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Computer-assisted instruction as a learning resource for applied anatomy and kinesiology in the occupational therapy curriculum.

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Computer-Assisted Instruction as a Learning Resource for Applied Anatomy and Kinesiology in the Occupational Therapy Curriculum

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Key Words: computers • education, occupational therapy

Objectives. *The purpose of these studies was to examine the learning outcomes of a computer-assisted instruction (CAI) tutorial in applied anatomy and kinesiology for occupational therapy students and to determine its applicability for use in two university settings.*

Method. *Two separate pilot studies were conducted at two universities. In each study, the learning outcomes of an experimental group of occupational therapy students using a CAI program and a control group using books to study the same material were compared. Learning outcomes were assessed with posttest achievement test scores on an applied anatomy and kinesiology test and responses to an attitude questionnaire with Likert-scale items and open-ended questions.*

Results. *There was no significant difference in the means on achievement test scores for the experimental and control groups in the first pilot study. In the second study, the CAI group scored significantly higher on the achievement test than the control group. In both pilot studies, subjects displayed significantly more positive attitudes toward the CAI program as a learning tool than they did toward traditional self-study with books.*

Conclusion. *A CAI program in applied anatomy and kinesiology can be an effective supplemental resource for occupational therapy students and can offer a learning experience that students value and perceive as helpful. Establishment of clear learning objectives, use of a theoretical base to design instruction, and development and testing in different educational settings can help improve the quality of CAI programs and ensure their relevance to other curricula.*

Computer technology offers many possibilities for presenting information and enhancing the teaching—learning process. Computer-assisted instruction (CAI) has emerged as a valuable tool for this purpose and has been widely used in medicine and allied health curricula since the 1970s. Its use in occupational therapy education appears to be growing, with about 25% of professional programs currently using CAI (Stucky, 1992). Occupational therapy educators cite many advantages of CAI, such as its capacity for advanced graphics display (Zemke, 1992), active learner involvement (Farrow & Sims, 1987), individual control of the rate and sequence of instruction (English, 1975; Farrow & Sims, 1987; Zemke, 1986), and provision of immediate feedback (English, 1975; Farrow & Sims, 1987).

Reported applications of CAI for occupational therapy curricula include neuroanatomy (Dengler, 1983), simulated patient evaluation (Egan, 1992), use of the CAI development process to facilitate cognitive skills (Farrow, 1993), instruction in back care principles (Farrow, 1986, cited in Farrow & Sims, 1987), and biomechanics (Cron-

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inger, 1992). CAI appears particularly well suited to visually intensive, detail-oriented subjects, such as anatomy and kinesiology, because it allows textual information to be combined with still and moving graphics with the sequence and timing of information controlled by the learner. Additionally, CAI appears appropriate for such topics because the subject matter consists, at least in part, of highly structured cognitive information. Stern and Hassanein (1992) suggested that subjects comprising this type of information may be taught efficiently using an "externally developed organizer" (p. 257). This term appears to apply directly to CAI programs.

Although CAI appears to have great potential as a learning tool for occupational therapy students, at least four major concerns about its use have not been addressed. The first concern is that developers of CAI have tended to focus on the technological capabilities of the computer, with little attention given to the development of appropriate program objectives (Jonassen, 1985). Although current technological features are impressive, it is important to realize that any kind of technology is merely a tool; the value is in *how it is used* (Schwartz, 1986; Bracy, cited in Sidler, 1986).

A second related concern is an overemphasis on the technological aspects of CAI, described as a "technocentric" approach (Hannafin & Phillips, 1987, p. 44). This overemphasis has led to inadequate theory development from which to understand and evaluate learning outcomes in health care education. The literature on CAI in health care tends to be descriptive (Belfry & Winne, 1988; Hmelo, 1989; Marion, Niebuhr, Petrusa, & Weinholtz, 1982), and relatively few studies have focused on the effectiveness of CAI. In occupational therapy education, only three formal studies have been reported (Dengler, 1983; Farrow, 1986, cited in Farrow & Sims, 1987; Farrow, 1993). Studies of CAI effectiveness in health care and education are difficult to compare because these studies have used many different research methods and examined a variety of populations. Further, because CAI comprises many different symbol systems and activities, "any generalization emerging from [CAI] research is limited to particular kinds of programs and activities" (Salomon, 1992, p. 892).

