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ABSTRACT

A review of Project Themis, which focused on the computer as a teacher, is presented. Descriptions of research into four related areas of strategy are first provided. These research areas are: 1) learner strategies focusing on the internal cognitive and personality processes of the learner who is involved in computer-based learning tasks; 2) training strategies such as computer-managed instruction, adaptive testing, adaptive instructional systems, the automation of intellectual and personality measures, and the development of sequential and tailored testing; 3) validation strategies, concerning problems and research needs of ongoing Navy training programs; and 4) computer system strategies, including management systems, interactive systems and data analysis development. The development of human resources through the Project are documented and the principal findings are presented. (PB)

Final Report

OFFICE OF NAVAL RESEARCH SPONSORED PROJECT ON COMPUTERS AND INSTRUCTION

By

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ABSTRACT

At the inception of the ONR Themis Project in 1967, researchers were concerned with "the computer as the teacher." At the end of five years of research, the principal finding of the FSU investigators is that the context of computer-based training is broader than the original conception, and profits best from a management model for instruction. During this research period, the four interrelated areas of investigation were learner strategies, training strategies, validation strategies, and computer systems strategies. The primary focus of investigation for the learner strategy research was the study of internal cognitive and personality processes of the learner while in computer-based learning tasks. The trend in all learner strategy research is toward exploration of an adaptive instructional design that interacts with task and learner characteristics. The area of computer-managed instruction, first priority in the area of training strategies, was investigated with positive findings on its training effectiveness and cost benefit outcomes. Both adaptive testing and adaptive instructional systems were researched as training strategies, as were the automation of intellectual and personality measures, and the development of sequential and tailored testing. Applications of simulation and information retrieval systems in training and the use of simulation for research indicated that the techniques should be implemented and investigated in a wider array of applications. In the area of validation strategies during the Themis Project, every effort was made to interrelate with ongoing Navy training,

its associated problems, and its need for research. In computer system strategies, three areas of study and development were carried on during the five years of Themis at FSU: management systems, interactive systems, and data analysis development. Following the descriptions of these four strategy areas, the final report documents the results of the development of human resources through the Themis Project, and lists the varied technical documents which were produced as a result of project-related activities.

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1.0 The FSU Themis Project

If the group of researchers who began the ONR Themis Project in 1967 had envisioned the contents of the final report, the image of the table of contents would have centered about "the computer as the teacher." The group mind set was framed about the vision of enriched, detailed, student-computer interaction with training control via optimization. Now, in the light of the five-year research pathway, the FSU investigators can report their principal findings: the context of computer-based training is broader than the original conception and profits best from a management model for instruction. The FSU team found that there is no singular way to individualize instruction to its optimal level without employing some of the older techniques, such as group discussion, or the newest ones, such as multimedia splitscreen presentations. This requirement for a broad multifaceted approach to training resulted from facing research as it evolved through study after study toward "the computer as the manager of instruction." Using a computer-managed instructional (CMI) model to encompass computer-assisted instruction (CAI), simulation, adaptive testing, natural language dialogues, media management, scheduling, record keeping, and evaluation, the potential of each of these components as training processes became most enhanced.

For purposes of project management over the years, the studies were organized into four categories: learner strategies, training strategies, validation strategies, and computer systems strategies. In learner-oriented research, investigators sought to find the students' cognitive and personality processes reflective of computer-based training. Therefore, studies included rule learning behaviors, behavioral objective learning, memory, subjective organization, anxiety, and curiosity. Those involved in training strategies studied effectiveness of computer-managed instruction, the possibilities of adaptive testing and modeling, and the uses of simulation and information retrieval systems. The focus was on the design, implementation, and evaluation of CMI components. The area of validation studies led to the evolution of a Naval Research Interdisciplinary Team, an important ideational contribution in its own right. Computer strategies produced, over the years, insight into interactive systems, instructional management systems, and data analysis systems.

Brought together, the strategies, the studies, and the results lead to the repetition here, and throughout this report, of those themes which yielded the most profitable outcomes.

1. A model of computer-managed instruction yields a sufficient, integrated, and cost-effective approach to training.

2. The individual difference variables reflective of the behavioral processes of memory, anxiety, curiosity, and rule application are critically important to a CMI adaptive training model. Further research is requested to extend the set of available indices reflecting training in learning behavioral objectives, graphics, etc.

3. The selection and integration of media components and the requirements for optimal resource allocation of training elements (instructors, simulators, peer instructors, etc.) have received limited research attention and represent promising areas of the future.

4. The requirement to build substantive liaison models between the Navy and university researchers is essential if the design characteristics and requirements of training on the one hand and the theoretical concepts on the other are to merge in productive fashion. The FSU Interdisciplinary Navy Research Team was an exemplary model of this liaison process.

5. In reference to computer strategies, the creation of management or central programs was highly profitable and the need to create training-oriented management systems is of the highest importance.

6. The developmental techniques to implement CMI were originated and should be extended especially for semantic models for natural language interaction and online management review of adaptive training procedures.

1.1 Interdisciplinary Efforts

The DOD Themis Program was initiated to facilitate the growth of university interdisciplinary efforts. From its inception, the FSU team reflected this interdisciplinary DOD theme and the requirements for it in an area like computer-based training. While no formal evaluation was attempted, each researcher did comment on the intellectual benefits of the FSU interdisciplinary project meetings. Moreover, the benefit of collegial critiques, assistance, and joint studies was highly productive. From this person-to-person view, the interdisciplinary team was outstanding.

As viewed at the university level, the interdisciplinary effort tended to be a failure. First, the existence of interdisciplinary institutes and groups at FSU diminished markedly over the last five years. Secondly, interdisciplinary research work is commonly treated as an overload activity to be pursued after the departmental duties are completed. Finally, the recent fiscal stresses on universities have led to a traditional retrenchment that combats all interdisciplinary innovation. All in all, the university climate today is quite negative towards interdisciplinary efforts. These observations would probably hold for the majority of American universities and are not unique to FSU.

2.0 Learner-Oriented Research

As the prior section of this report indicates, the primary focus of investigation for the learner strategy research was devoted to studying the internal cognitive and personality processes of the learner while in computer-based learning tasks. Studies of rule learning behavior, anxiety and curiosity, and memory lead to positive indications that can be predictors within an adaptive CMI system. Results of research into the role of behavioral objectives in learning, and into subjective organization have led investigators to view these as less rewarding areas.

2.1 Rule Learning Behaviors

Probably the most common type of learning undertaken by students is the acquisition of principles or rules. By learning rules in a specific situation as one of a class of situations, the rule-governed behavior of the learner permits more effective learning strategies that generalize to more than one situation.

In this discussion of rule learning behavior, it will be helpful to consider three interrelated concepts. These are the rule statement, the rule, and rule-governed behavior. A rule statement describes the procedure to be followed in performing a specific operation on inputs from a specified class of inputs to produce a specific output from a class of outputs. The rule is considered to be the procedure or operation described by the rule statement. Rule-governed behavior is that behavior that would result from a student correctly applying the rule. The ambiguous term "rule learning" may now be divided into two appropriately descriptive terms: (a) learning the rule statement which refers to learning to verbalize the rule statement, and (b) acquisition of rule-governed behavior which refers to the correct application of the rule.

At FSU, a study was implemented to investigate prior findings that presented rule statements reduced the number of examples needed, and total time required to meet a prespecified criterion. Further, presentation of rule statements increased performance on a transfer task and reduced the requirement of reasoning ability in learning the task. The presentation of objectives also reduced the number of examples and reduced the requirement for reasoning ability. The study showed that presentation of rule statements reduced the number of examples required to meet criterion performance, increased posttest performance, reduced total time required to meet criterion performance, increased retention performance, and reduced the level of state anxiety within the learning task.

