# Interactive Technologies in a Large Enrollment Class

A Case Study in Information Technology
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**Problem**

Teachers are likely to teach in the way that they were taught. Today's research in learning indicates that the most appropriate way for children to learn science is through hands-on activities. Yet many universities provide for future teachers science courses which are primarily in the lecture format. Thus future teachers learn a model of teaching that is not appropriate for them to use.

The most common way to offer hands-on activities is in small classes. Yet, the economic constraints on our departments precluded offering a large number of small classes to future teachers. We needed to find a way that provided strong instruction in physics and an appropriate role model for the teaching of science. The course needed to be designed so that the faculty load was similar to a traditional lecture-laboratory course for about 100 students.

**Program Description**

Concepts of Physics at Kansas State University is an introductory level physics course which serves students who are preparing to teach in elementary school. Each year approximately 100 students, mostly sophomores and juniors, enroll in Concepts of Physics. Their goal is to obtain a sufficient background in physics so that they can teach at the elementary school level.

*Instructional Model*

The instructional model used in the course is the Learning Cycle which was originally developed by Robert Karplus in the 1960s. The Learning Cycle is derived from the intellectual development model of Jean Piaget and includes three different types of activities. The first activity, exploration, requires the student to explore a concept by performing a series of activities. Students are given a general goal, some equipment, and some general ideas about the concepts involved. They are asked to explore the concept experimentally, in as much detail as they can, and to relate it to other experiences they have had. The second phase of the Learning Cycle, concept introduction, provides a model or concept to explain observations of the exploration. Frequently, the concept-introduction stage is not an experimental activity but expository statement of concepts and principles. Following the concept introduction, the students move to concept application. Here, they use the concepts that were introduced and apply them to new situations. This application of the principles and concepts leads to further understanding of the theories and the models. The complete cycle has been used successfully to teach a wide variety of topics to students at all grade levels.

Because of the emphasis on student-centered activities, a Learning Cycle class usually has an enrollment of less than 30 students. However, the economics associated with small class size has limited adoption of this method at many universities, including mine. To overcome this difficulty, I have adapted the Learning Cycle for a class of about 100 students with one faculty member assigned to it. During the past 19 years the course has evolved into one with an emphasis on the nature of science and on learning science by doing scientific activities.

**Figure 1: Traditional hands-on activities as well as interactive multimedia are used in the explorations and applications.**

An important component in all three phases of the Learning Cycle is the use of technology. During both the exploration and the application phases students frequently use interactive video to make observations, take measurements, and see how the physics is related to their everyday experiences. During the concept introduction phase and parts of the application phase, students use a classroom response system so that they and the instructor can interact even though they are meeting with a class of about 100 students.

*Interactive Video in Explorations and Applications*

In an exploration students might be asked to view a short video sequence which shows a mannequin in a car which runs into a wall. Another mannequin would be in an identical collision but would have an airbag in the car. Students would be asked what is similar about the two events and what is different, and to speculate on why the airbag makes a difference in the amount of damage done to the mannequin. In general students would make comments such as "the airbag is softer than the windshield" or "the mannequin sinks into the airbag but it bounces off the windshield." Their wording would not be in terms of Newton's Laws of Motion or impulse which are the concepts to be studied after this exploration.

This same video sequence could be used for an application activity. After the students have been introduced to the concepts of impulse and Newton's Second Law, they can be asked to look at the two video scenes and describe in terms of these concepts why the mannequin which is protected by the airbag receives less damage than the one which is not. Thus, an identical video sequence can be used in both an application and an exploration. (This video sequence is contained on the videodisc, *Physics and Automobile Collisions* by Dean Zollman.)

