RESEARCH AND DEVELOPMENT OF INTELLIGENT TUTORING STRATEGIES FOR U.S. NAVAL RECRUITS

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ABSTRACT

Since 1990, the attrition rate of U.S. Navy recruits has increased significantly. While psychological disorders are the most significant cause of attrition for females, males separate primarily for disciplinary and legal offenses. Naval training experts have long realized that academic difficulties are often manifested in problem behaviors that lead to separation. The Navy also recognizes that their operational and training environments are male-dominated, and there is a growing concern that gender integration in training has not been appropriately addressed. To stem attrition, maximize the acculturation process, and align training to address Fleet requirements, the Navy is developing and testing new instructional strategies and pedagogical practices.

The objective of this research effort was to increase the academic success of female recruits in a technical aspect of recruit training, where historically female recruits have performed less satisfactorily than male recruits have. A multimedia Interactive Courseware (ICW) instructional intervention called the Advanced Organizer (AO) was developed and tested in the context of firefighter training, to provide a structure for acquiring and storing technical material. The AO utilizes an intelligent tutoring strategy, where behaviors which reflect a student's cognitive learning style are identified and accommodated.

Data was collected at the Recruit Training Center in Great Lakes, Illinois, with over 1,000 recruits participating in the study. Results indicate that the AO decreased stress and made a significantly positive impact on the academic success of both male and female recruits.

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BACKGROUND

In Fiscal Year 1997, the Navy launched extensive efforts to re-engineer training to improve its efficiency and effectiveness. The genesis of these initiatives was the significant need to man the Fleet with well-trained and disciplined warriors capable of operating the highly technical platforms. As the re-engineering training progressed, Navy recruit attrition became a major concern. Analysis of attrition factors at the Recruit Training Commands (RTC) indicated that the attrition rate for U.S. Navy recruits increased from 8.9% to 13.4%. Attrition data analysis pointed to psychological disorders as the most pronounced reason for the separation of recruits. Training experts understand that there is a high correlation between this type of attrition and learning difficulties. Accordingly, they began exploring instructional theories and paradigms that would enhance and support the re-engineering training efforts. Research efforts focused on recruit learning strategies within the Navy training context to gain greater knowledge of which training paradigms and supporting technologies would effect a greater yield in terms of optimized training effectiveness and reduced recruit attrition.

The focus of this paper is to report on the development and testing of an instructional aid entitled the Advanced Organizer (AO). The goal of the AO was to bridge the gap between what the recruits already knew and what they needed to know in the context of the firefighting environment. The AO orients recruits toward learning strategies, which parallel their cognitive learning styles. To determine the effectiveness of the AO, the research assessed basic psychometric information on stress measures, i.e., role clarity (the part a recruit plays in a firefighting team) and self-efficacy (confidence in recruits' ability to perform a task), role conflict (recruit interaction with team leaders) and negative affect (recruit mood—sadness, annoyance, depression, cheerfulness); and impact on final firefighting test scores. Analysis factored in the Armed Forces Qualification Test (AFQT), a subset of the Armed Services Vocational Aptitude Battery (ASVAB). The AFQT has a strong correlation to general intelligence. It was used as a barometer of accession quality along with the educational level.

The recruit population involved in the study reflected a cross section of the normal annual RTC population. The control and experimental groups were comprised of recruits from the fall and summer month cohorts. Demographics for the study participants are shown in Table 1.

Table 1. Distributions of Demographic Characteristics

Group	% of Sample
Age	
17 years	7.7%
18 years	53.7%
19 years	15.9%
20 years	7.9%
21-34 years	14.7%
Ethnicity	
American Indian	4.0%
Asian/Pacific Islander	5.4%
Black	25.1%
Hispanic	11.8%
White	52.7%
Education	
Less than 12 years	3.8%
12 years	91.3%
More than 12 years	4.9%

ADVANCED ORGANIZER (AO) TREATMENT

To design the AO treatment, research was conducted in the areas of cognitive learning styles (Pask, 1976; Rowland and Stuessey, 1988; Hanson, 1994; Shlechter, 1986; Kolb, 1976; Messick, 1984; Tannen, 1994; Jonassen and Grabowski, 1993) and learner control (Daniels, 1996; Frey and Simonson, 1994; Merrill, 1984; Williams, 1993; Reigluth and Stein, 1983). The research findings were used as a basis for deriving the instructional strategies on the following premise: to overcome difficulties with the content of technical material, represented by the academic component of firefighter training, not only do recruits need analogies they can understand, they need an introduction to the information in a way that complements their unique learning styles.