A further study in this area found that the presentation of objectives increased the total amount of time spent studying a rule learning task. The presentation of sample test items within the learning task reduced the requirement for memory, but neither objectives nor sample test items had an effect on post or retention performance.

Implications from these studies for instructional method in acquisition of rule application skills appear to be threefold:

1. Instruction should present general instructional objectives to inform the student as to what is expected of him but not for specific learning.

2. Presentation of rule statements can prevent the "discovery" of an incorrect rule.

3. Presentation of sample test items gives the student a chance for practice and immediate feedback.

Further studies at FSU revealed that availability of prior examples reduced problem response latency and reduced the requirement for reasoning ability. A present investigation appears to show that memorization of work statements reduces both the number of examples and total time to reach criterion performance on complex rule application tasks. However, no memorization effect has been found on the posttest or retention test of rule application skills. Implications for instructional development are (a) the requirement of memorization of rule statements to facilitate the correct choice of a rule when more than one is being learned, and to aid in recognition of operational symbols if they are used is of marginal benefit; (b) the use of several examples to show the statement instances of the correct application of the rule is critical; and (c) the use of review if more than three rules are being learned in one session to provide simulated testing is required.

2.1.1 Future

In addition to apparently useful generalizations given for the development of instruction for acquisition of complex rule application skills, implications for fruitful research in this area have grown out of the FSU investigations. It should be ascertained what type(s) of examples are most profitably presented to the student: nonexamples, examples, or both. A second topic of research recommended is the investigation of design of rule learning materials dependent upon the abilities of the learner; this would contribute to the adaptive model research. A final topic which appears to offer promise is the area of optimal number of examples for presentation before sample test items. All of these studies relating to number of examples would contribute to a drill and practice adaptive model.

2.2 Behavioral Objective Learning

Only in the latter part of the decade was research undertaken to examine empirically the claims made for objectives in instruction. Of the approximately 35 studies conducted, about half failed to confirm the hypothesis that providing students with objectives leads to increased learning. Remaining studies showed facilitative effects. The research on interactions between objectives and type of learning provided few positive findings. No general conclusions are evident in the research, which found a few significant interactions between objectives and learner characteristics.

Investigations at FSU found that objectives significantly increased study time with no posttest difference between groups, and that objectives partially reduced anxiety without affecting performance. The hypothesis that objectives add structure to learning as is done by advance organizers was not confirmed. A further study found that objectives focused learning on relevant materials and depressed incidental learning.

To generalize from studies overall, it seems that objectives have only a peripheral effect on learning, and this effect does not appear to be as strong or as pervasive as originally assumed.

2.2.1 Future

It is anticipated that research on behavioral objectives will continue the trend away from exploration of their effect on learning. The trend will be toward exploration of interactions with task and learner characteristics. The exploration of hypothesized cognitive functions which may be fulfilled by objectives in the learning situation is anticipated to grow, but to have limited positive potential.

2.3 Memory Research

An important capacity of memory is the ability to discriminate. This is an idea which has been reinforced by the research which was conducted on direct forgetting. Important to the retrieval of some previously stored event is that the individual be able to discriminate it from other stored information. Voluntary forgetting appears to be largely a matter of sharpening the capacity to discriminate between material which is to be remembered and that which is not.

This way of looking at memory raises the question of the nature of information storage. If the ability to discriminate among memories is important, then perhaps encoding is in terms of dimensions which offer a basis for discriminating among memories, and more specifically, in terms of the values of such dimensions. Just what these dimensions are is unknown. The point is simply the proposition that events are encoded according to abstracted features.

Another study investigated short-term memory (STM) prerequisites to development of more complex mental processes. Of special interest were the possible differences between white, advantaged children and black, disadvantaged children. Differences would seem to indicate that memory characteristics are not the same for these two groups.

The findings were also compared with prediction of three of the more characteristic information processing models for STM: Sperling's Visual STM Model, the Feigenbaum-Simon Computer Simulation Model, and the Atkinson-Schiffrin Model. It was found that some of the results could be incorporated into the structure of all models, but that no one model could account for all the findings. An alternative model was developed which included an IQ parameter, a more complex rehearsal process, and an operational representation of organizing strategies.

Conclusions for both the directed forgetting and STM research are that they both indicate possible individual differences which could be useful in adaptive instruction. It is necessary to continue research to fully operationalize appropriate memory indices.

2.3.1 Future

In the near future of memory research, the computer will be used to construct theories and to simulate memory performance rather than to assist in the conduct of experiments. This will be particularly true in the areas of semantic and long-term memory. These theories are particularly complex and it will be especially useful to simulate performance. By contrast, experiments to test such theories may be simple and fairly easy to conduct with relatively unsophisticated equipment.

2.4 Subjective Organization

The purpose of the research on subjective organization (SO) was to determine if SO is a meaningful individual difference variable in the learning of verbal discourse. Furthermore, the relationship between SO and other aptitude variables thought to be important determiners of learning from prose materials was examined. In order to accomplish this, a new measure of subjective organization had to be developed because previous measures had certain limitations which were thought to mitigate against finding a meaningful relationship between memory organization and recall. Thus, as an outcome of this research, a new measure has been examined and partially validated in relation to other SO measures and other individual difference variables.

The basic research paradigm was one in which SO and other measures were administered to subjects and then those subjects were asked to learn paragraphs which were organized in various ways. The results indicated that high organizers are highly influenced by the external structure of the learning materials, and they tended to mirror that organization in their recall. High organizers, however, were able to reorganize the materials, but that was not to their advantage because of the time constraints involved. That is, high organizers actively sought alternative relationships among the sentences, thereby reducing the amount of time spent memorizing them.

Four generalizations can be made on the basis of the studies which were conducted at FSU on subjective organization:

1. The ability to reorganize material can be a limiting factor to a learner if sufficient learning time is not provided.

2. Low organizers need to have learning materials structured to a higher degree in order for them to learn effectively.

3. High organizers perform equally on materials of high and low structure.

4. Our current measures of SO are too limited and lack sufficient validity.

2.4.1 Future

The conclusions of the investigations in this area indicate that future research should consider the following:

1. A practical, reliable, and valid instrument for measuring SO must be developed. In this regard, the potential use of a computer for realtime presentation and scoring is promising.

2. Explorations on more complex instructional tasks must be undertaken on the finding that low organizers need highly structured materials whereas high organizers perform the same on both high and low structured materials.

Continuation of research in these areas should provide instructional designers with a set of findings which would guide the structuring of textual materials such that the learning of all students will be maximized.

2.5 Anxiety and Curiosity Research

The FSU investigation of anxiety and curiosity behaviors of a student while being trained was primarily focused on the use of these personality indices as predictors of optimal instructional treatments. While state/trait theory initially guided our efforts, the subsequent inconsistencies between replicatable findings and the theory indicated its limited role in a training context. The theoretical study of curiosity did provide us with a new framework which appears to resolve many of these prior inexplicable complexities.

The development of state/trait anxiety theory, based on drive theory, allowed a number of derivations for prediction of performance relevant to computer-assisted instruction. At the same time CAI seemed an excellent vehicle for testing the theory. The results were not encouraging for confirming a drive theory interpretation of state/trait anxiety. However, anxiety was shown to be an indicator of CAI performance and the thrust of research continued in this area. Studies included anxiety effects on memory support, test taking, and interactions with response mode, subject matter familiarity, and learning time.

