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IMPLEMENTATION OF COMPUTER-BASED INNOVATION: A CASE STUDY

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In investigating the implementation of computer-based instruction in a college-level introductory music theory class, a gap in expectation became apparent. Initially, the class seemed an ideal setting for the use of computers for education. Essential prerequisites so often neglected in implementing such innovations were present. However, the actual integration of the computer into instruction did not meet expectations. Even when an educational innovation offers significant advantages, its adoption and use may create problems for teachers and students. In seeking to understand the barriers to successful implementation, we employed qualitative methods to explore contextual aspects and capture participant beliefs and perceptions of the innovation. Our findings highlight the crucial role of incorporating the computer within required (vs. voluntary) activities in determining student involvement, and the implications for the integration of the computer into the formal curriculum. It is the people and the institutions they create and sustain who determine the success or failure of an innovation. Even when an innovation meets people’s expressed needs, it may still not succeed unless it fits the patterns by which they run their lives as students and teachers.

As this article is being written, we have more classroom computers at all educational levels, from daycare centers to universities, than we ever did before. Is education any better than it was before? Is it different than what it was before?

The introduction of CAI stimulated numerous studies on computer effects on students’ learning. Most of these studies focus on students’ achievements. Results are controversial: some find the computers to have positive effects, others find no effects or negative ones. We believe that these conflicting results reflect an inherent complexity. The impact of the technology on students’ success cannot be extricated from the contextual conditions, as some researchers have attempted (sometimes unknowingly) to do. Factors such as teachers’ and students’ attitudes, extent of integration into the curriculum, and user interface with hardware and software, determine the impact of technology on achievement no less than the technology itself.

Amongst the many studies of computers and education, some tackle the issue of innovations in their human context. Jackson’s The Teacher and the Machine (1968) is an early, philosophical work that deals with computers and the role of the teacher. Jackson argues that several of the educational benefits alleged to accompany technological change will either fail to materialize or, at best, will prove to be mixed blessings. He raises some fundamental issues of humanistic vs. mechanistic ideology in the educational process. In Teachers and Machines, Cuban (1986) looks at similar issues in the context of technologies at large — film, radio, instructional television, and computers. Cuban, employing an historical approach, is interested in the degree of teacher use of the new technology, and their reasons, as well as in the potential influence of computers.


Methodology

In contrast to the studies whose goal is to assess outcomes associated with the use of computers, the
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Most educationally interesting uses of the computer require adjustments in the traditional roles of teachers. These roles have been created around the capabilities of print media, in this case a textbook, and the conventions of written musical notation. Our observations revealed that the teacher's role was mostly didactic — delivery of information and checking that assignments have been done — rather than facilitating independent learning on the computer. This is even more true of a non-music academic curriculum, which is largely training in how to use print media. Teachers cannot be expected lightly and readily to change established teaching styles which they have found satisfying.

If we expect students to allocate free time to the use of computers, we must make the computer-based system intrinsically rewarding, change continually to remain in fashion, and create an impression of novelty.

The proper integration of the computer involves change in three distinct levels: (1) the actual use of the computer, (2) change in teaching approaches (e.g., introducing new activities, adopting a less centralized approach to teaching), and (3) change in beliefs (e.g., the role of the students, teacher and technology in teaching) (Fullan, 1982).

The computer, like any new medium, requires introductory support. Beyond this initial introduction, there is need to provide constant maintenance. Unlike a book, the computer is an interactive machine. Successful operation is based on how the system responds to students' answers. In this case, as in many other, system and program "bugs" hindered the continuity of students' work. Maintenance of machines is not a regular function within the school system and thus requires initiative and funding. Because of the novelty of the medium, a wise choice of software in terms of user-friendliness, clarity of goals, structure, content, and instructional quality is crucial.

Teachers, from their position of authority in the classroom, are in the best position to integrate the computer into the curriculum and have a decisive role on the effectiveness of the computer on students' learning. Teachers already have an investment in the print-based system; devoting time, energy, and attention to systems based on other technologies threatens to make that earlier investment obsolete. As mature adults with responsibilities for jobs and families, teachers have little free time for learning a new system. Efforts should be made to relieve mature individuals from competing responsibilities and to provide an extended period for mastering the new technology. Perhaps, those who seek to implement innovations should rely more on young people just beginning their careers who have not yet accumulated competing responsibilities and who have a vested career interest in advancing the new technology.