The goal of the AO treatment was to bridge the gap between what the recruits already knew and what they need to know in order to meaningfully learn to fight fires. The AO treatment provided a context of meaning for new information to be learned. It was designed to help orient the students to the firefighting subject matter in such a way that the subject matter was directly related to any pre-existing knowledge students may have. It was expected that the AO would help the students anticipate the performance requirements of the job by letting them know what to expect, as well as demonstrate the desired behaviors and attitudes for acceptable job performance. The overall objective of the AO was to provide recruits with a context of knowledge that would prepare them to succeed in the academic and hands-on components of firefighter training.

One of the goals for the design of the AO was to present a conceptual framework for the new knowledge and skills presented in firefighter training, a framework that would appeal to different learning styles. In designing the strategies, two broad categories of learners were created from the different cognitive strategies. Various instructional strategies, expected to be effective for different learning styles, were applied to each of the two broad categories of learners. They were applied as prescriptions for strategies that would present the material most effectively for each type of learner. The instructional strategies supporting the two learning styles are described in Table 2. This does not imply that a learner is expected to use one cognitive strategy in all situations. We strongly suspected that learners would switch strategies to accommodate different subject areas and different circumstances. Therefore, the AO provided different instructional modes to accommodate different cognitive strategies, and recorded which strategies were being used at particular points in the instruction.

Table 2. Instructional Strategies for the AO

Field-Dependent Learners	Field-Independent Learners
Provide structured instructional sequencing.	Provide learner control features.
Provide continuous performance feedback.	Provide necessary feedback.
Provide a verbal overview.	Provide a graphic overview with complex graphics.
Structure information to be presented.	Allow students to derive the structure of the information.
Associate ideas with their practical application.	Show (graphically) why the material is important.
Provide explicit information about performance outcomes.	Allow students to inquire about performance outcomes.
Explain how the various components fit together, then provide a global perspective.	Show the performance (global perspective) and let students identify the components.
Provide a verbal organizer.	Provide a graphic organizer.
Explain why damage control is important and how each individual contributes to the welfare of all.	Explain why it is necessary to acquire all the knowledge and skills to perform effectively.
Provide a verbal description of the “big picture.”	Use a graphic presentation to show the “big picture” and let students derive the specifics.
Provide “context” for the roles the learners will perform as part of the team and what they will need to know to fulfill their responsibilities.	Provide “context” in terms of what they will learn and how they will use the knowledge to perform their roles in the firefighting team.
Use an expository presentation: Present a generality and demonstrate the necessary skills to understand the higher-level skill.	Use a discovery presentation; allow the learner to discover the higher-level skill.
Emphasize that during training, “hands-on” experiences will be provided.	Emphasize that during training, learners will use knowledge gained in academic training.
Provide information from the specific to the general.	Provide information from the general to the specific.
During demonstrations, emphasize “feeling” aspects of activities: working toward the common good.	During demonstrations, emphasize “thinking” aspects of activities; develop expertise.

The AO used a combination of learner control and intelligent tutoring, with assessment of student requirements and presentation of appropriate material, to provide a unique instructional experience to each student. The system presented information in ways that specifically addressed the style and/or concerns of the learner.

Learner Control

In addition to the typical learner control features such as pacing and review, the learner can select two different expository approaches: a structured instructional approach (linear), or an approach in which the learner imposes his or her own structure (concept map). Given the learning preferences indicated in the research, it was expected that a field-dependent learner would prefer the linear approach, while a field-independent learner would prefer the concept map approach.

Selection of Linear Approach

If the student selected the linear approach, this indicated his or her preference for structured instructional sequencing and a verbal overview of the topic. Since the student had exhibited characteristics of a field-dependent learner, the system structured the lesson for the student from specific to general.