The important results indicated a consistent inverse relationship between state anxiety and learning, differential effects of trait anxiety especially as it revealed learner latencies, the complex role of memory aids and response modes as facilitators under some conditions, and the complex functional relationship of anxiety, curiosity, and latencies. This latter finding could be a promising future framework for studying latencies within training.

In addition, the anxiety theory and research directly initiated and influenced new work on state/trait epistemic curiosity. Curiosity provides an additional indicator of performance within instruction and specifically CMI. The concurrent interests in adaptive instruction models resulted in postulating the value of these personality variables as useful predictors in decision models for selecting alternative individualized treatments. One study, utilizing regression techniques, especially found state anxiety to be a useful predictor for selecting remedial instruction.

2.5.1 Future

For the future, the investigators anticipate that the effort within adaptive models and the theory of anxiety-curiosity within training will be highly fruitful. The use of anxiety-curiosity concepts to study response latencies may help explain the highly variable results thus far found.

2.6 Graphics Research

In order to employ the research capabilities of computer presentation of graphics in instruction, an initial study at FSU provided the opportunity for devising techniques to code graphics onto the cathode ray tube screen. This general model of graphic encoding was then used to develop studies of selection and sequencing of graphics for realistic training materials. Further attempts to learn the rules of graphic learning revealed that the search for such rules is difficult, and can even be considered unprofitable.

Furthering the graphics investigations, FSU pursued research in mapping sentences onto graphics. Studying this instructional technique provided data which were complex. More appeared to be going on in this instructional situation than could be easily interpreted by learning theory.

Used as a teaching aid, computer graphics proved helpful in instructing engineering dynamics students in the traditional stumbling block of Euler angles. Graphics assisted in visualization of the angles, and subjects reported positive attitudes toward the instruction.

2.6.1 Future

Generally, given current constraints, the search for rules in learning from graphics appears to be unsuitable for study. As an aid in problem solving, graphics apparently lend assistance to learning and the experience can be positively viewed by learners.

3.0 Training Strategies

A major investigation of computer-managed instruction was conducted as a priority in training strategies, to study training effectiveness, and cost benefit outcomes. Further training strategies in the areas of adaptive testing, adaptive systems, simulations, and information retrieval systems were also researched to various degrees. The research, generalizations, and future trends are described in the following sections.

3.1 Computer-Managed Instruction

Throughout the duration of the contract there was a concurrent set of investigations in computer-assisted instruction (CAI) and computer-managed instruction (CMI). The primary purpose of the investigations of CMI was to determine its training effectiveness and associated cost benefit outcome in comparison with CAI and other more conventional means of instruction. As pursued at FSU, computer-managed instruction involves the following:

1. diagnostic assessment and the assignment of individualized learning prescriptions,
2. the use of CAI for practice and remediational purposes,
3. the use of simulation for role and decision-making training purposes,
4. the use of the computer for ease and objectivity of curriculum development, and
5. the development of a record system so that the individualized training process can be effectively monitored and managed.

Within this CMI conceptual context, a number of studies were pursued. All of these studies indicated that CMI at the collegiate level is highly feasible, cost effective, and provides for learning results similar to CAI. However, due to the mastery level learning approach utilized in the instructional materials, the relationship of individual difference variables to learning rate or performance was more limited. Where extensive media and recitation sections were used, the effects of individual difference variables seemed to be more pronounced. Finally, learning attitude toward the instructional materials was quite positive and could be manipulated by the form of training.

In turn, investigations of CAI indicated that it is useful in a number of technical training areas. It proved especially useful for dynamic graphics such as found in engineering dynamics. However, while CAI was shown to be viable in areas like chemistry, the results did not tend to exceed those found in CMI.

It is important to note the fact that the development process for CMI, while not quite as demanding as that of CAI, still was considerable. Dependency on a sound training model, use of formative evaluation, and effective monitoring of students in an individualized mode seem to be the critical factors in the design and implementation of CMI.

From this, consequently, the following research generalizations can be derived:

1. Terminal-oriented computer-managed instruction has shown to be more effective than conventional instruction and less costly than computer-assisted instruction.

2. The most significant gains in the quality of instruction have not necessarily been due to the use of computers, but have been through the implementation of systematic approaches to the training process required for application of the computer.

3. Although the computer provides the instructional developer with more information about the instructional process than has been available, the revision process remains the least well understood and utilized component of the systems approach; however, the provision for systematic, reliable data encourages attention to this problem.

4. Interdisciplinary collegiate development teams will not necessarily produce better computerized instructional materials than those produced by conceptually integrated teams.

3.1.1 Future

During the time period since the initiation of the Themis Project, educators have come to understand that in order to implement individualized instruction for the learner, there is a need to provide similar training for the trainer. This new form of teacher training has been labeled "competency-based" or "performance-based" training. The implementation of such training programs has more clearly identified the needs which such programs have for a computer. These computer needs, in general order of priority, are listed below:

1. Record keeping of computerized and noncomputerized assessments of student performance for monitoring purposes

2. Scheduling

3. Assessment of "computer-testable" skills

4. Adaptive remediation, including CAI and drill and practice exercises.

If this list is an accurate reflection of the needs of such programs, then it would appear that the role of the computer must be first as a general management system and only secondarily as an assessment and instructional tool.

3.2 Adaptive Testing

The initial undertaking with adaptive testing concerned itself with the automation of intellectual and personality measures. This effort successfully resulted in the automation of an individualized intelligence test (Slosson Intelligence Test) with satisfactory reliability and validity coefficients. Moreover, a complex personality test, namely, the MMPI, was also satisfactorily implemented. These studies indicated that response latency contributed to the score information and concurrent validity when measured against a conventional administration. This line of research eventuated in a systematic review concerning the various uses of automated testing.

In turn, the development of sequential testing and tailored testing continues to be investigated. Utilizing simulation techniques, sequential testing can be shown to be a profitable approach. The general goal of sequential testing is to present the smallest number of test items necessary to accurately classify an examinee into two or more exclusive groups, or in conceptual terms, to improve reliability and validity of or the decision process within CAI testing. Previous computer-based sequential testing models have been based upon right-wrong measures of performance. The FSU sequential testing effort differs from previous models in that both univariate and multivariate performance measures are utilized. The multivariate prediction model is expected to increase classification accuracy beyond that possible using binary-coded item response data alone. More importantly, the use of tailored testing is currently being investigated as an approach for the administration of attitude items in a training situation. It is conjectured that the number of test items can be minimized and the assessment of learning satisfaction can be improved in terms of its accuracy.

These studies of sequential testing led to the development of adaptive reading comprehension tests. The adaptive reading tests provided for a more dynamic individualized search of the student's current comprehension level, especially under paced conditions. The rationale for using paced conditions is based on learning time savings being pace contingent.

3.2.1 Future

In the future adaptive testing will most likely focus on two aspects. First, an investigation of incorrect as well as correct alternatives via Bock's multiple category model shows great promise. This approach should allow for adaptive selection of items by item alternative characteristics and the assignment of sequentially derived confidence bands about the student's performance level. Given the improved information from this approach, it is then conjectured that a sampling approach to sequential testing can more effectively provide for the early classification of a subject especially if complex confidence band techniques are utilized. Thus, the future tends to hold a continued seeking for more efficient testing procedures as well as ones which will have psychometric properties appropriate for the individual and not just the group.