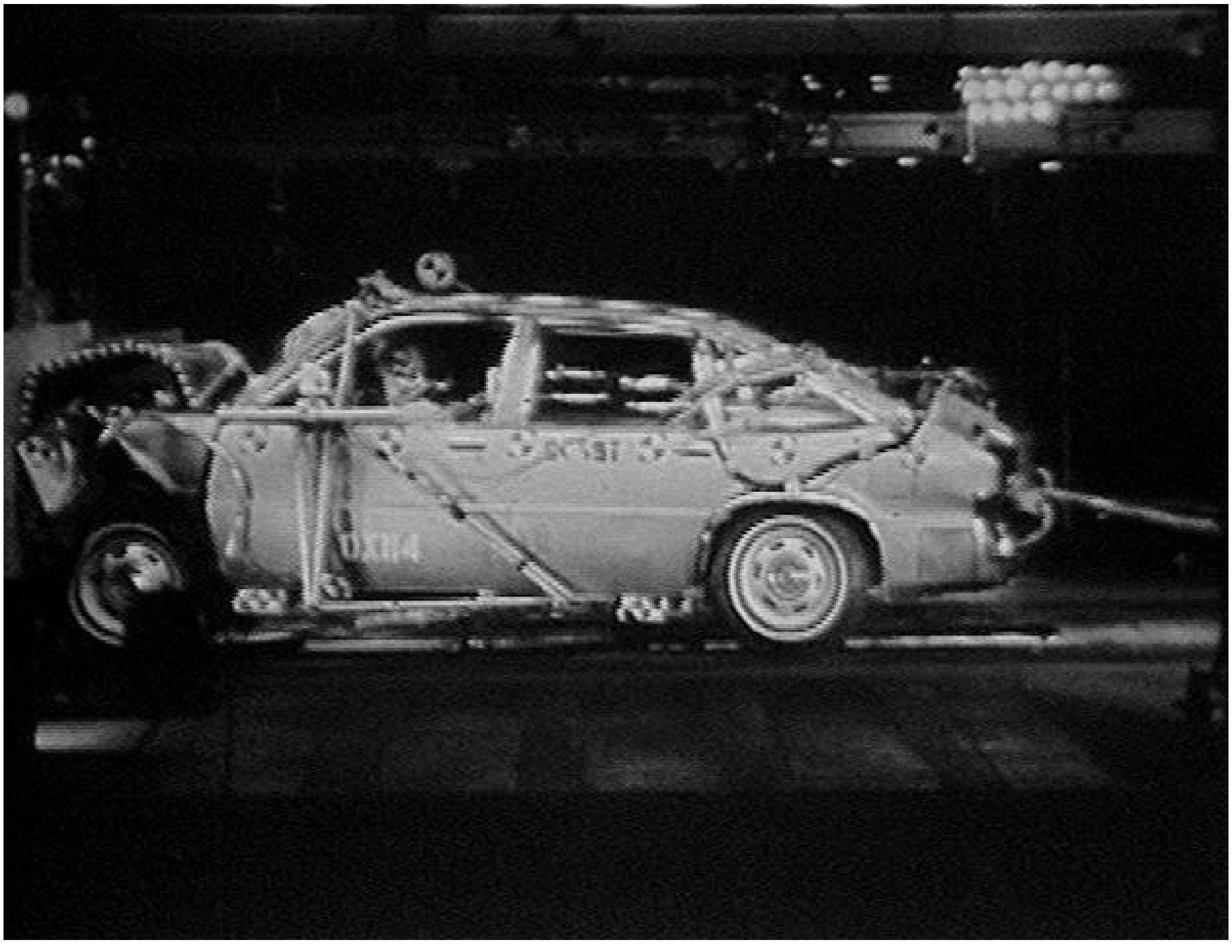

**Figure 2: A scene from *Physics and Automobile Collisions***

Video scenes such as these can also be used in situations where the students need to apply their knowledge of physics but for which there is no right answer. One of the favorites in this category is a video sequence from the second Mohammed Ali-Sonny Liston prize fight. In this sequence, Ali swings at Liston and Liston falls down. A voice-over narrator says that this punch was very controversial, and some people do not believe that Liston was actually hit. The students are asked to watch the video one frame at a time and try to determine if Liston was hit. However, they can not just say, "Yes, I think so," or "No;" they must state their reasoning in terms of conservation of momentum which is the concept being applied. Thus, they must talk about the momentum of Ali's fist before the interaction as well as the momentum of Liston's head. They must then look at the momenta of these two objects after the collision and come to some conclusion. However, because the camera angle does not allow for extremely careful measurement, no definitive answer can be determined. Thus, the students are required to come to their own conclusions and defend their conclusions based on the laws of physics. They are told that either yes or no is correct but that their reasoning is what really counts.