Selection of Concept Map

If the student selected the concept map, this indicated his or her preference to have control over the sequencing of information, thus exhibiting characteristics of a field-independent learner. Since the student had indicated that he or she was a field-independent learner, the system provided a graphic overview of firefighting in the form of a multimedia concept map. Once the introduction was over, the student was able to select specific topics in any order. In doing so, the student was deriving his or her own structure of the information and exercising learner control over the structure and sequencing of the information. The concept map structure fits the field-independent learning style by providing a "big picture" of the lesson material before the student's attention turns to the details of the subject.

Learner Questions

The student can ask the system questions which are provided on each expository screen in the AO, regardless of whether the user is accessing the screen via the linear approach or the concept map approach. The purpose of the questions is twofold. First, they provide individualized, personalized instruction within the context of the computer-based training environment. Questions and answers are specific to the content in the lesson. Second, they provide a basis for automatically tailoring the information presented in the lesson to the user, based on the computer's assessment of the user's concerns. There are four categories of questions: gender, information, role, and remember. If the user asks more than one question in a category as he or she proceeds through the presentation, additional information relevant to that category is automatically presented for subsequent content areas. For example, the user may indicate, by asking questions in the gender category, that he or she is concerned about whether females can be effective firefighters. After the user has asked two "gender" questions, information on females in firefighting is provided in subsequent content areas.

Table 3 shows the four categories of questions, the sample questions, the instructional concerns which the questions are designed to address, and the purpose of providing answers and additional information in the AO treatment.

The learner questions are answered using multimedia presentations with motion video, audio, still photographs, and text, then the presentation is continued. Throughout the instruction the learner retains control of the pace and presentation. The learner can take the test at any time. The average recruit took 55 minutes to complete the AO treatment.

Table 3. AO Learner Questions

Category	Sample Question	User Concern	Purpose
Gender	Is the weight of the equipment a problem for female sailors?	Recruit is showing concern about the ability of females to perform successfully in firefighting.	Information is designed to bolster confidence in males and females that females can be successful at firefighting.
Information	How is this like something I already know? Can you explain the ID system further?	Recruit is asking for additional information specific to the topic. In some cases the recruit is asking the program to help relate new information to known information.	Information is designed to help users who need additional tutoring to understand concepts.
Role	Why is this information important to me?	Recruit is exhibiting a concern for how the activities relate to the common good. This is a typical concern for a field-dependent learner.	Information is designed to provide users with information that will help them understand their role in firefighting teams.
Remember	What exactly do I have to remember about this topic?	Recruit wants to know exactly what information is important to remember. This is a typical concern for a field-independent learner.	Information is a synopsis of the content area, which the user can use as a mental checklist for what is important to remember.

Learning Style Pretest

A learning style pretest was designed to provide specific data regarding which instructional strategies were the most successful at preparing students for the academic portion of the course. The learning style pretest was computer-based and contained 15 items which determined the broad category of learning style for the student (see categories of learners described in Table 2).

PROCEDURES FOR DATA COLLECTION

Development of CD-ROMs for Each Instructional Strategy

The AO program was organized into six separate programs, one for each of the six instructional strategies. The six instructional strategies or "routes" through the AO were:

- Concept Map/No Questions. In this program, the students were in the concept map approach and they were not able to ask the computer any questions.
- Concept Map/All Questions. In this program, the students were in the concept map approach and they were provided with all the questions and answers that were possible in the program.
- Concept Map/Student Selected. In this program, the students were in the concept map approach and they were able to ask questions if they wanted to.
- Linear/No Questions. In this program, the students were in the linear approach and they were not able to ask the computer any questions.
- Linear/All Questions. In this program, the students were in the linear approach and they were provided with all of the questions and answers available in the program.
- Linear/Student Selected. In this program, the students were in the linear approach and they were able to ask the computer any questions.

Preparation of Classroom-Based AO

The control group in the data collection effort was provided with one hour of classroom instruction covering the basic firefighting content of the multimedia AO. The instructor at Great Lakes prepared this one-hour block of classroom instruction prior to the data collection effort.