3.3 Adaptive Modeling

A major theme throughout the ONR-sponsored research has been that instruction should not be fixed for all students either in treatments or time. The alternative to fixed instruction is adaptive instruction which attempts to match an individual's unique characteristics with optimum treatment dimensions. Models for selecting appropriate alternative treatments consist of contingent, mediated, and optimizing algorithms designed to achieve the objectives.

The initial studies of adaptive models at FSU investigated learning and personality variables which might prove useful in predicting and assigning remedial instruction, lesson length, and other instructional variables. Multiple linear regression methods were developed and used in an early modeling attempt with predictor variables consisting primarily of performance variables. Personality variables were added, in a phased approach to determine useful predictors, which resulted in outstanding performance levels for the adaptive group. A major study which manipulated the assignment of remedial instruction was undertaken. The order of outcomes in terms of superiority were the adaptive model strategy, remediation for all strategy, a learner choice strategy, and a no-remediation strategy.

These results and models were then considered for employment in reading comprehension. More recently, models based on the experience gained in the ONR-sponsored research were developed for the Air Force Advanced Instructional System. In addition, ONR adaptive modeling has continued with an investigation of drill-and-practice in terms of lesson structure composition. Further, the study of the utility of measures which relate information processing to reinforcement contingencies for adaptive instruction has resulted in a model which takes into account both memory and motivational processes and procedures.

3.3.1 Future

It is anticipated that investigation of the monitoring and managing aspects of both training resources and of the individual will provide payoff in the future. This will involve managing such alternatives as the problem set size, the sequences among sets, the assignments of media, the assignment of instructor and peer time, and the use of incentives.

3.4 Simulations

3.4.1 System Simulation

One of the major methods of using simulation in education, as well as other spheres, is the projection and analysis of systems. By simulating a prototype computerized management system intended as a subcomponent of the FSU elementary teacher training model, the CAI Center examined a number of problems in data acquisition and instructional systems. The following generalizations resulted from the system analysis: (a) a computer-managed system is technically feasible for use with an individualized teacher training program, and (b) computer processing for trainee scheduling and testing data, as well as program management, is necessary.

Simulating a teacher training system using information from a behavioral simulation, FSU found advantages in experimentation capabilities, and resulting predictions about the teacher training program. Further, advantages were found in the utilization of regression techniques in combination with A Programming Language (APL) for designing, constructing, and utilizing a system simulation.

3.4.2 Behavioral Simulation

A behavioral simulation was used at FSU to train prospective teachers by providing an environment facilitating transfer to the classroom. Analysis for the behavioral simulation proceeded through assessment of entry behaviors, collection of data on trainee performance during instruction, collection of data on criterion variables, and analysis and evaluation of the required training process in terms of the dimensions of simulation theory to estimate the nature and validity of the behavioral simulation. Behavioral simulation appeared to permit change in participants' behavior patterns.

3.4.3 Instructional Simulation

A further major function of simulation is instruction. Much of the debate in this area continues to be over the potential for simulation to affect attitudinal and/or cognitive growth. One game, or simulation, developed at FSU was designed to allow the player to relate his knowledge of science to situations in elementary classroom instruction. Use of the game by graduate students indicated that a learning environment of this nature can foster growth in both cognitive and affective areas.

One of the primary advantages seen in instructional simulation is the ability to reduce cost (e.g., by reduction of expensive laboratory equipment) and a second is experimentation without danger (e.g., investigating dangerous chemical combinations without use of the chemicals). Investigation into simulating laboratory experiences at FSU showed that simulation, as opposed to traditional laboratory methods, was equally effective as evaluated by posttest performance and total instructional time.

3.4.4 Statistical Simulation

As is suggested in the Computer Systems section of this report, A Programming Language (APL) proves to be an outstanding computer language for the simulating of statistical analyses, due to its mathematical capabilities. It is possible for a student to explore the meaning of various statistical concepts through sample problems and exercises, which he works as often as he wishes. He can be guided through the hypothesis testing procedure by inspecting data, successively making appropriate inferential decisions as further hypothesis testing information is given him. This type of APL simulation continues to expand as its utility and appeal are exposed to wider audiences at FSU.

3.4.5 Simulation Development

Investigators of simulation generally predict a more widespread use of the technique, both in education and in other spheres, for research and analysis as well as instruction and training. Advances in the development of such simulations, however, are meager. The major problems affecting progress are seen in evaluation:

1. Many authors feel that their simulations produce affective rather than cognitive changes, and are unsympathetic to stating behavioral objectives. Since an equal number of authors and users request behavioral objectives for simulation, this problem may not be resolved until statements of affective objectives are

satisfactorily developed, and can be evaluated.

2. Evaluation of instruction by simulation is correspondingly difficult. A search for satisfactory new methods of evaluation may be a future activity, or a satisfactory relating of simulation evaluation to existing techniques.

3. The validation of the simulation model itself remains the most difficult part of simulation development. While mathematical simulations appear to have potential to solve this problem through output comparisons, simulations of human behavior, for example, provide a requirement for establishment of other model validation procedures.

3.5 Information Retrieval

3.5.1 IR for Inquiry

Information retrieval (IR) systems, like simulations, can be developed and used for research and/or instruction. FSU research on a CAI-based information retrieval system containing 5312 social science generalizations was directed toward examination of human inquiry behavior and appraisal of affective factors within the task. Both the feasibility of the approach to improving inquiry behavior and the positive nature of learner reaction were established in the IR application.

3.5.2 IR Instructional Tasks

In the library science area, recognition of the future growth of automated IR systems led to provision of computer-based IR tasks for advanced students. Both instructional and research goals were set for the use of the online searched coordinate index, which referenced 1856 documents prior to its transfer to the

IBM 6400. As a teaching aid in graduate courses, the IR system served several instructional purposes: (a) a demonstration of an on-line search was available to students, (b) the system provided lessons in preparing and searching coordinate indexes, (c) the system permitted students to develop skills in the use of computerized IR, and (d) students were able to perform test searches of the index with reference questions.

For research purposes, all student uses provided data which were collected by the computer system and stored for use in IR evaluation and revision. Data collected on student attitudes were positive, as were professional observations. This system was one of the first implemented in library schools.

3.5.3 Future

Since good inquiry skills are universally useful, the potential of IR systems in enhancing these skills is an area of interest in which future research is recommended. It is suggested that the new techniques of observation and evaluation gained in participation in these developmental efforts become part of the individual's professional research, development, and teaching approach, thereby enriching members of such groups.

The development and use of information retrieval systems in library science is an example of uses that can be made of specialized IR systems in a number of fields. Since the number of fields which will add computers and IR systems to their requirements continues to grow, the development of this type of instruction should be present in concomitant instructional areas.

4.0 Validation Strategies

During the Themis Project, every effort was made to interrelate with ongoing Navy training, its associated problems, and its need for research. Contact was maintained at a professional level with the Navy Research Laboratories at San Diego, Memphis, and Orlando. As an integral part of Themis, a team of FSU professors who were also active in the Navy Reserve was formed into a functional unit. This group represented a bridging process between the various research studies formed here at FSU and their application within the Navy. Secondly, experience developed under the ONR Themis Contract allowed performance of associated Department of Defense activities. The most significant of these was the design and specification for the Advanced Instructional System at Lowry Air Force Base.

4.1 Navy Research Interdisciplinary Team

The team of FSU professorial investigators who also had active relationships in the local Naval Reserve pursued a number of objectives. First and foremost, the group applied the concepts and procedures of computer-managed instruction (CMI) to local training of the Seaman 1 classification. This CMI implementation study was quite successful in that there was both a significant increase in performance level as well as a significant savings in training time. The results were tempered by the small number of participants and are in the process of being replicated at such bases as the Air-Naval Station at Memphis, Tennessee.