A third concern is the applicability of CAI programs developed for one educational setting to another. Most occupational therapy departments who use CAI (68.8%) are using programs developed within their own department or university setting (Stucky, 1992). However, no studies to date have examined whether locally developed CAI programs are applicable to similar courses in other occupational therapy curricula. This is important because CAI development often requires considerable time and expense. Applicability across curricula cannot be assumed because similar courses in different educational settings vary in specific content, objectives, and format of instruction.

A fourth concern is the time at which a CAI program is introduced in a course or curriculum. Do students benefit more from an introductory CAI program in a particular subject used *before* or *after* participating in lectures and other educational experiences related to the course? The literature on CAI in health care education does not address this question.

Therefore, two pilot studies were conducted to examine the learning outcomes of a CAI program to determine its effectiveness as a learning tool in anatomy and kinesiology of the elbow joint in two different educational settings in Philadelphia. The first pilot study was conducted at Thomas Jefferson University, the site for which the software was developed. It examined the learning outcome of using the CAI program before students attended lecture and laboratory on the topic. The second pilot study was implemented at Temple University in Philadelphia. It examined the learning outcome of students using the CAI program after they attended lecture and laboratory.

Method

Each pilot study used a pretest and posttest randomized experimental design to compare learning outcomes of students using a CAI program on anatomy and kinesiology of the elbow joint with those studying the same topic with books (i.e., the traditional learning mode). The learning outcomes evaluated in each pilot study consisted of objective tests of achievement in anatomy and kinesiology and attitudes of students toward the learning experience collected with a self-report instrument.

Subjects

Participants were obtained through convenience sampling and consisted of 39 subjects in Pilot Study I and 47 subjects in Pilot Study II. In Pilot Study I, the experimental group consisted of 19 subjects (18 women and 1 man, 20–44 years of age). The control group consisted of 20 subjects (18 women and 2 men, 20–39 years of age). In Pilot Study II, the experimental group consisted of 23 subjects (16 women and 7 men, 20–42 years of age). The control group consisted of 24 subjects (16 women and 8 men, 20–47 years of age). *T* tests indicated that there were no significant differences between experimental and control groups within each of the two pilot studies with regard to age, gender, or educational level.

Educational Tool

The pilot studies used a CAI program of the musculoskeletal anatomy and kinesiology of the elbow. This program, *An Illustrated Guide to Applied Anatomy and Kinesiology,* was developed with PLUS™ authoring software[1] and

[1]Manufactured in 1992 by Health Sciences Libraries Consortium, 3600 Market Street, Suite 550, Philadelphia, Pennsylvania 19104-2646.

used on Macintosh II computers at both sites. The CAI program was developed through a funded project at Thomas Jefferson University and field-tested at Thomas Jefferson University and the University of Pittsburgh in 1992. An instructional design consultant reviewed the program throughout the development process.

Theoretical Base

Gagné's theory of instructional design provided the theoretical basis for development and evaluation of the CAI program. Gagné's theory is based on information processing theory, which uses a systems approach to conceptualize human learning. In this approach, information, data, and theoretical principles provide input to the instructional system (Gagné, Briggs, & Wager, 1988). This input is then transformed into throughput, which includes the performance objectives and content of the lesson, the physical form through which the lesson is conveyed (e.g., a CAI program), and the plan for formative evaluation. The output consists of the learner's responses to the instruction, which provide both feedback and additional input to the instructional system.