In other scenes careful measurement can be completed. Students are asked to apply the principle of conservation of energy to a pole vaulter on the videodisc *Physics of Sports* by Dean Zollman and Larry Noble. They step through a pole vault sequence one frame at a time and measure the distance which the vaulter is moving during each frame before he leaves the ground. With this information they can calculate the vaulter's speed and then his kinetic energy. They then move to the frame at which he is highest above the ground and measure the distance to which he has ascended. Now, they can calculate the gravitational potential energy of the vaulter. The students must then determine if all of the gravitational potential energy that the vaulter obtained came from his kinetic energy when he was running on the ground. If not, they must speculate on where the remaining energy may have come from. Thus, this applica tion is also an exploration for the next concept --- there are many forms of energy in addition to kinetic and gravitational potential energy.

Another example which is partially quantitative and partially qualitative involves the students analyzing the forces on a diver as she goes from a three-meter board into the water. The students are asked to look at the scene and then to go to several frames which have been pre-selected by the instructor. For each of these frames they are to state all of the forces acting on the diver and then the net force on the diver. This activity is particularly useful in bringing out some of the students' conceptions which are not consistent with the accepted way in which Newton's laws are applied. In particular, many students will state that as the diver is ascending, she must have a force in the up direction acting on her. The reason that the students give is she is moving up therefore there must be a force acting up. By the time the students come to this interactive video activity, they have already learned that a force does not necessarily need to be in the direction of motion. However, this idea is very firmly held by most students when they enter a physics class and is difficult to change. Thus, a "real-life" example helps bring it out so that the instructor can discuss it further. These and other similar activities are particularly helpful in this respect because they apply to real events with which the student can identify.

*Multimedia in the Large Class Setting*

A lecture response system, Class Talk, allows the instructor to pose questions to the entire class during the large class meetings which are the concept introduction and part of the applications. With the system the instructor can send to all students in the class a multiple-choice or open-ended question. When the students respond, the responses are collected by the instructor's computer and analyzed in terms of the type of response. Thus, the instructor and students can interact regularly even though the class is rather large.

An example of a large class meeting in which both multimedia and the classroom response system are used in combination is one in which students summarize work on the transfer of thermal energy. To begin the activity the class watches a scene from the *Wizard of Oz* in which Dorothy throws water on the Wicked Witch of the West, and the witch melts. The instructor states that, because the witch melted, we should be able to determine the latent heat of fusion for her. The students are then asked if they have a sufficient amount of information to calculate this particular variable. The majority will answer that they do not, so they are asked to enter into their computers the variables which we need to know to make the calculation. From the students' responses the instructor can make a list of variables which the class will either need to estimate or measure and can also address variables which are listed by the students but are not necessary in this situation. Thus, the interactive system enables the instructor to uncover student misconceptions and address them in real time. For each of the variables which are needed the students are asked to enter in their computers an estimate based on the information on the screen. Thus, they estimate the mass of the witch, the temperature in the castle, the change in the water temperature, and the amount of water which struck the witch.

The estimates are made by looking at individual pictures in the film. The students can request any picture. Because the film is stored on a random-access videodisc, the instructor can quickly find any request. (The most common requests are barcodes in the instructor's notes.) For each variable the students enter an estimate into their computers. The instructor uses the values which were entered to determine an approximate average value for each variable. These averages are then used in the determination of the latent heat of fusion of the Wicked Witch of the West.