Secondly, the group pursued broad systems concepts for the planning and management of Naval training. This led them to attend many conferences and provide consultative help to the Naval Reserve system itself. In many cases the team members performed active duty at Omaha, which led to significant plans whereby more effective reserve drills could take place.

Lastly, the team provided leadership for the Navy concerning university and community relationships. As university models, they effectively contribute to and are utilized within Naval Reserve operations. Secondly, in regard to community involvement, they advanced the Navy concerning such special training problems as race relations, drugs, and other associated behavioral matters. Perhaps more directly related to computer activity, they assisted in the design of information management systems and associated adaptive training and testing systems.

In regard to some constraints, the usual problems of communication and lack of goal understanding handicapped the group at many turns. Given a fair degree of isolation in Tallahassee, Florida, the group maintained a vigorous information exchange which undoubtedly led to the successes that it achieved.

4.4.1 Future

For the future, this university-Navy liaison should be pursued with more vigor. The benefits of mutual problem solving are sufficient to make it an essential part of any large training R and D effort. The two-way communicational and educative process has the highest potential.

4.2 DOD Computer-Related Activities

As an indirect consequence of Themis, the project personnel was also able to serve the Department of Defense on other training projects. The most significant one of these was the AF Advanced Instructional System (AIS). FSU could not have designed and specified the AIS without the prior work of the Lowry Human Resource Laboratory group or its own critical experience and data from Themis. A description of the AIS project follows.

The Advanced Instructional System (AIS) is a development within the Air Force Human Resources Laboratory (AFHRL) to implement the latest demonstrated state-of-the-art training techniques, media usage, management procedures, and computer technology to Air Force Technical Training. The CAI Center was awarded a contract by AFHRL to develop functional design specifications for the individual multimedia computer-based training system which would provide significant cost-effective improvements in the operation of technical training courses at Lowry Air Force Base, Colorado.

In addition to the goal of providing individualized training, AIS will focus on the managerial processes which can be enhanced by the computer, cost-effective multimedia approaches which may provide time-savings, modular implementation which will provide both flexibility during development and revision of learning materials and additional cost savings during expansion throughout the Air Force.

AIS will be implemented within three technical training courses with a total enrollment of over 2000 students. The courses of Inventory Management (inventory and supply), Precision Measuring

Equipment (precision electronics measurement and calibration), and Weapons Mechanic (tactical weapons loading) represent a broad range of technical training requirements.

The AIS consists of seven subsystems which reflect the scope and complexity of the effort: (a) instructional materials, (b) instructional strategies, (c) media hardware and software, (d) management components, (e) computer hardware, (f) personnel and training requirements, and (g) related requirements. These subsystems are designed to provide for all aspects of the instructional process from materials development and evaluation through student use and management to review and revision. Operational considerations, including computer systems design and maintenance, CAI languages, and the selection and training of AIS personnel are also considered in the design.

5.0 Computer Systems Strategies

There were three main areas of design and implementation of computer systems for instruction, namely, (a) interactive programming languages, (b) management schemes, and (c) data analysis systems. The software or language developments employed a common strategy, to maximize the ease of use while devoting a minimum of developmental effort. The topics within this theme will be organized around the above three topics.

5.1 Interactive Systems

5.1.1 Coursewriter Functions

Of the institutions utilizing the IBM 1500 system, FSU probably developed the least number of additions to Coursewriter capabilities in the form of functions. This is due to the frame-oriented Coursewriter language and the fact that the already available functions were sufficient within limits.

The frame or PI orientation of Coursewriter is important to recognize because of its tendency to direct the type of instructional material and strategies for both learner and researcher/developer. A major lesson learned from use of this language was the need for non-frame oriented, algorithmic style languages when expansion of research and development is the goal.

5.1.2 A Programming Language (APL)

The development of the programming language APL (A Programming Language) on the IBM 1500 CAI system was a project oriented toward determining the capabilities of this type of language for meeting the diverse requirements of computing in education. The elegant and powerful data structures and commands of APL appear suitable to the areas of instruction, data processing, and computer science.

5.1.2.1 APL Generality

A measure of any programming language is its need for extensions. In the instance of APL, extensions in the form of functions were developed in the areas of programming aids, statistical analyses, character handling, numerical manipulation, and graphic control. The fact that such APL functions can be created and so extend the language is to its credit; however, the fact that extensions were needed is an indicator of educational requirements for more than one computer language.

5.1.2.2 APL Instructional Programming

APL's usefulness for statistical analyses and simulation activities has been documented by FSU, and demonstrated through certain graduate-level courses in the College of Education in which the majority of students chose to learn APL as a programming language for educational purposes. Beyond the use of APL for instructional simulations, however, there appears to be reasonable doubt as to its feasibility as a general CAI language. In the experiences at FSU, little instructional programming with APL was performed other than simulation packages.

5.1.3 Natural Language Processing

One of the initial dreams for research in CAI was the possibility of nearly natural communication between student and computer for the purpose of instruction. Over the past few years this research has become actuality based on the concept of semantic processing and semantic nets as defined first by Quillian. Carbonelle terms most CAI systems "ad hoc, frame-oriented" systems, in that all stimuli presentations and responses must be fully planned ahead. With a natural language processing system and appropriate semantic-oriented data bases, such preplanning is not necessary, and, in fact, the flexibility of the system may be more powerful and realistic for learning.

5.1.3.1 FSU Dialogue

The thrust of FSU natural language research has been not so much on the technical aspects of computing that must be solved for such a system, but rather on the pedagogical considerations for specifying and planning the desired type of instructional dialogue. To accomplish this, a systematic technique was developed which utilized the typically stated steps for instructional development, oriented toward natural language instructional dialogues. More specifically, the analysis of instruction was based on determining a semantic network of information which the student was expected to have learned by the end of the dialogue. On the basis of this semantic network, a data base and questions to the student can be specified as performance objectives and so programmed. While this particular type of system is limited in its power for developing semantic networks, particularly for syntactic analysis of student input, the project was nevertheless a success as a prototype development. A complete dialogue was developed for a humanities course, and students using the dialogue in this course did generally acquire the semantic content as specified in the systematic approach to the dialogue development. A more extensive research program would be required to fully research and evaluate the techniques used.

5.1.4 Remote Communications

One of the major problems experienced with the IBM 1500 instructional system was the lack of a teleprocessing capability. The requirement for teleprocessing became apparent as projects developed for transporting CAI and CMI capabilities to rural areas in North Florida and to government laboratories. The cost for initial CAI capability was obviously beyond the financial reach of these institutions, and the cost-effective manner of providing the capability was through the FSU system. Thus a remote teleprocessing communications system was developed in house including both software and hardware design. FSU personnel worked with personnel from Digital Equipment Corporation in this project, as IBM regarded these requirements as impossible. The major lesson learned from this effort is the necessity to consider teleprocessing capabilities as an essential requirement for any computing system which is to be used in education.

5.1.5 Computer Art

Recently, the art community has discovered the computer in its quest for new media for artistic involvement. To provide support for this movement, in the belief that computer use in education means more than programmed instruction, FSU convened a seminar in computers in the arts. Art prototypes were produced. A notable advantage which seemed salient was the development of interactive computer art through which art observers could be placed in a responsive and controlled art environment. This interactive dimension of the medium lends itself to the artist's creativity beyond other current media forms.

5.1.6 Future

It is anticipated that further exploration to the area of interactive systems is very promising, especially in terms of multi-media approaches. Present language capabilities will continue to be expanded, while more interactive dialogue and natural languages will be developed.