Academic Firefighting Test

During the data collection effort, the control and treatment group students were given the academic firefighting test twice. The first time they took the test was immediately upon completion of the multimedia AO or one-hour classroom instruction. The second time they took the test was upon completion of the firefighter training course, which lasted five days.

Firefighting Stress Questionnaire

A 40-item stress evaluation questionnaire was developed and administered to the students prior to and after firefighter training. The questionnaire measured self-efficacy and perceived stress. The Committee for Protection of Human Subjects approved the protocol to administer the stress questionnaire and instructional treatment to the recruits.

DATA ANALYSIS

Data was collected over a three-year period at the Recruit Training Center in Great Lakes, Illinois. One thousand and eighty-three (1,083) recruits participated in the study.

The analysis approach consisted of five steps. First, the relationships between potential determinants of academic performance were examined. The objective was to determine whether there was significant risk of confounding the effects of one determinant (e.g., gender) with that of another determinant (e.g., field dependence).

The second step in the analysis created several residualized performance variables. Raw scores on performance tests were adjusted to take into account differences in intelligence as measured by AFQT.

The third step in the analysis examined gender differences in anticipated stress, and assessed the differences between anticipated stress measured at the beginning of firefighter training and the actual stress perceived at the end of firefighting. Independent and paired sample t-tests were performed.

The fourth step in the analysis examined the effects of AO design. This part of the analysis compared the different AO types (linear/concept mapping) and the use of questions (none/student-selected/all) in what was basically a 2 x 3 analysis of variance (ANOVA). The key issue in this part of the analysis was the determination of whether particular elements of AO design affected performance. The basic ANOVA in this step was extended to include gender (male/female) and learning style (field-dependent/independent) as group classification variables. These extensions made it possible to determine whether the effect of AO design depended on the recruits' gender and learning style. The final ANOVA design, therefore, was a 2 x 2 x 2 x 3 group classification based on gender, learning style, AO type, and question utilization.

The fifth step in the analysis compared the AO to the control group. Gender and learning style were retained as variables to determine whether the general effect of the AO, in contrast to specific effects of particular types of AO, depended on these variables.

RESULTS

This study examined four variables that might explain differences in firefighting performance: gender, AFQT, learning style, and experimental treatment. The study also examined anticipated stress. The results of the study are as follows:

a. Males and females were evenly distributed across treatment groups ($\chi^2 = 2.06$, 7 χ, p = .956).

b. AFQT scores were comparable across the treatment groups ($F_{7,271} = 0.49$, p = .841).

c. Learning style was mildly confounded with treatment group ($\chi^2 = 10.05$, 5 df, $p = .074$), largely because a higher rate than expected of field-dependent individuals were in the linear/all questions AO condition (65.5% vs. 40.9% in the other conditions).

d. The average male had a slightly higher AFQT score (62.1) than the average female (58.5), but the difference was statistically trivial (point biserial $r = -.09$, $t_{277} = 1.58$, $p = .116$).

e. Females were more likely to be field-dependent than males (60.5% vs. 51.4%), but the trend was not significant ($\phi = .09$, $\chi^2 = 1.50$, 1 df, p = .221).

f. On the first academic firefighting test, gender produced a significant main effect on adjusted performance ($F_{1,148}$ = 4.11, p = .045). Men scored higher than women (Male average = .23; Female average = -.19).

g. On the first academic firefighting test, two interactions were statistically significant: AO type x gender ($F_{2,148}$ = 5.58, p = .005) and question utilization x learning style ($F_{2,148}$ = 3.41, p = .036).

h. On the second firefighting post test, where academic test performance was adjusted for AFQT, the main effects of AO type and question utilization were nonsignificant.

i. On the second firefighting academic test, where academic test performance was adjusted for AFQT and the first firefighting test performance, AO type and question utilization main effects were weak (ε2 < .014) and statistically nonsignificant (p > .407).

j. The AO decreased stress. Recruits who completed the AO reported greater role clarity and self-efficacy at the end of firefighter training.

