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Addressing Cognitive Learning Styles in Job Performance AIDS

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Within the dynamic environment of active flightline maintenance, training is important to successful mission accomplishment. This paper will discuss the development and evaluation of a Job-Aiding and Training Tool (JATT) designed to enhance flightline learning by providing for a variety of learning preferences.

Overview

On-the-job training for novice U.S. Air Force flightline environments is designed to leverage expertise from the experienced trainer as well as step-by-step instructions from technical manual job guides or checklists. Reduction in workforce and increased system complexity limits such personal opportunities for training new technicians. Further complicating the situation, job guides and checklists are typically presented in a textual format requiring the technician to read content. Most often they are reading paper and sometimes, they will be reading a computer screen. Research in learning preferences shows that people learn in a variety of ways, and that they are sensitive to how information is presented to them. When these styles are supported, learning is enriched and occurs faster.

This paper will discuss an Air Force research project aimed at changing the flightline learning environment by providing for a variety of learning styles through a job aiding and training tool. To achieve this goal, the research team adopted data collection activities aimed at enhancing the student's training experience by designing a Job-Aiding and Training Tool (JATT) supporting a variety of learning styles. The team's strategy began with in-depth analysis of the learning styles and strategies used by educators in their teaching methods.

A quick review of the literature demonstrates that the term learning style is not used consistently. As this work was intended for a multimedia job aiding training tool, the team was most interested in the ways in which people prefer to have information presented to them and the ways in which they prefer to deliver their communication. The VARK survey was selected because its questions are based on situations where there are choices about how that communication might take place. This survey was structured specifically to improve learning and teaching.

The team's analyses identified situations in which current computer-based aids do and do not support various styles. The next activity focused on gathering information from experienced maintenance training specialists about learning style cues or techniques they use when teaching (e.g., what specific aircraft sounds do they notice and convey to students). Finally, cognitive walk-throughs were conducted for several representative maintenance tasks whereby integrated learning style cues were identified by trainers.

This information was assimilated to develop an on-the-job computer training aid that supports visual, auditory, reading and kinesthetic learning. For example, in addition to reading text directions for maintenance tasks (which would support the learner with reading preferences), the user is able to manipulate a switch and hear the sound it would make (which would support the learner with kinesthetic preferences). A variety of different cues were added for each of the learning preferences.

Evaluations were conducted using a K'NEX assembly to simulate maintenance activities. By comparing the new multimedia job aiding tool to traditional presentations of the maintenance information, assessments were made for the improvement in completion time, number of errors and required assistance, confidence, and degree of learning. The ability of the new tool to effectively address a variety of cognitive learning styles gave it a clear advantage over traditional electronic presentations of the same information.

Learning Styles

The team was most interested in determining the ways in which people prefer to have information presented to them. The VARK (an acronym for visual, aural, read/write, and kinesthetic) questionnaire was chosen because its questions are based on situations where there are choices about how that communication might take place. This survey was structured specifically to improve learning and teaching.

Although we have known for some time about the different modes, this inventory, initially developed in 1987 by Neil Fleming, Lincoln University, New Zealand, was the first to systematically pair a series of questions with help-sheets for students, teachers, employees, and others to use in their own way. Although there is some overlap between categories (Fleming & Mills, 1992), they are defined (Fleming, N. 2006, Morgan 2006_a, Morgan 2006_b) as follows:

Visual (V). This preference for visual information that is nonverbal includes the depiction of information in charts, graphs, flow charts, and all the symbolic arrows, circles, hierarchies and other devices that instructors use to represent what could have been presented in words. It does NOT include movies, videos or PowerPoint. This student prefers to always have a visual aid present during any learning situation. They learn best through maps, diagrams and charts. This type of student may not like to work with study groups and prefer to review by themselves in a quiet room.

Aural / Auditory (A). This perceptual mode describes a preference for information that is "heard or spoken." Students with this modality report that they learn best from lectures, tutorials, recordings, group discussion, email, speaking, web chat, or talking things through. This student needs to hear a lesson out loud before they can truly begin to absorb the information. This person may find it hard to read silently and after the learning session, they may need to read the information again out loud to actually retain it. Group discussions work well for this type of learner and it may be a good idea for this person to record lectures so they can listen to them later when they are reviewing.

Read/write (R). This preference is for visual information displayed as words. This preference emphasizes text-based input and output - reading and writing in all its forms. This person will learn that they prefer to have information presented to them visually and in a written language format (Fleming & Bonwell, 2007). They work well when their teacher presents important information to them in a bullet point format. This type of learning preference excels when notes and study sheets are color coded with highlighters.