Gagné's theory emphasizes that both internal and external factors influence learning and must be considered when designing instruction (Gagné et al., 1988). Instruction is conceived as "a deliberately arranged set of external events designed to support internal learning processes" (Gagné et al., p. 11). The external events are designed to stimulate internal learning processes. For example, computer graphics serve as external cues that can help the learner associate verbal knowledge of a structure with its physical appearance and assist recall of this information.

The overall design of the CAI program in this study was organized with a cognitive strategy called the *frame,* which organizes knowledge with a matrix or grid (see Table 1). This cognitive strategy is an example of *chunking,* or categorizing information into its component parts. Frames are powerful strategies that aid learning and comprehension (West, Farmer, & Wolff, 1991). Their effectiveness has been demonstrated in college physiology and neuroanatomy courses in addition to other subject areas (Vaughn, 1984). In this program, the frame design served as an *external event* of instruction that cued learners to the basic structure within which information was organized.

Table 1
Frame Design of Instructional Program

Type of Information	Information Obtained
Joint and motion	Which joints are involved in performing the activity, and what type of motion (e.g., flexion) is involved?
Agonist or prime mover	What muscle is acting as the agonist (prime mover)?
Range of motion	What is the approximate range of motion for the joint(s) involved?
Class of lever	What class of lever is the agonist—first, second, or third?
Assisting muscles	What muscles are acting to assist the agonist in performing the activity?
Type of contraction	Are the agonist and assisting muscles performing a concentric, eccentric, or isometric muscle contraction?

Instruments

The instrument for measuring achievement in applied anatomy and kinesiology was designed by the author and consisted of 40 pretest and posttest questions that covered muscle attachments, lever systems, types of muscle contraction, and activity analysis. The format consisted of 36 multiple-choice, 2 matching, and 2 fill-in questions. Questions were generated from the learning objectives of the CAI program, which were derived from the learning objectives of the applied anatomy and kinesiology course at Thomas Jefferson University.

To establish content validity of the pretests and posttests, a draft of 40 multiple-choice, fill-in, and matching questions was given to three instructors with expertise in applied anatomy and kinesiology. They were asked to review the items and provide feedback on the relevance of each question and the accuracy of each answer The resulting feedback was used to refine the wording on specific questions. The pilot version of the achievement test was then tested on 10 student volunteers. Reliability, measured by the split-half method, was 0.827.

Subjects' attitudes toward the educational experiences were assessed by a self-report instrument of seven Likert-scale items and four open-ended questions. The Likert-scale items asked the subjects to rate the clarity of instructions, the level of engagement that the learning experience provided, their assessment of the achievement of learning outcomes (which included three responses: "I learned a lot," "it was a waste of time," "it was a useful review"), whether the experience was helpful because they learned visually, and whether they would use this mode of learning again. The four open-ended questions required subjects to comment regarding the best and worst features of the medium and appraise its effectiveness compared to other ways of learning.

Procedure

In each study, subjects were randomly assigned either to the experimental CAI group or to a control group in which they examined the same information with books. Before random assignment, the sample was blocked according to two factors identified as potentially confounding variables: (a) subjects' level of self-reported computer competence and (b) the perceived value of their prerequisite anatomy course. This ensured that the experimental and control groups were equivalent in regard to subjects' perceived level of computer knowledge and anatomy.

The two studies were time limited; after taking the pretest, the subjects assigned to the experimental group used the computer program for 1 hr while the control group studied the same material with textbooks for 1 hr Subjects with textbooks used the same books from which the information in the computer program had been derived. They were allowed to study individually or in groups but remained within the classroom. In both studies, experimental and control group subjects took the posttest after the 1-hr study.

Subjects in the CAI group were given instructions about the technical aspects of using the program (e.g., how to use the mouse to point and click on buttons identifying topics included in the program) and were instructed to review the entire program. Subjects in the control group were instructed to study the muscle attachments, lever systems, types of muscle contraction, and muscle actions of the elbow joint. They were informed that they could study individually or in groups. Reference books were provided for each subject; these were the same books from which the information in the CAI program was derived.