A more profound change is the change of pedagogical approaches and beliefs. Offering alternatives to traditional roles and activities is mostly the responsibility of colleges of education. Special courses should be designed and offered as part of the formal requirements for teacher preparation.

A number of writers claim that the freedom to choose or not to choose CAI is one condition of its successful implementation: some personality types do not mesh well with CAI, and these students should not be forced to use a medium with which they feel uncomfortable (cf. Hartig, 1984). We, however, found that the integration of the computer with the formal curriculum as part of the requirements (rather than being an embellishment) is a necessity. In an academic environment, the great majority of students do what they are required to do. Becker, Geer and Hughes (1968) point out the main elements of what they call the Grade Point Average perspective. Since the university is so organized that one can neither remain a student nor graduate without receiving adequate grades, and a successful student is defined as somebody who is doing well in academic work as measured by the grades, success consists of getting a good grade point average. Intellectual or other interests may suggest that rewards other than grades be sought. But where the actions necessitated by the pursuit of grades conflict with other interests, the latter will be sacrificed. If students are to dedicate their time and attention to computers, computers must become an integral part of the formal curriculum.

If there is a conclusion to our study, it must be that it is the people and the institutions they create and sustain who determine the success or failure of an innovation. Even when an innovation meets people's expressed needs, it may still not succeed unless it fits in with the patterns by which they run their lives as students and teachers.

References


view, working on the computer entailed providing specific guidance on how to take advantage of the strands and problems on the software for their benefit and to overcome difficulties. It seemed that the instructor expected that the computer-based part of the course would run itself without requiring his attention and guidance.

*Lack of external incentives and peer support.* Even though the department purchased the materials, nobody showed involvement in the program operation, concern for problems and difficulties, or stimulation of ideas. That was true for the top administration, for the program designers (who, as indicated in the interview, felt they fulfilled their responsibility by presenting the program to the instructor), and for the other teachers. MusicMaster was designed for Music 1, and none of the other teachers were involved in using computers for instruction. Because of the lack of incentives and social support, there was no counter effect to the obstacles discussed above.

*The Program Designers*

*Integration.* The program manual shows that the designers intended the program to be integrated into the curriculum. The manual refers the students to the teacher in numerous situations and lacks an explicit statement of goals or tutorial information. The designers explained in the interviews that they assumed that all of this would be explained in class. A related expectation for involvement of the instructor in the computer materials can be seen in the provision for printing a log of students’ work.

However, the designers did not give explicit guidance on how integration should be done. That was particularly intriguing since one of the designers worked within the same institution and the other in close proximity. Apparently, poor communication is not only a function of geographical distance.

*The Students*

*Tests and formal requirements.* Most students enrolled in the course so that they would be motivated to pursue their interest in learning music. They depended on the course to tell them what to study, and tailored their activities in and out of class and their allocations of time to the pattern laid down by the instructor, especially to the instructor’s definition of success as embodied in the grading formula. The following quotations represent a dominant theme. Prudence, a junior majoring in Industrial Engineering, and a B student in class:

“I was thinking about going to the computer, but it ended up that I was working on using the book and trying to understand those things. The material in the book was more of what we were tested on in the course.”

Bud, a sophomore majoring in English, and an A student in class:

“My schedule is so busy, it helps to have something connected to my interest that I’m required to do, so it does not seem as quite so extracurricular. I generally fill the curricular into my schedule. As soon as it becomes extracurricular, it seems to become like expendable, there is a paper or a test to be studied for.”

As to the extracurricular, it became clear during interviews with students that they allocated their voluntary time on the basis of the pleasure principle: How much fun is it? This drill and practice program required repetitive work and perseverance. The screen and visual information was unimaginative and plain (in part due to computer memory problems), and the musical content was presented in the abstract—musical elements such as scales, intervals and chords, rather than melodies. Most elements that make games entertaining were absent. (For a taxonomy of what makes things fun, see Malone, 1984; Malone and Lepper, 1984). This computer system was not a lot of fun.