Kinesthetic (K). By definition, this modality refers to the "perceptual preference related to the use of experience and practice (simulated or real)." Although such an experience may invoke other modalities, the key is that the student is connected to reality, "either through concrete personal experiences, examples, practice or simulation", Fleming & Mills, 1992. This student is a real "hands on" learner. They do not like to be cooped up in a classroom listening to a lecture. Movies, videos and active PowerPoint messages help to “include” this learner in the experience.

They like to be a part of demonstrations, outdoor field work and lab work. They would much rather "do" than sit and take notes. When learning, they should try incorporating action - read when on the exercise bike or walk back and forth while reciting information (Morgan 2006). This type of learner needs to “do” things to understand (Bouldin, & Myers 2003).

Sensory Cues

The next step in the development process was to identify situations in which traditional job-aids do not support these learning styles. The team sat down with experienced C-17 maintenance trainers and encouraged them to explore the sensory information they use and what they try to teach their students.
They were asked questions such as, “What do they see that may or may not be in the job guide?” It was found that they look for colors, part orientations and positions. They look for problems like wetness, burns and cracks that identify a problem.

They were asked, “What sounds do they hear?” Of course the flightline is a noisy environment, but they listen to the sounds of different motors – did they start or stop at the right time? Is the whine the right pitch? When they insert or remove a part they listen to make sure they’ve got the right contact. They can hear when they activate a switch – or if they can’t they need to know if they were supposed to. Obviously they listen for alarms.

They were asked, “What are they ‘looking for’ with their hands?” They told the team that they might feel a sudden rush of air from an air leak. They might feel wetness or slickness. They can also feel that a part is not in the right position or orientation.

They also rely on their noses to do their jobs. Most smells signify burning, and each has its own special smell. Electronics, brakes fuel and hydraulics all smell different.

Subsequently, tasks and cues that were impossible or not important for the current software application were ruled out. This job-aid wasn’t going to teach about air leaks or wetness, or any kinds of smells. The team identified the sensory cues that would be part of the enhanced training. These were to include

- Sight – colors, orientation, position
- Sound – clicks from insertion or removals, and switch activations
- Touch – part position and orientation

JATT

The JATT software was specifically designed to support each of the VARK learning preferences and to include the sensory cues recommended by maintenance trainers.

Design

The technical data used for the multimedia job aiding tool will come from electronic Technical Orders in PDF format. This data has textual instructions with line diagrams. A person with a strong preference for learning visually with text (Read/Write preference) may be able to extract the necessary knowledge, but the addition of a few extra cues would support the preferences of all other users as well.

The visual/nonverbal learner (Visual preference) would be helped with colors, or arrows highlighting important areas. Instant access to diagrams and charts (e.g., schematics) would help them to put the pieces together. Visual learners like to review by themselves, so access to the tool away from the aircraft would help them go over the materials.

Learners with an Aural Preference learn best when information is “heard or spoken.” A text-reader built into the multimedia job aiding tool would help this person “hear” the TO. Including the sounds of engines, or switches being activated would help them as well.

To help a Kinesthetic Learner, the tool should help the user feel actively involved in the learning process. User inputs should simulate (as possible) the actual input required on an aircraft. Videos and 3D models would help to recreate the learning environment.

Evaluation

Now that it was prototyped, did JATT provide more efficient training and performance than the current OJT process, while supporting student learning? To make that determination, a “toy task” was developed to simulate an actual maintenance task. The team built a Ferris wheel system with a K’NEX assembly, complete with realistic technical data and fully operational training software for the toy task. Two groups of thirty-two people participated in the study (64 total participants). One group was trained using only written technical data (in PDF format), while the other group trained using the JATT program.

The team collected both objective and participative results: time to complete the task, number of instructor assists, number of errors, confidence, and training effectiveness. Overall, JATT improved training; particularly by reducing the amount of time people took in doing the assigned task, the amount of instructor assistance, the number of errors committed, and by increasing confidence in the ability to complete the trained task.

Method

Research Design

This study was conducted using two groups of 32 participants: the traditional presentation group and the training enhanced presentation group.

The traditional presentation group was given instructions for performing the maintenance tasks presented in a standard Air Force technical manual style (see Figure 1). These instructions included the same characteristics of current Air Force electronic technical manuals. Using a PDF file, instructions included step by step directions on how to perform the task. Adjacent to these instructions were black and white illustrations. Links between maintenance tasks allowed the participant to navigate among the tasks.