Table 3
Pilot Study 1: Independent *t* tests on Posttest Attitude Scores ($N = 39$)

Category	Experimental X̄ (*SD*)	Control X̄ (*SD*)	*t* value
Clarity of instructions	4.5 (.772)	3.7 (.826)	2.86**
Interesting	4.6 (.496)	3.1 (.938)	6.44***
Useful review	3.9 (1.25)	2.5 (1.10)	3.63***
Would use again	4.4 (.955)	3.2 (.985)	3.77***
Helpful because visual	4.2 (1.13)	2.9 (.758)	4.14***
Waste of time[a]	1.3 (.452)	2.6 (.856)	−5.79***
Learned a lot	3.8 (.918)	2.9 (.873)	2.87**

Note. High score indicates positive response for these items.
[a]Scoring reversed so that low score indicates positive response.
$^*p \leq .05$ $^{**}p \leq .01$ $^{***}p \leq .001$

Results

Achievement Tests

Analysis of covariance was used to analyze the dependent measure, the posttest score, with the pretest as a covariate. Results are displayed in Table 2.

There was no significant difference in the means on achievement test scores for the experimental and control groups in the first pilot study ($p \leq .05$). In the second study, the CAI group scored significantly higher on the achievement test than the control group. All subjects in the second study, including those in the control group, attained higher achievement scores than subjects in the first pilot study.

Attitudinal Measures

Each Likert-scale item was analyzed with *t* tests for independent samples to compare experimental and control group responses at posttest. These findings are presented in Tables 3 and 4.

Results demonstrated a similar pattern of differences in both pilot studies between the experimental and control groups. In each pilot study, subjects in the experimental groups agreed that the CAI learning experience was interesting (X̄ = 4.6 for both Pilot Study I and Pilot Study II). Subjects in the control groups reported scores at or near the neutral point of the scale (X̄ = 3.1 for Pilot Study I and X̄ = 2.5 for Pilot Study II). Subjects in the

Table 2
Analysis of Covariance: Achievement Test Scores

Pilot Study	Pretest: Experimental *M* (*SD*)	Pretest: Control *M* (*SD*)	Posttest: Experimental *M* (*SD*)	Posttest: Control *M* (*SD*)	*F*
Pilot Study 1					
Achievement score	11.53 (1.50)	11.05 (1.89)	12 (2.69)	12.05 (2.24)	.058
Pilot Study 2					
Achievement score	13.26 (3.09)	14.38 (3.16)	17.17 (2.70)	16.46 (2.78)	4.24*

$^*p \leq .05$

Table 4
Pilot Study 2: Independent *t* tests on Posttest Attitude Scores ($N = 47$)

Category	Experimental X̄ (*SD*)	Control X̄ (*SD*)	*t* value
Clarity of instructions	4.6 (.59)	3.6 (1.01)	3.87**
Interesting	4.6 (.59)	2.5 (1.06)	8.02***
Useful review	4.7 (.487)	3.1 (.974)	6.94***
Would use again	4.4 (.839)	2.7 (1.20)	3.77***
Helpful because visual	4.1 (.9)	2.7 (1.13)	4.76***
Waste of time[a]	1.5 (.665)	2.6 (1.44)	−3.62***
Confusing[a]	1.6 (.583)	2.5 (.978)	−3.77***

Note. High score indicates positive response for these items.
[a]Scoring reversed so that low score indicates positive response.
$^*p \leq .05$ $^{**}p \leq .01$ $^{***}p \leq .001$

experimental and control groups in both pilot studies demonstrated similar positive responses to three other Likert-scale items: (a) the visual benefit of the learning experience, (b) the extent to which they thought the experience was a waste of time, and (c) their willingness to use this mode of learning again.