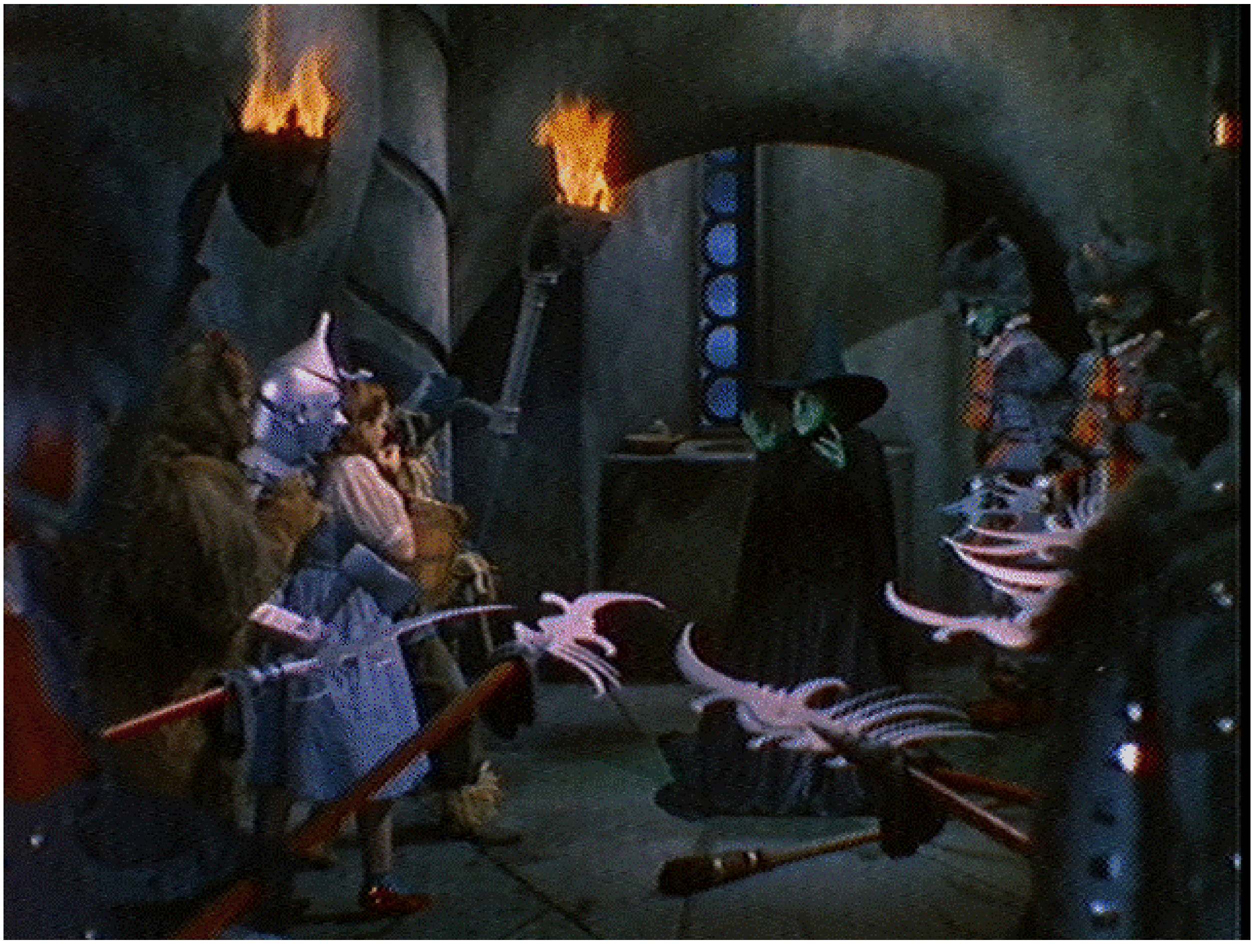

**Figure 3: Dorothy is getting ready to throw water on the Wicked Witch of the West. From information in this scene students can determine the amount of energy needed to melt a witch. (Copyright clearance has not yet been sought for using this picture in a publication. It is included here for evaluation purposes only.)**

While on the surface this activity is a calculation of one number, the process which the students go through reviews most of the concepts related to thermal energy transfer. Further, the process shows students how we can use estimation as part of the scientific process. The students will also raise questions about thermal energy which we cannot account. For example, "steam" rises from the witch. That would indicate that she did not simply melt. Then, we must estimate if these contributions are significant. Thus, the overall result of the activity is an interactive discussion which takes almost a full class period and includes a variety of topics related to the process of science as well as the concepts that are studied. The combination of interactive video and a class response system provides motivation and assures that all students are involved.

