at all	Occasionally	Regularly	Often	Continually
0	1	2	3	4

This question was written in a subjective manner to measure the use of algebra in their own lives as opposed to the use of algebra in scientific fields generally. Students' initial responses to the usefulness of algebra are indicated below:

Not at all	Occasional	Regularly	Often	Continually
7%	27%	32%	16%	18%

When "Not at all" was given a score of 1 and "Continually" was given a score of 5, the average was 3.74. Which seemed to indicate that students initially felt that algebraic knowledge was useful to them.

The affective attitude post survey included three questions related to attitude toward the usefulness of algebra.

1. Workers use algebra in occupations or fields which I am considering or for which I am preparing.
2. The illustration of real-world applications of roots and radicals has changed my feelings about their usefulness in a positive direction.
3. Introducing illustrations of real-world math material beyond the classroom takes too much time away from math instruction.

The results are summarized below:

	Strongly Disagree 1	2	3	4	Strongly Agree 5
Ques #1	7%	28%	21%	31%	13%
Ques #2	3%	7%	54%	28%	8%
Ques #3	28%	31%	28%	10%	3%

Question #1 was most closely aligned to the pretest item of usefulness. The average of this item was 3.15. This appeared to be a drop in the attitude of usefulness, but when followed with question #2 which directly asked the students if they felt a change in attitude the average score was 3.58 which is learning toward a positive change in attitude toward the usefulness of algebra. There is a contradiction between these two scores which will need further study. It is felt that the rating for this question should be more precise, with equivalent forms and more than a single pretest item.

Question #3, regarding use of class time for examples of real-world applications, was worded negatively for an average of 2.29. This score indicated a general disagreement with the statement, "Introducing illustrations of real-world math material beyond the classroom takes too much time away from math instruction."

Two questions on the post survey dealt with multi-media presentation.

Question #6: A multi-media presentation of math topics helps students to understand the uses of algebra. Average score was 3.74.

	Strongly Disagree 1	2	3	4	Strongly Agree 5
Ques #6	0%	8%	33%	36%	23%

This results of this question were of particular interest because it dealt with two aspects of the project, multi-media presentation and algebraic applications. Students seemed to feel that the visual examples of applications were appropriate and helpful.

The next question was worded negatively but also dealt with the presentation.

Question #7: Computer graphics and video do not add to my understanding of algebra.

	Strongly Disagree 1	2	3	4	Strongly Agree 5
Ques #7	33%	31%	21%	8%	10%

With an average of 2.4, there appears to be support for a multi-media approach.

When students were asked what they liked about the presentation the responses included the following:

Any multi-media helps because it is an understanding of more than just numbers.

It enlightened me more concerning jobs which used algebra.

I didn't really have much problem grasping it. It was clear and easy to comprehend.

I like how it related real-life situations where you would use radicals and roots. It helped with understanding them.

It's helpful when we can see the different ways we can apply math in our lives and know that it will be useful to us.

I liked the applications.

I think I learned what I needed to know so the presentation was successful for me. I liked most of it.

There were a lot of new rules to learn. Worked with what we have learned already. The presentation was good. I grasped it better than previous chapters.

It's fine. I liked the every day uses such as the river search.

I thought that the presentations were interesting. I didn't ever think you would use square roots so much. It gives you a new appreciation. I appreciate others' jobs because of this. I never knew they had to use square roots to find skid marks.

I didn't ever think you would use square roots so much. It gives you a new appreciation.

I liked to see where they came up with some of these equations.

It was interesting. It answered questions that I had. I realized how important math is in the real-world.

Suggestions for improvement to the unit included the following:

The things we learned were neat and all, but I will never be measuring bones or measuring how long it takes for a car to stop skidding. Maybe it would be more effective to apply it to something we are interested in or may be doing someday.

It took too much time.

Too fast. I only regurgitate it.

I wanted to try to solve more of the illustrations so I could understand exactly what they were doing.

As can be seen from the review, there was support of the multi-media approach.

Instructor Interviews

The instructors who presented the unit also had suggestions which dealt mostly with the multi-media presentation format rather than the content.

It was felt that the set up time for the multi-media presentation was excessive because of the circumstances of sharing hardware with other instructors. If a single configuration could be agreed upon by all instructors, then each would not have to reconfigure for each class presentation. The instructor found that

rolling in hardware cart took more preparation than just walking into the classroom and using a chalk board to review questions and present new material. He felt that if he could teach in the same classroom without having to move the hardware from one room to another room then it would be worth the effort.

The instructor, who was not the author of the unit, found that more background information was needed for him to answer students' questions regarding the applications.

Both instructors felt that students enjoyed the opportunity to work with computer displayed graphics on a dry-erase board, but that the technique was useful for it's variety and that students might lose interest if every class period was organized around a multi-media presentation.

It was difficult to arrange the presentation displays for instructor's individual styles and needs. For example, due to student questions, one instructor fell behind the class schedule and had to combine two concepts into a single class period. He found it difficult to move within the structure of the computer graphics and still have time to emphasize only the main points which he wanted to cover.

Overall, both instructors enjoyed the material and the experience enough to continue building this resource for class presentations.

Critique

The development of this unit was a worthwhile project for both the producer of the material and the department for which it was created. It has been adopted by the Learning Enrichment Center as a resource for both adjunct and contract instructors.

The instructional material is built solidly on instructional design theory with creative approaches to layout and format. Both instructors and students felt the material aided learning and introduced new and thought provoking insights.

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