In both pilot studies, subjects displayed significantly more positive attitudes toward the CAI program as a learning tool than they did toward traditional self-study with books. All subjects using the CAI found it more interesting and more helpful because of its visual benefits, and reported that they would use it again.

Responses to Open-Ended Questions

Open-ended questions (i.e., what subjects liked best and least about the learning experience and how it compared to other ways of learning) were analyzed by noting each subject's responses on the questionnaire, then classifying responses into major topics. In Pilot Study I, all but two subjects in the experimental group completed the questionnaire. In Pilot Study II, all but two subjects in the control group completed the questionnaire.

Analysis of the responses to open-ended questions identified major topics that were grouped into two primary categories: (a) *learning enhancers and* (b) *learning detractors.* The specific topics for each category are listed in Table 5.

Table 5
Responses to Open-Ended Questions

Learning Enhancers and Detractors	Experimental Groups		Control Groups	
	Pilot 1	Pilot 2	Pilot 1	Pilot 2
Enhancers				
Visual learning	•	•		
Concise format	•	•		
Learn at own pace	•	•		
Feedback	•	•		
Opportunity to test self	•	•		
Can review information	•	•		•
New way to learn	•	•		
Work with peers			•	•
Usual study mode			•	•
Pretest guided choice of information to study				•
Detractors				
Slow screen changes	•	•		
Narrow focus of topic	•	•		
Trouble using mouse	•	•		
Did not always receive feedback		•		
Information was redundant		•		
Not enough time to study			•	•
Not sure of what to study			•	•
Not a good time of day to study				•
Not a good day to study			•	
Not enough visual input			•	•
Environment too noisy			•	•
Distracting	•			
Hard on eyes	•			

Note. Table reflects comments reported by two or more respondents.

Ten topics classified as learning enhancers were identified by subjects in both experimental groups. These topics included visual benefits and the program's concise format and organization, as well as the subjects' ability to progress at their own pace, test their knowledge, receive feedback, and review information easily. Learning enhancers reported by the control subjects in both pilot studies consisted of six topics. These topics included the ability to receive feedback from peers and familiarity with the traditional study mode (e.g., some subjects stated, "I always study this way"), as well as the opportunity to review the subject matter and to use the pretest as a guide for studying.

Learning detractors identified by subjects in both experimental groups consisted of the CAI program's slow screen changes, the narrow focus of the subject matter, and difficulty with the mouse. Additionally, each experimental group reported categories of learning detractors not mentioned by subjects in the other pilot study. Experimental group subjects in the first pilot study reported eyestrain and difficulty concentrating on the program (e.g., "the program provided too much sensory stimulation"). In contrast, the experimental group subjects in the second study focused on redundancy of the information covered in the program and inadequate feedback on the self-quizzes (e.g., "the program did not always tell why answers were incorrect"). Learning detractors reported by control subjects in both pilot studies were lack of time to study the material, inadequate direction (e.g., "I was not sure exactly what to study"), lack of access to visual aids, the noisiness of the learning environment, and studying on a day or at a time of day unsuitable for them (e.g., "I always study at night," "I couldn't concentrate today").

Discussion

These pilot studies demonstrated that a CAI program and self-instruction with books resulted in different achievement test outcomes when used by students at two different universities. Learning outcomes with regard to student attitudes were very similar in both pilot studies.

In Pilot Study I, experimental and control groups did not significantly differ in posttest achievement scores. These students received the experimental (i.e., CAI) treatment before they were introduced to other learning experiences on applied anatomy and kinesiology. Experimental subjects in Pilot Study II, who used the CAI prográm as a supplement to previously learned material, performed better than their cohorts in the control group. The finding that all of the subjects in Pilot Study II attained higher achievement scores may have been related to their previous exposure to lecture and laboratory; however, the degree to which these other learning experiences could have influenced achievement test scores is unknown.