*What Would It Have Taken?*

Computer activities do not stand on their own any more than books do. One of the main benefits students seek from courses is relief from the burden of making decisions about what to learn, in what order, how fast, etc. As we have read in a previous section, students repeatedly claimed that as far as school related things were concerned, they did only those things which were required for class. However strong students’ desires to learn something, it would be unrealistic to expect them to override the priorities built into the structure of courses. If computer activities are not incorporated into the overall course structure, then students will regard them as competing for their free time.

Incorporating computers into the structure of courses means that teachers must rethink the course curriculum. In our study, it was clear that the computer invited the inclusion of goals in music theory, goals which were impossible to achieve without the aid of the computer (or an additional resource such as an ear training section). These goals were acknowledged by the department as essential to music theory. The instructor, however, continued to teach as he did before the aid of the computer. Rethinking the curriculum is a substantial undertaking and there is no way to avoid it. Reorganization of the curriculum would allow more time for teaching new things, or a clear decision to reduce time devoted to things formerly taught. We cannot always expect that all pre-existing goals and contents can be covered in less time, freeing time for new material.
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In view of all these favorable signs, we were surprised to discover that the computer was barely used at all in Music 1. It was never used in class-related activities or even mentioned after the first day. As Figure 1 shows, only 17 of the 38 students who attended the first day of class in Music 1 came to the computer room at all. Only five of these came more than once. And only three came often enough to get significant ear-training.

![Figure 1. Distribution of students' time at the computer.](image)

Why did this attempt at using computer-based ear training fail despite so many favorable signs? What can we learn from this about barriers to implementation of other computer-based innovations?

Barriers

_The Instructor_

_Curriculum organizers: goals, content and evaluation._ The instructor did not state explicitly the course's goals either in his syllabus or during his lectures. In one of our interviews, however, he noted that:

"Probably the biggest thing is their initial approach to reading music, the written form. They are learning a skill in that class. We are dealing with written elements. I think it is much more valuable, if I have them for ten weeks, to give them all the reading I can and all the theoretical stuff."

The instructor did not reconsider the non-computer aspects of the course in order to integrate the computer-based ear training and music theory. He worked from a textbook, _Practical Beginning Theory_ by Benward and Jackson, 1983 which, with the exception of some minor alterations, he followed closely. The textbook provided a ready-made organization of the material, as well as homework assignments which were used in all the lessons. Obviously, organizing the lessons around the textbook saved him energy and time.

The grading formula, which included tests, final project, and class attendance, was another curriculum organizer. Work at the computer was not part of the requirements. The tests focused on the textbook material — pen and pencil problems. Ear training was given a marginal place and accounted for only 12 points out of the 300 in the three tests. Establishing the connections between the symbols (notation, technical terms) and their representations (sound) received only modest attention.

Faced with too little time to achieve all course goals, the instructor chose to place priority on the mastering of the analytic concepts and the reading of musical elements, in part because he knew how to teach these, in part because he considered them more fundamental. When asked what he would do had he had more time, the instructor said he would like to include more "visual" topics, rather than cater to the neglected, aural subjects.

_Pedagogical assumptions._ The class, fast paced and efficient, with an emphasis on memory and application of concepts and a systematic-analytic approach to the material, was a combination of a didactic, lecture-based style, with a fact-based questioning style (Sternberg and Martin, 1988). Even though the systematic-analytic and the questioning approaches matched the computer-program style, the source of authority was not the same. Classroom observations, as well as observations of the dynamics between the instructor and his teaching assistant, indicated that he showed a strong preference for being the center of attention and for being in control during class.

Sending students to the computer would mean delegation of responsibilities.

Another pedagogical assumption included a view of the student as passive and having no say in curriculum planning; classroom observations revealed a scarcity of student-gear examples, as well as little attention to students' problems in tests and in the classroom. The computer program, in contrast was student-controlled. Users had to choose on which strands, topics and problems to practice, and had control over different musical and operational parameters such as clefs, tempo, sound, direction of presentation, and video display.

_Organizational and instructional barriers._ Integrating the computer into the curriculum introduced an inconvenience from an organizational as well as from an instructional perspective. Making sure that all the students could work at the computer presented a chore. In order to use the computer, students had to sign up in advance, pick up the lab key at the department secretary, and return it to her. All these required some kind of supervision which would demand an additional load on the instructor's already crowded schedule. From an instructional point of
synthesizer and a musical keyboard entry device. Music-Master is a student controlled program in music theory and ear training that allows the student to choose what exercises to work on. The student may change his choice of task at will. The use of the computer was voluntary for students in the class, and they could work in their own free time.