DISCUSSION

Effect of AO on Stress

Two results merit special attention with regard to stress in the context of the application of firefighting. The first point is regarding communication. Stress arises in part when communication lacks clarity and consistency (Kahn, et al., 1964; King and King, 1990). Particularly in dynamic teamwork situations, such as those likely to occur in firefighting, the process of communication and coordination plays a key role in determining the stress level. Thus, communication problems such as those outlined by Tannen (1994), and gender-driven behavior, as detailed by Gray (1987) become more pronounced. One objective of the AO, which was achieved, was improved communications. The experimental group had improved role clarity and self-efficacy.

The second point is that role ambiguity and role conflict tend to be positively correlated when people are asked to describe their jobs. If this trend is generalized to firefighting as a specific element of sailors' jobs, measures of these stresses may be correlated. In the present research, the hypothesis was posited that female recruits would exhibit more stress than males since females were being trained in a environment that has been historically all male. Again, role clarity and self-efficacy were improved for the experimental group. However, the assumption that females were more stressed than males was not supported. Male and female recruits were shown to be equally stressed.

Effect of AO on Recruit Performance

With regard to recruit performance in firefighting, the following points summarize the results.

A course overview helps with academic performance. Both the multimedia AO and the classroom/instructor AO improved performance significantly over standard instruction. This finding supports the premise that in order to overcome difficulties with the content of technical material, represented by the academic component of firefighting, not only do students need analogies they can understand, they also need an introduction to the information in a way that will help them bridge the gap between what they know coming into firefighter training and what they need to know to pass the course.

The format of the AO was more important in the short term than over the full duration of the course. The multimedia AO produced significantly better performance on the test immediately following the treatment than the classroom/instructor AO. However, the recruits given the classroom/instructor AO "caught up" by the end of the course and did as well on the final firefighting test as the multimedia AO group. However, even though the classroom/instructor and multimedia AO's had the same end result on performance, the multimedia AO may be more efficient. The multimedia AO significantly improved immediate performance relative to the control, which indicates there was less learning for the AO recruits during the subsequent formal instruction.

This inference follows from the equivalent level of final performance. If final performance reflects an asymptote determined by the nature of the material and the abilities of the student, the initial advantage to the multimedia AO suggests it approached this asymptote more rapidly than the classroom/instructor AO. Both methods appear to raise the asymptote, based on comparison to the standard instruction controls. Perhaps a series of multimedia instructional tools would significantly shorten the total required instructional time.

This question cannot be resolved in the present design for two reasons. First, more interim measures of learning would need to be developed to fully define the learning curve. Second, additional multimedia instructional tools would need to be developed to determine whether this approach was superior to standard instruction after the initial introduction.

Instructional strategies had some impact on the effectiveness of the AO. The combination of concept map and student-selected questions provided the most opportunity for the student to just "wander around" through the information. Recruits who were in the concept map/student-selected AO strategy did not perform as well on the academic firefighting test. This indicates that it may be important to avoid giving the recruits too much freedom. This finding should not be given too much weight until it is replicated.

Learning style may be important if trainees are forced to view all questions and answers. The overall pattern of differences was clear. Forcing the student to listen to all the questions and their answers improved performance for field-dependent recruits, but tended to impair performance for field-independent recruits. This finding supports previous studies which showed that field-independent learners do not adhere as well to externally imposed structures (McGee, 1979). They are more capable of developing their own internal referents and do not need external referents, such as the AO questions, to process information. On the other hand, field-dependent learners were shown to do better with an externally imposed framework, and external referents (McGee, 1979).

Effect of Gender. The study supported previous research findings that showed that females are more likely to be field-dependent learners, and males are more likely to be field-independent learners (Witkin, 1981). However, exploration of gender issues was not critical to the effectiveness of the AO, and learning style effects were the same for females and males.

CONCLUSIONS

Because the AO decreased stress and improved recruit performance, the application of the instructional aid to firefighter training was supported. The implication of these results is significant for future Navy curriculum development and for the professional development of Navy instructors. Communication and role definition should become major items in instructor professional development. Development of instructional aids such as the AO should be continued as an instructional approach for training technical information such as firefighting.

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