5.2. Instructional Management Systems

Instructional management systems consist of the computing software and hardware necessary for control and monitoring of the instructional process. Operationally, it is convenient to talk of the instructional data base as the associated files within the data base as well as the manipulation of those data for control and monitor functions. It is a prime tenet of computer systems analyses that the specification, design, and utility of instructional systems data bases are tied to appropriate identification and integration to the educational functions. The focus of the FSU approach has been development and dissemination of data base software appropriate to educational users in both service and research.

5.2.1 APL File System Package

One of the prime limitations of the APL/1500 system, and indeed most APL systems, was the lack of a file establishment and manipulation capability. To overcome this limitation, the APL/1500 File-Access Subroutine Package was developed. The package permits offline access to data generated through instructional and research applications of the system. It was found that needs of users which must be filled by the system are: (a) the capability to access data for analysis by other computer systems, (b) the capability to access data for acquiring hard copy in a quicker mode than is available on an IBM 1500 system, (c) the capability to build input data to APL files, and (d) the capability to extend data base sizes. It should be noted that the file access subroutine package was built as a direct extension onto the file system capability which already had extended the APL data base functions. For example, these capabilities allowed a major project of instructional usage in information retrieval systems for the School of Library Science. The IR Project was able to develop a system of automated abstracting and retrieval on the APL file system. The system also provided instruction for graduate library science students in the areas of automated library retrieval systems. Experience with this IR function indicates that any system of computers in education must provide the capability for a well-defined file system with variable structuring and flexible manipulation.

5.2.2 Data Base Manipulation on the Coursewriter System

Specific requirements were found for manipulation of large files on a regular basis. Because of the volumes of data collected in CAI research, highly efficient programming was needed to allow maximization of program execution times and therefore operations. One of the major problems in all computer systems, not just in education systems, is the bottleneck of input and output functions. That is, program execution is no faster than the time it takes to pass data through it, the "throughput" time. However, throughput is primarily a function of the time for input and output. Throughput improvements were accelerated by programming internal execution speeds so that programs approached the I/O boundary conditions while still maximizing execution efficiency.

5.2.2.1 Sort and Merge

An internal, sequence-sensitive, bi-directional sort was developed to take advantage of the fact that CAI records and data are not randomly ordered, but are rather more often slightly out of sequence. This occurs because data are recorded for students within specific courses at approximately the same time and dates.

The bi-directional sort locates the correct sequence position of a currently encountered, out-of-sequence record in no more than eight comparisons for any 100 response records. The software management allows blocking of records in groups of 100. In addition to the fast location finding of the sort, no data are immediately swapped because a table of locations is kept and accessed for addressing the individual records. That is, intermediate data swaps have been eliminated by indirect data examinations via a bi-directional linked-index listing procedure.

In addition to the high speed sort, it was also necessary to develop specialized merging programs which allowed the ordering of data by specific request. For example, it might be desirable to have records only for a given course, records for a given course within a specific time period, or records only for a segment of a course. For computational efficacy, it is expedient to block these specific records together and eliminate others. The merge and sort programs, when specifically oriented toward the type of semiordered data accumulated in CAI, fulfill these requirements most efficiently.

5.2.3 Instructional Support System (ISS)

A major software development project undertaken at FSU was the redesign of the FSU data management system and IBM CAI system such that they operated under one complete support and operating system. That is, either system could be controlled under one set of operating procedures. This integration of the two programming systems allowed greater optimization of computing hardware utilization, and a significant improvement in computer operations.

5.2.4 Management Operational Procedures

Prime sources of maximizing the utility of any instructional management system are the operations procedures and scheduling. FSU has made a major effort to ensure that the human component of the instructional management system is well integrated with the software and hardware components. Software programs which allow editing and preparation of data for data analysis were developed, along with complete user documentation. For researchers, the special need for manipulating data for use in statistical software packages was taken into account. Given the variety of data which may be collected on a sophisticated CAI or CMI system and the varieties of research designs for analysis requirements, flexible and powerful control of data must be available for researchers.

5.2.5 Future

In the future, investigations should focus on the development of new technologies for recording vast amounts of data during computer-aided and computer-managed instruction activities. As instruction becomes more individualized and personalized, managing and monitoring systems must be expanded.

5.3 Data Analysis Systems

The business of all instructional research is analysis and interpretation of data gathered. In order for the data to be useful, however, the CAI/CMI system must be well integrated with data analysis systems. The thrust of the FSU effort with concern to data analysis has been in the direction of providing new user capabilities for analysis of data.

5.3.1 Online Versus Offline Systems

Many CAI researchers have suggested the need for data reduction and presentation in an online mode, with data output to the researcher as students proceed through instructional treatments on display devices. The offline mode allows gathering of data on intermediate storage media which are accessible at later times for data reduction and presentation. The offline mode has been primarily emphasized at FSU. The advantages of offline data recording are in ease of operations and flexibility with which raw data can then be transmitted to data analysis systems. Many manual operations necessary for online data gathering are bypassed with offline functions.

5.3.2 Report Generation

Both the EDIT and DATA PREPARATION programs provide punched output of data collected during CAI coursewriter activities for use on various computer system statistical packages. In addition, two programs were developed at FSU which provide summaries in the form of printed output reports of CAI data. The ITEM ANALYSIS SUMMARY program provides summary statistics such as the percentage of students who answered an item correctly and the average latency time for the item. The DETAILED PRINT program prints a comprehensive detailed description of a student or subject's record. Information such as course name, date, EPID, MID, student response, response latency, and value of counters and switches is provided. This program has a great deal of flexibility through the use of

32 options for output specification to select or suppress specific information elements.

5.3.3 Future

If, in the future, the trend continues toward more powerful general purpose and algorithmic-type languages for CAI, then more general and powerful report generation systems will have to be developed with some loss in execution optimization for the gain of power and flexibility.

6.0 Development of Human Resources

A corollary goal of the ONR Themis project was an explicit commitment to develop a cadre of instructional researchers with an interest in computer-based training systems. During the project at FSU, a large number of these students, at both the Ph.D. and Masters Degree levels, have participated extensively in the research activities. As a review of the reference list will reveal, these individuals participated as researchers and as authors. Most encouragingly, these Themis-related graduate students continued the themes pursued under Themis. Explicitly, one can identify the continuing interest in and widespread developments of computer-managed instructional systems. A brief review of some of these on-going research activities, and then a listing of all of the participants, will document this proposition.

6.1 Outstanding Computer-Managed Instructional Research Projects

The following individuals have assumed significant roles in other institutions or organizations, and are continuing the themes developed under Themis.

1. Paul Gallagher, Ph.D., Assistant Dean for Instructional Systems, Florida International University.
2. Lorraine Gay, Ph.D., Assistant Professor of Education, Florida International University.

These researchers are responsible for the development of an individualized performance-based teacher education program. Within this activity they have specific responsiblities for the development of a computer information management system which supports the essential monitoring and control functions necessary for this innovative model. For those research training endeavors in colleges of education in the United States, the Florida International University performance-based instructional program is considered to be further ahead and to be "breaking new ground" at this time.

3. Barbara Leherissey McComb, Ph.D., Department of Engineering Psychology, McDonnell Douglas Corporation.

For the past year this researcher has been responsible for formulating the conceptual ideas required to implement the instructional strategies subsystem of the Advanced Instructional System at Lowry Air Force Base. McDonnell Douglas Corporation has been the successful bidder and is now proceeding in the development of the instructional approach. Again, the adaptive models to be used will have heavy emphasis on the management of the training process.