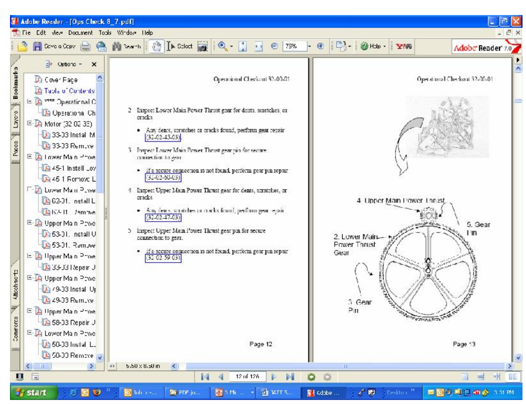

Figure 1. Traditional electronic presentation of technical orders

The training enhanced presentation group was also given the same series of instructions for performing the maintenance tasks. Their enhanced instructions explicitly supported the four learning styles of visual, auditory, reading, and kinesthetic (see Figure 2). For example, in addition to reading text directions for maintenance tasks (to support the learner with reading preferences), the user was able to manipulate a switch and hear the sound it would make (to support the learner with kinesthetic preferences).

A variety of different cues were added for each of the learning preferences. Using design principles established by Horne in his work on Visual Language (1998), these learning styles were integrated into a composite view for the learner. That is, each step integrated the visual, aural, read-write and kinesthetic information into a unified perspective on the information presented.

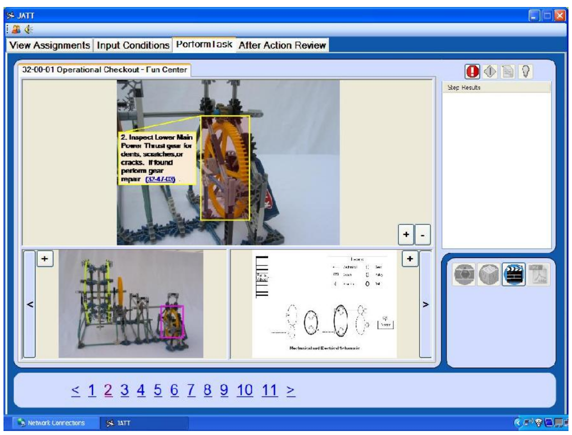

Figure 2. Training enhanced presentation of technical orders

Participants

The participants included college students, adult professionals, and graduate students. All participants had some computer experience; and were American citizens.

Materials

Assembly. Materials used for this test consisted of a K'NEX construction kit and two different presentation types on a laptop computer. K'NEX is an off-the-shelf construction kit, consisting of component parts which can be assembled in a manner similar to Tinker toys or Lego's. The K'NEX Education kit chosen was intended as a kit for teaching physical science concepts to young adults. The construction, resembling a Ferris Wheel, included gears, motors, pulleys, and other mechanical and electrical components. See Figure 3.

*Technical Data Generation***.** The K'NEX assembly was constructed to allow the user to simulate several types of typical aircraft maintenance activities. These included a test of the system operation, inspection of the system, remove and replacement of components, and an upgrade to system components. All technical manuals were modeled after Air Force maintenance technical manuals.

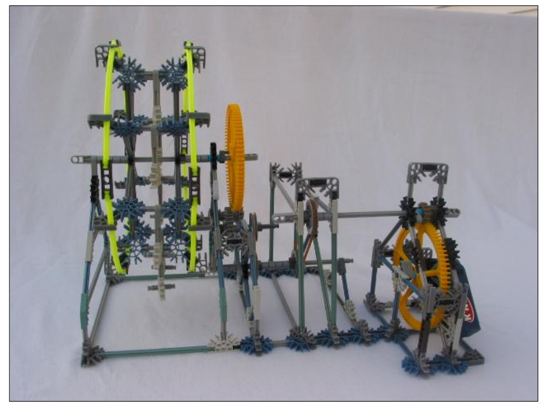

Figure 3. The "toy task" assembly used to simulate maintenance activities.

Procedure

The participant's session began with a brief description of the study and the expectations of the participant in the study. The session continued with a brief training period to familiarize the participant with the K'NEX parts and connection types. Next the participants were exposed to the job aiding tool, either the traditional (PDF) or enhanced (JATT) presentation, to which they had been randomly assigned. An example task was used to explain features of the job aiding tool which could be used to perform the task. The example task was a C-17 Open Cargo Door task.

Once they felt comfortable with the tool, participants were given their maintenance directions for the task. Participants then began the task and worked through the maintenance actions as per the procedures given. After finishing the task, each participant completed a questionnaire about their experience with the helpfulness of the presentation information.

Results

Objective Data

Time. Overall, participants in the JATT presentation (45.8 min) performed the task 16% faster than the participants in the PDF presentation (54.3 min), $t(62)=-3.092$, $p<.01$.