The need for visual input to assist learners in studying anatomy and kinesiology was a major issue reported by the experimental and control groups of both studies. Subjects in the experimental groups reported that the CAI program's visual emphasis was one of its most valuable qualities, whereas subjects in the control groups commented that they needed additional visual aids. This finding underscores the importance of visual media for learning anatomy and kinesiology and is consistent with findings from another study (Walsh & Bohn, 1990) in which medical students using CAI reported that graphics displays in the program enhanced their understanding of human anatomy. Other features reported by subjects in Walsh and Bohn's study as most valuable were identical to the learning enhancers identified by experimental groups in the present study: the self-paced format of the CAI, its concise organization, and its capacity for testing and feedback.

It is interesting to note that experimental and control group subjects in both studies valued the opportunity for interaction and feedback, regardless of the type of learning tool or the point in the learning cycle at which the tool was used. Subjects in the experimental groups valued the self-testing and feedback capabilities of the CAI program; those in the control group cited the opportunity for feedback and interaction with peers as aspects of the learning experience that they liked best and found helpful.

As with any other structured learning tool, CAI should be carefully chosen and used to achieve maximum benefit. Occupational therapy educators must exercise caution when using external structure to facilitate learning (Stern & Hassanein, 1992). Students need and continually seek structure in their efforts to integrate the vast amount of information required in occupational therapy curricula. This need was illustrated in the relatively unstructured learning environment of the control groups, in which many students reported use of the pretest to guide study efforts as the feature they "liked best" about the learning experience

Excessive reliance on structured learning experiences could have negative effects on learning. Students using highly structured CAI (particularly programs designed by their instructors) may believe that the program contains everything they need to know about the topic. This belief might discourage them from using additional learning resources or conceptualizing the topic in a different way.

Study Limitations

Each pilot study in this investigation was designed to measure student learning outcomes under a different learning condition. Because subjects were evaluated at different points in the learning cycle, the results of achievement tests in Pilot Study I and Pilot Study II cannot be compared statistically.

Because the pilot studies measured immediate achievement, results cannot be generalized to include retention effects. Administration of a second posttest sometime after the first posttest would have provided a comparison of immediate achievement versus retention of the material. In general, studies that measure immediate achievement after using CAI demonstrate larger effects than those in longer duration studies (Kulik & Kulik, 1987).

Conclusion

These pilot studies address a gap in the occupational therapy literature by investigating the learning outcomes of a CAI program in two occupational therapy curricula. Findings suggest that CAI in applied anatomy and kinesiology can provide an effective supplemental resource for occupational therapy students.

The students' positive response to the CAI tool suggests that carefully designed programs using CAI's visual and interactive capability can offer learning experiences that students value and perceive as helpful. Positive response to a learning tool is as important as its effectiveness in teaching the material. As Schwirian (1987) stated, "learning is an innately pleasurable activity . . . the imaginative use of CAI can and should contribute to joy in learning" (p. 130).

Analysis of the open-ended questions in these pilot studies revealed specific elements that enhanced or detracted from the learning experience (e.g., capacity for providing feedback, narrow focus of material). This information complemented the quantitative data and contributed a deeper understanding of the students' overall response to the learning experience. It also underscored the students' needs for structure, visual input, and feedback in the teaching–learning process.

Use of CAI in occupational therapy education is expected to increase in the future, and further technological enhancements are likely (e.g., use of virtual reality for patient simulations). The question is, how *well* will CAI be used? Using CAI to its best advantage includes establishing clear learning objectives and designing the program on the basis of current knowledge of how persons learn. Development and testing of CAI in different educational settings in collaboration with other instructors and an instructional design consultant can help improve the quality of the programs and ensure relevance to other curricula.

In all types of educational research, including studies on CAI, it is important to understand that substantial gains in learning outcomes are not easily achieved (Salomon, 1992). Furthermore, human learning and the teaching – learning process are complex and, as yet, not clearly understood. Future discoveries about human learning, as well as new ways of applying our existing knowledge to CAI development, may ultimately provide the most important advances for use of CAI in occupational therapy curricula. ▲

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