4. Gary Lipe, Ph.D., Director of the CAI Center at Texas Christian University.

Texas Christian University has been pursuing individualized teacher education, emphasizing units on educational technology. The TCU Center has developed unique computer- and media-related presentations which are having significant impact in building competencies for future teachers.

5. John Hedl, Ph.D., Chairman of the Educational Psychology Department, University of Texas Medical School, Allied Arts Medical Center.

This researcher is developing a computer-managed instructional approach to allied medical manpower development. In addition to being competency based, the computer approach will emphasize professional competency profiles and a system for retraining in the future.

5. Arthur King, Ph.D., Director of Instructional Systems, Dental School, University of Florida.

This researcher has developed a computer-managed instruction approach to all of the medical science requirements found in dental schools. This system is now operating and is undergoing extensive formative evaluation.

6. Kenneth Majer, Ph.D., Assistant Professor of Educational Psychology, Indiana University.

This researcher has developed an individualized graduate assistant teacher training system using systematic principles and computer management. This system provides instruction to graduate assistants from departments throughout this large university. The developments are considered so exemplary as to have won an award during this past year.

7. Dr. Harold O'Neil, Ph.D., Co-director of the CAI Center, University of Texas.

This researcher is providing the intellectual leadership and management of a large research program in CAI and CMI at Texas. Special efforts are focusing on the nature of learner control of instruction and affective processes found in anxiety and curiosity, in addition to the development of a CMI approach to instructional science for undergraduate and graduate students.

While other individuals can be cited, these give a representative sample of the graduate students who have used their training and substantive themes developed under Themis in order to pursue profitable careers throughout the United States.

6.2 Themis Associated Faculty and Students

During the project, some faculty members moved on to more responsible positions in other organizations. These are as follows:

1. Bob Brown, Director of the CAI Laboratory, University of Iowa, Iowa City, Iowa.
2. Henry Lippert, Instructional Coordinator for CAI, Army Medical Training School, Fort Sam Houston, Houston, Texas.
3. Walter Dick, Director of Planning and Head of the Instructional Systems program, Florida State University.

The following graduate students also participated in the Themis project. Their present job titles and research activities are offered for the reader's analysis. Readers will observe that these former students have continued their interests in instructional and management systems as well as the whole area of training.

1. Wallace E. Bell, Ph.D., is a Coordinator of Information Management Systems for Evaluation and Research, Florida Department of Education, Tallahassee, Florida.
2. Allen A. Blair, M.S., District School Superintendent, State of Washington, is implementing individualized instruction in his school district.
3. Walt Blomquist, M.S., Coordinator of CAI and Instructor of Speech, Brevard Community College, Brevard County, Florida, is an innovator in computer activities.

4. Thomas Dunn, Ph.D., Assistant Professor of Education at Toledo University, Ohio, is very active in the performance-based computerized teacher education program.
5. Edwin Durall, Ph.D., Director of the Department of Research and Evaluation, Myrtle Grove Instructional Center, Escambia County School Board, Pensacola, Florida, is active in computer-supported evaluation.
6. Paul Geisert, Ph.D., Assistant Professor, University of Wyoming, is developing individualized courses in science education, and is implementing a competency-based Masters and Ph.D. program.
7. Fernando Gonzalez, Ph.D., Assistant Professor of Psychology at Florida International University, is active in computer-based testing.
8. Darol Graham, ABD, Research Associate in the FSU Habilitative Sciences project to individualize teacher training, is developing a computerized management system.
9. William R. Halstead, Ph.D., Director of Higher Education Planning, Department of Education, State of Florida, is developing a computerized data system for planning.
10. Nancy K. Hagerty, Ph.D., Assistant Professor, Department of Continuing Education, University of British Columbia, is working with inservice teacher training particularly using performance-based teacher education.
11. Robert Handelsman, Ph.D., Director of Financial Aid, Miami-Dade Junior College, developed media learning systems.

12. Wallace Hannum, Ph.D., Research Associate, Center for Educational Technology, FSU, is developing workshops in instructional design for foreign students.

13. Edward Harris, Ph.D., Assistant Professor, Department of Educational Administration, Florida State University, is teaching systems analysis and computer techniques for administrators.

14. William Harvey, Ph.D., Assistant Professor of Educational Technology, University of Southern California, is developing teaching-management simulations and games.

15. Karl W. Heiner, Ph.D., Assistant Professor of Education, University of California, San Francisco's Medical School, is teaching in the allied health professions program and developing computer-based evaluation systems.

16. Darlene Heinrich, ABD, is currently investigating anxiety and curiosity within systematic learning situations.

17. Edward N. Hobson, Ph.D., Program Director, National Laboratory for Higher Education, Durham, North Carolina, is directing the junior college division that is preparing materials and activities to train professors in the use of systems approach and planning.

18. Robert M. Hogan, M.S., is completing a degree in mathematical psychology at the University of Colorado.

19. Thomas James, Ph.D., Research Associate, Center for Educational Technology, is assisting in the development of workshops in instructional design, and is developing an information retrieval system for the CET library.

20. Barbara F. Johnson, ABD, Assistant Director of the Computer Applications Laboratory at FSU, is involved in computer applications throughout the university.

21. John B. Keats, Ph.D., Associate Professor of Statistics, Southwest Louisiana State University, is pursuing statistical algorithms for management.

22. Cyrus Kirshner, M.S., Associate Professor of Vocational Education, Los Angeles State University, is completing his dissertation in applying a systems approach to the development of instructional materials for vocational education.

23. Dewey Kribs, ABD, Research Psychologist, Naval Personnel and Training Research Laboratory, San Diego, will implement advanced instructional systems concepts.

24. Raymond F. Latta, Ph.D., Associate Professor, Western Washington State University, is working to train educational administrators in systematic planning analysis techniques based on computing systems.

25. Robert M. Lawler, Ph.D., Assistant Professor, Allied Health Program, University of California at San Francisco, is developing a performance-based training program with computer support.

26. Michael H. Moncrief, Ph.D., Research Associate, Southwest Regional Education Laboratory, Los Angeles, is preparing individualized learning systems.

27. Merle Morgan, Ph.D., Director of Innovative Instructional Design, St. Petersburg Junior College, is developing new teaching learning systems.

28. James Papay, Ph.D., Research Associate, Dallas Public School System, is conducting research and evaluation on Title 1 Projects in Dallas.

29. William Proctor, Ph.D., President of Flagler College, St. Augustine, Florida, is pursuing a systems approach to college administration.

30. Gail T. Rayner, Ph.D., Research Associate, Training Division, Center of Educational Technology, is developing training activities for students from the Organization of American States.

31. Lee Rivers, Ph.D., Staff Psychologist, HRB Singer, is specializing in the development of instructional materials for training systems.

32. Worth Scanland, Ph.D., educational specialist with Naval Training Command, is specializing in educational technology for Naval training systems.

33. Charles Sisson, ABD, Executive Director of Management and Information Services, Colorado State Department of Education, is in charge of budget control, PPBS computer services, and internal business management.

34. Ben Stevens, M.S., Research Assistant, University of Florida Medical School, is assisting in the development of instructional materials.

35. Peter Stoychef, M.S., Research Associate, School of Dentistry, Ohio State University, is pursuing the systematic design and evaluation of CAI.

36. Susan Taylor, ABD, is currently investigating adaptive instructional models at the FSU Computer Applications Laboratory.

37. David B. Thomas, Ph.D., Research Associate, Department of Data Processing, State of Virginia, is reorganizing the State's use of computers in education for better management of instruction.