Data Collection

Data were collected from the following sources (see Table 1):
1. Extensive and detailed observations of all sessions of the music class.
2. Observations of all individual sessions of 17 students at the computer (ranging from one to 13 sessions per student).
3. Open-ended, taped, transcribed interviews with the classroom instructor, with the two software designers, and with 20 students — of whom, six worked only at the classroom and 14 worked at the computer and the classroom. Each individual was interviewed between 2-4 times at different stages of the research.
4. Written materials including the textbook used in class, materials distributed in class (e.g., syllabus, policy, guideline to final project), quizzes given to students in class with their answer books, students' final compositions, students' notebooks, and records of students' scores at the computer.
5. Two sets of questionnaires distributed to students at the beginning and at the end of the quarter. The questionnaires examined students' musical backgrounds, habits and goals, their attitudes to computers and to ear training.

The Promise

Music 1 was in many ways an ideal setting for studying the use of computers for education. All the essential prerequisites so often neglected in implementing such innovations were present. Computers dedicated to the project were available only a few feet from the classroom. They were equipped with electronic keyboards and software that enabled the computer to generate sequences of notes of different pitch — musical intervals, chords and scales — and then to tell if the student's identification of the played elements was correct. This is traditionally the basic skill taught in ear training, which heretofore had required expensive individual tutoring. The system had been developed by a former member of the Music Department at this institution specifically to teach the ear-training and music theory goals of Music 1. The department had purchased the hardware and allocated space for its use.

The course description of Music 1 reads as follows:

Music 1: Introduction to Music Theory — A preparatory course in the fundamentals of music notation, basic sight reading, sight singing, ear training, keyboard harmony, and melodic, rhythmic and harmonic dictation. This is a skill-oriented course, using piano and voice as basic tools to develop listening and reading skills.

The match between the contents of the computer program and these goals was very close.

The instructor was a programmer who had written a harmony program of his own. He expressed great support for the potential contribution of computers to music teaching. He told us at the beginning of the course, when we asked him what he thought of computers for music education:

"Oh, yes. I am all for it. I am totally pro the computer, because it can do all sorts of things that require repetition and simple error checking. It does not take the time of a teacher or a tutor of some sort. Also this is the computer generation and students in this university in particular, are very computer oriented."

He claimed that the program was "perfect for a course like this."

Most students, interviewed at the beginning of the course, said they had one or both of two main reasons for taking Music 1:
1. To learn the fundamentals of music theory.
2. To improve their ability to compose or perform music.

Ear training was perceived by most students as an essential vehicle for the latter goal.

The music theory part of the computer would be especially helpful to the students with no musical background — a majority at the beginning of the class. These students found it extremely difficult to keep up with the material, as shown by their evidence in interviews, their test results and the high drop-out rate. The ear training part would have been most useful for those students who came to class to improve their ear training, since, in this circumstance, it was practically impossible to achieve without the computer. We volunteered to provide students with assistance in getting started with the computer. To summarize, we had the following reasons to expect successful implementation:
1. Adequate hardware.
2. Appropriate software.
3. Institutional commitment.
4. Well established program within the course.
5. Instructor who supported, and knew how to use, computers for music instruction.
6. Students who were interested in learning what the computer system taught and had mostly favorable attitudes toward computers.
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The Setting

We chose to study a college-level introductory music theory class in an affluent private university located in the midst of a thriving high tech industrial community with a computer-sophisticated group of students. Unlike other studies which were conducted at an early stage of the implementation, computer use was well-established. The computer had been operating for 13 years, using for the first 10 years older versions of the current program. We assumed that the "childhood disease" of an innovation would have been taken care of.

Thirty eight students were enrolled in the course, and 25 completed it. Slightly more than half of the students in the class majored in engineering, computer science or math. All grade levels from freshmen through fourth year graduate school were represented. Although not a prerequisite, all students except two had previous exposure to computers, from word processing to professional programming. The course was given during a ten week quarter, and consisted of three 50-minute sessions per week for a total of 27 sessions. The software used was MusicMaster implemented on an Apple II computer equipped with a

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