In all parts of the course, the multimedia and interactive classroom activities are not separated from other hands-on activities. Students move quickly and easily from an experiment involving standard laboratory materials to an interactive video station and then back to lab apparatus within a single class period. Likewise, in the large class activities the instructor uses computer modeling, interactive video and physics demonstrations together with the response system. Thus, the interactive media component of the course is fully integrated with all other aspects and provides a model for including these types of activities in their future teaching.

**Process**

The physics course for elementary education majors began in its present form in 1977. The multimedia integration was first introduced in 1979 with a stand-alone MCI-DiscoVision videodisc player which was controlled by a small keypad. This system was somewhat programmable and had 1 kilobyte of memory. In 1981 the stand-alone player was replaced by Apple II+ computers which were connected to consumer-level videodisc players. These systems which had separate video screens for the computer output and the videodisc output provided much greater programmability than the previous system but were still somewhat limited. They were replaced in 1990 by IBM InfoWindow multimedia systems. These systems were based on 286 computers and allowed input from a touch screen as well as keyboard and mouse.

**Figure 4: An early form of the interactive video hardware.**

Throughout the history of the course a primary challenge has been to use technology well, yet maintain a level that teachers were likely to have available. For many years we used some multimedia systems which would not be in typical classrooms but would give future teachers a view of what was possible.

More recently, the technology in an elementary school classroom has improved significantly. Thus, for the past few years we have been using a system which elementary teachers are most likely to find in their own classrooms --- a videodisc player which uses a bar code reader as input. The system is somewhat simpler and less capable than the previous computer-controlled systems. However, they provide a rather large amount of interactivity with a minimal amount of additional hardware. Because many elementary schools have invested in the videodisc and barcode system the students are likely to see this type of multimedia apparatus when the go into teaching. Thus, we provide them with a way to see how to use such interactivity in their future classrooms.

For the two scenes that are shown by using the barcodes, calculate Dr. Hume's velocity. (Even though Dr. Hume is speaking you will hear no audio.)

Scene 1:

Cinema Classics Side A
Hume's motion 2
Frame Play 8051, 8142

Scene 2:

Cinema Classics Side A
Hume's motion 1
Frame Play 7157, 7467

Show your calculations and determine the velocities in the scenes.

Now, Dr. Hume has a question for you to answer.

Cinema Classics Side A
Hume's motion 3
Frame Play 7163, 7467

Answer his question but remember the questions is not "Is he …" but "How do you know that he is …"

**Figure 5: A section of the student activities book.**

The students have a small book which contains the information about the explorations and applications. Whenever the activities involve an interactive video sequence the appropriate barcodes are printed in their books. They go to the video station in the activities room, scan the barcode, and answer questions based on the video.

The course was designed and implemented by one faculty member who began with a small grant from the National Science Foundation. A challenge was to convert the course from "Zollman's Course" to one which other faculty would feel comfortable teaching. This process began last year when another faculty member taught Concepts of Physics while the originator acted as his mentor. The transfer seems to have been successful.

The new instructor had never used any method other than the lecture mode. Yet, he found Concepts of Physics enjoyable to teach and plans to continue the course in its present mode.

**Outcomes**

During the past 19 years Concepts of Physics has been the primary course in physics for future elementary teachers. When the course was first introduced, a study indicated that students in the course learned the content better than in a traditional mode. More recent studies have focused on the use of technology in the course. [Escalada and Zollman, *Journal of Research in Science Teaching*, 467-490 (1997) and Jolly, Zollman, Dimtrova and Rebello, *American Journal of Physics*, to be published). The studies show that the students attitudes toward physics and toward the methods of learning are very positive.

We find that students who complete the course frequently make statements such as, “I could not have succeeded in physics without the activities.” Further, when they become student teachers or teachers, the return to borrow equipment or discuss how to teach certain topics. Thus, the goal to provide an appropriate role model for teaching science has been achieved.