38. Nelson Towle, Ph.D., Research Associate at CCSI, Florida State University, is helping faculty develop CAI/CMI units.

39. William Whaley, ABD, Project Director, Department of Education, State of Florida, Program Services Division, is developing differentiated staffing patterns with management support by computers.

7.0 List of Technical Reports, Technical Memos, Systems Memos, and Working Papers

Between 1967 and the close of the FSU Themis Project, approximately 100 technical documents were written and distributed as a result of research activities connected with the project. These technical reports, technical memos, systems memos, and working papers are listed below by type of paper, number of paper, author, title, and date.

Technical reports

6. O'Neil, H. *Effects of stress on state anxiety and performance in computer-assisted learning,* 1969.

7. Spielberger, C. *The effects of anxiety on computer-assisted learning,* 1969.

8. Hobson, E. *Empirical development of a computer-managed instruction system for the Florida State University model for the preparation of elementary school teachers,* 1969.

11. Hagerty, N. *Development and implementation of a computer-managed instruction system in graduate training,* 1970.

12. Gallagher, P. *An investigation of instructional treatments and learner characteristics in a computer-managed instruction course,* 1970.

13. Scanland, W. *An investigation of the relative effectiveness of two methods of instruction, including computer-assisted instruction, as techniques for changing the parental attitudes of Negro adults,* 1970.

14. Spielberger, C., O'Neil, H., & Hansen, D. *Anxiety, drive theory, and computer-assisted learning,* 1970.

15. Lipe, J. *The development and implementation of a model for the design of individualized instruction at the university level*, 1970.

16. King, A. *An application of simulation techniques to an innovative teacher training program*, 1970.

17. Harvey, W. *A study of the cognitive and affective outcomes of a collegiate science learning game*, 1970.

18. Gay, L. *Temporal position of reviews and its effect on the retention of mathematical rules*, 1971.

19. Lawler, M. *An investigation of selected instructional strategies in an undergraduate computer-managed instruction course*, 1971.

21. Hedl, J. *An evaluation of a computer-based intelligence test*, 1971.

22. Dunn, T. *The effects of various review paradigms on performance in an individualized computer-managed undergraduate course*, 1971.

23. Leherissey, B. *The effects of stimulating state epistemic curiosity on state anxiety and performance in a complex computer-assisted learning task*, 1971.

26. Motley, D. *An on-line computer-managed introduction to indexing: An individualized multimedia instructional package compared to the traditional method, nine hours of teacher-group contact*, 1972.

27. Rivers, L. *Development and assessment of an adaptive strategy utilizing regression analysis techniques for the presentation of instruction via computer,* 1972.

Technical Memos

1. Dick, W. *Implementation of CAI at Florida State University,* 1969.

2. Hansen, D. *Current issues in CAI,* 1969.

4. Ehlers, W. *CAI in social work,* 1969.

5. Dick, W. & Latta, R. *Comparative effects of ability and presentation mode in computer-assisted instruction and programmed instruction,* 1969.

8. Hansen, D. & Dick W. *The data world of CAI,* 1969.

10. Hansen, D. & Harvey, W. *Impact of CAI on classroom teachers,* 1969.

11. Hansen, D. *Development processes in CAI problems, techniques, and implications,* 1969.

12. Gay L. *An investigation into the differential effectiveness for males and females of three CAI treatments on delayed retention of mathematical concepts,* 1969.

14. Lee, R. *Information structure in military history: An application of computer-assisted instruction,* 1970.

15. Hanseh, D. *The role of computers in education during the '70's,* 1970.

16. Adair, C., Hansen, D., Rayner, G., & Agarwal, A. *The behavior of teachers involved in two simulated inquiry environments: A social simulation game and a CAI-based information retrieval system*, 1970.

18. Sheldon, J. *Computer-assisted instruction in engineering dynamics*, 1970.

19. Bruce, D. & Papay, J. *The primacy effect of single-trial free recall*, 1970.

20. Leherissey, B., O'Neil, H., & Hansen, D. *Effects of memory support on state anxiety and performance in computer-assisted learning*, 1970.

22. Jahoda, G. & Foos, F. *The development of an on-line searched coordinate index for use in teaching and research*, 1970.

23. Kromhout, O., Hansen, D., & Schwarz, G. *Conference on computers in undergraduate science education: A computer-assisted and managed course in physical sciences*, 1970.

24. Geisert, P. *A comparison of the effects of information mapped learning materials and traditional materials on the learning of concepts via the printed page and computer cathode ray tube*, 1970.

25. Graham, D., Schwarz, G., & Hansen, D. *Multimedia simulation of laboratory experiments in a basic physics lesson on magnetism*, 1970.

27. Merrill, P. *Task analysis--An information processing approach*, 1971.

23. Dunn, T., Lushene, R., & O'Neil, H. *The complete automation of the Minnesota Multiphasic Persality Inventory and a study of its response latencies*, 1970.

30. Hansen, D., Hedl, J., & O'Neil, H. *Review of automated testing*, 1971.

31. Thomas, D. *Two applications of simulation in the educational environment*, 1971.

32. Dick, W. & Gallagher, P. *Systems concepts and computer-managed instruction: An implementation and validation study*, 1971.

33. Rappaport, E. *The effects of trait and dogmatism on state anxiety during computer-assisted learning*, 1971.

34. Leherissey, B. *The development of a measure of state epistemic curiosity*, 1971.

35. Hansen, D. & Johnson, B. *Measurement techniques for individualized instruction in CAI*, 1971.

36. Brown, B., Hannum, W., & Dick, W. *An investigation of the effects of two types of instructional terminals in computer-managed instruction*, 1971.

37. Brown, B. & O'Neil, H. *Computer terminal selection: Some instructional and psychological implications*, 1971.

38. Hansen, D. & Johnson, B. *CAI myths that need to be destroyed and CAI myths that we ought to create*, 1971.

39. Summerlin, L. *A feasibility study of tutorial type computer-assisted instruction in selected topics in high school chemistry*, 1971.

40. Jahoda, G. & Foos, F. *The use of an on-line searched and printed coordinate index in teaching*, 1971.

41. Leherissey, B., O'Neil, H., & Hansen, D. *Effect of anxiety, response mode, and subject matter familiarity on achievement in computer-assisted learning*, 1971.

42. Leherissey, B., O'Neil, H., Heinrich, D., & Hansen, D. *Effect of anxiety, response mode, subject matter familiarity, and learning time on achievement in computer-assisted learning*, 1971.

43. Tobias, S. *A history of an individualized instructional program of varying familiarity to college students*, 1972.

44. Tobias, S. *Review of the response mode issue*, 1972.

45. Merrill, P. & Duchastel, P. *The effects of behavioral objectives on learning: A review of empirical studies*, 1972.

46. Towle, N. & Merrill, P. *Effects of anxiety type and item difficulty sequencing on mathematics aptitude test performance*, 1972.

47. Merrill, P. & Towle, N. *The effects of the availability of objectives on performance in a computer-managed graduate course*, 1972.

48. Lushene, R., O'Neil, H., & Dunn, T. *Equivalent validity of a completely computerized MMPI*, 1972.

49. Tobias, S. & Hedl, J. *Test anxiety: Situationally specific or general*, 1972.

52. Tobias, S. *Distraction, response mode, anxiety, and achievement from CAI*, 1972.

54. Hansen, D., Manning, P., & Johnson, B. *A systems approach to learning simulations*, 1972.

56. Tobias, S., Hedl, J., & Towle, N. *Latency and test anxiety*, 1972.

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