Errors. Overall, participants in the JATT presentation (9.8) had 49% fewer errors than the participants in the PDF presentation (19.0), $t(62)=-5.501$, $p<.01$.

Assists. Overall, participants in the JATT presentation (4.3) had 73% fewer assists than the participants in the PDF presentation (16.0), $t(62)=-5.23$, $p<.01$.

Qualitative Data

After completing the task and the post assessment, participants were asked to complete a questionnaire regarding their opinion of the overall system. Participants were asked specific questions, and then given space to freely describe their interactions with the system.

Likeability When asked how well they liked the job aid, a score of 0 meant that it was "very unliked" and 10 meant that the job aid was "very well liked" (terminology used in questionnaire). JATT users liked the system (M=8.3) significantly more than PDF users (M=6.8), $t(61)=3.4$, $p<.01$. That is an improvement of 22%.

Helpfulness When asked "How helpful were the images in the interface", a score of 0 meant "not helpful" while 10 meant "very helpful." JATT users (M=8.9) found the interface significantly more helpful than PDF users (6.8), $t(61)=5.86$, $p<.01$. That is an improvement of 30%.

Frustration When asked what percentage of the time they found themselves frustrated, a percentage score of 0% meant NOT frustrated while 100% meant VERY frustrated (emphasis duplicated in survey). PDF users (M=44%) were significantly more frustrated than JATT users (M=15%) during their performance of the maintenance activity, $t(61)=-5.24$, $p<.01$. That is a reduction in frustration of 66%.

Confidence When asked how confident they were in performing the maintenance task, a percentage score of 0% meant they had NO confidence while a score of 100% meant they felt COMPLETELY confident. JATT users (M=87.0%) were significantly more confident than PDF users (M=64.2%) while performing the maintenance task, $t(61)=4.96$, $p<.01$. That is an improvement of 35%.

Conclusions

Using JATT, participants were able to complete the task faster, with fewer errors, less instructor assistance and felt more confident in the training they received. Learning was improved when all learning preferences were addressed in the training tool. The "toy task" participants became highly qualified, multi-skill maintainers able to meet Ferris Wheel Assembly mission requirements safely, effectively, and efficiently.

The tool developed during this project presents an opportunity to improve training efficiencies, significantly reduce the cost of flightline maintenance, and improve the mission capability of military forces. A training program that supports multiple learning preferences will be vital as troop strength levels decrease and aircraft maintainers are asked to become less specialized. Deployment of tools, such as JATT, would enable consistent OJT training material and support worldwide availability of effective just-in-time training that reduces maintenance downtime and technician errors.

In addition to application to military environments, job-aiding and training tools that support various learning styles have application to a variety of important environments. As people are expected to maintain more complex systems with only intermittent failures, technicians must become generalists with the ability to troubleshoot and maintain these complex systems. These environments range from aircraft maintenance to emergency response to oil refining.

The research conducted in this study clearly indicates that when people are given the opportunity to learn in a manner which presents information in a multi-modal manner on a multimedia tool, they learn faster, require less instructional assistance, make fewer errors, and are more confident in their ability to perform a task on which they have been trained.

References

Air Force News (January 24, 2007). Senior maintenance leaders look forward with defined goals. [Retrieved] 2/4/07, [from] http://www.af.mil/news/story.asp?storyID=123038648

Bouldin, A.S., & Myers S.M (2003) Learning

Style Preferences Revisited at the University of Mississippi School of Pharmacy. [Retrieved] 2/4/07, [from] http://64.233.167.104/search?q=cache:yLAcBI70y70J:www.aacp.org/site/view.asp%3FCID%3D825%26DID%3D5383+Learning+Style+Preferences+Revisited&hl=en&ct=clnk&cd=1&gl=us

Fleming, N. (2006) VARK – A Guide To Learning Styles. [Retrieved] 2/4/07, [from] http://www.vark-learn.com/english/index.asp

Fleming, N & Bonwell, C, (2007) VARK -- Advice to Users of the Questionnaire [Retrieved] 2/4/07, http://www.ntlf.com/html/lib/suppmat/74vark2.htm

Fleming, N.D. & Mills, C. (1992). Not Another Inventory, Rather A Catalyst For Reflection To Improve The Academy, (11), 137-149.

Morgan J (April 23, 2006). VARK Learning Styles. [Retrieved] 2/4/07, [from] http://ezinearticles.com/?Vark-Learning-Styles&id=183961

Morgan J (March 04, 2006). The Four Learning Styles. [Retrieved] 2/4/07, [from] http://ezinearticles.com/?The-Four-Learning-Styles&id=155846