Knowledge Retention in Information Assurance Computer-Based Training:
A Comparative Study of Two Courses for Network User Training

Christie M. Fuller, David P. Biros
Oklahoma State University

Matthew J. Imperial
Barksdale AFB

Abstract

Organizations employ various tools, policies and techniques to improve their information assurance (IA) posture. One key area of concern is employee awareness of the IA environment. Some organizations use training programs of various levels of quality and interactivity in order to improve employee IA knowledge and mitigate vulnerabilities due to unsecure user behavior. Some awareness programs may be in the form of Computer Based Training (CBT)

This study examines two CBT programs previously used by one branch of the military. The main difference between the two programs was level of interactivity. Utilizing a quasi-experimental method, this study analyzed the effects of time on IA knowledge decrement and of CBT interactivity level on knowledge retention. The results depict that employee IA knowledge erodes over time suggesting a need for recurring training. Additionally, support was found for a positive relationship between interactivity and knowledge retention.

Keywords:

Information Assurance, Computer-Based Training, Interactivity, Knowledge Retention
Introduction

In today’s information assurance (IA) environment many organizations employ a host of layered security mechanisms to ensure their information systems are safe from unauthorized access, denial of service, and other similar incidents. Indeed, companies and government agencies have spent millions of dollars on intrusion detection systems, firewalls, and antivirus/antispyware/antispam programs. However, information security incidents continue to abound. One possible explanation for this is that organizations often overlook one of their most important components of IA: their employees.

Often lacking in organizational IA inventories is an effective employee training program. While Federal agencies are required by the Federal Information Security Management Act of 2002 (44 USC 3541, 2002) to provide employees with IA training, many state, local national, and private organizations provide very little training. Also, while FISMA requires that training occur annually, it does not examine the extent of the training. This can lead to suboptimal employee behavior. For example, in October 2006, an employee at the Los Alamos National Laboratories carried home a data stick containing classified lab information. Upon investigation, it was noted that the employee did not realize her actions were in violation of lab policy (Nuclear Lab, 2006). Under the FISMA, the lab is required to provide all of its employees, including its contractors, annual information security training. If we assume the lab followed the FISMA requirements and the employee was innocent of any nefarious intentions, then the training may have been inadequate to instill proper security behaviors in the lab personnel.

The incident at the Los Alamos National Laboratories is not isolated. Many organizations suffer from incidents due to employee ignorance or negligence of proper IA practices. This includes organizations with security training programs. Part of the problem might have to do with the quality and quantity of the training. Some organizations only provide their members with very rudimentary “training.” For instance, they may provide a small write-up of basic rules and policy or a few PowerPoint slides that the employee is requested to review when they start working for the organization. Other organizations go to great lengths to provide interesting, interactive, and informative IA training to their employees on a recurring basis. Still, information security incidents due to improper employee behavior remain a critical problem.

In consideration of this issue, we posit the questions:

1. How much and for how long do people retain IA training knowledge?
2. Does the level of content interactivity improve retention?

We believe that many organizations can improve their IA posture by providing their members with effective IA training at recurring intervals. The purpose of this study is to demonstrate that IA knowledge does indeed decrement over time and one-time training or infrequently recurring training does little to help an IA program. Furthermore, we will
demonstrate that a training curriculum that includes a greater level of interactivity will enhance IA knowledge retention and mitigate the effects of time.

Background

All types of organizations seek ways of creating more effective and efficient training programs. Utilizing technology in learning and training programs has been one way to do so. The earliest roots of technology use in education can be traced to the works of Pressley in the 1920s and Skinner in the 1950s with teaching machines (Dixon-Krauss, 1996). Teaching machines lacked the processing power and software capabilities necessary for high adaptation (Wiggs and Seidel, 1987). The advent of the microcomputer drastically altered technology-based training leading to the use of CBT. Today’s Internet-enabled technology-based training landscape has spawned a highly dynamic online CBT also known as web-based training (WBT). Due to the proliferation of Internet technologies, online CBTs are currently experiencing tremendous growth. A 1999 CBT study reported that 54 percent of individuals polled said that their companies deliver training or facilitate learning via the World Wide Web (Boisvert, 2000). Some industry experts further predict that WBT will constitute half of all training in the next few years (Roberts, 2001). Organizations typically transfer training materials into computer environments for one of three main reasons: “(1) the desire to customize learning environments to the changing needs of learners, (2) the need to improve how training-related administrative tasks are managed, and (3) the desire to reduce the cost of training” (Boisvert, 2000).

The U.S. military is among those organizations that must provide information assurance training to all of its network users. This study will focus on two network user training programs. One is an AirForce-wide, or central, program. The other was developed by a Major Command (MAJCOM) for use on its base (hereon referred to as “base specific”). The main difference between the two programs is the level of interactivity the program incorporates.

Previous studies of military CBT programs have focused on cost-effectiveness (Orlansky and String, 1979), or planning, selection, and implementation issues (Nason, 1992). The primary research question in this study is to assess the learning outcome of knowledge retention associated with two CBT programs. Research has demonstrated that the interactivity levels of technology-based instructional courses can have a significant effect on knowledge retention. However, there is a lack of evaluative studies on military CBTs that focus on the effect of interactivity on knowledge retention.

The main objective of any training program is to instruct employees in some type of subject matter, increase their knowledge and understanding of that subject, and ultimately affect their future behavior in encountering situations applicable to that training. In the realm of network user training, these objectives apply. This research study has the unique opportunity to test the effect of CBT interactivity on knowledge retention in a military training environment. Studies of this type are necessary to determine whether or not network users are being effectively trained through the use of CBT training courses.
Knowledge Retention

Psychological literature defines knowledge retention as the ability for an individual to recall or remember knowledge that has previously been learned (Hulse, et al., 1980). Academic studies have measured knowledge retention as some level of knowledge demonstration at some time interval following some type of instruction or training (Haynie, 1997; Roberts, 2001; Sanders et al., 2002; Williams and Zahed, 1996; Wisher et al., 2001; Yildrem et al., 2001). In this respect, knowledge retention describes a sustained level of knowledge over time and relative to initial learning. The close interrelationship between learning and retention is evident. It is important to note the complementary nature between the construct of knowledge retention and knowledge loss. Hulse et al. (1980) note that “the amount you have forgotten about something equals the amount you originally learned less the amount you have retained.” Knowledge retention specific to this research effort refers to the recall of facts, terminology, and concepts at varying time intervals following completion of an initial CBT training course and test.

Scores of literature have demonstrated the time-dependent nature of knowledge retention, whereby as time passes from an initial demonstration of particular knowledge, the ability to recall that same knowledge gradually declines, regardless of delivery medium (Hulse et al., 1980). Psychological research in this area has demonstrated that “forgetting newly acquired knowledge occurs naturally over periods as short as several hours to as long as many years” (Wisher et al., 2001). Although particular types of knowledge exhibit different rates of decline, the general behavior of knowledge retention curves exhibits a rapid decline shortly after initial training, followed by a continuous slight decline, and finally an asymptotic leveling (Hulse et al., 1980). Several studies have demonstrated that a majority of knowledge loss tends to occur within the first ten weeks after initial training (Wisher et al., 2001). The rate of decline in knowledge for this particular training, and the difference in this rate with varying levels of interactivity is unknown. Therefore, we propose that in this study, knowledge retention will decrease over time. However, our primary concern is how much retention will decrease and when training should be readministered to optimize employee awareness.

The majority of studies on CBTs involve a comparison against traditional classroom instruction. This is also the case in terms of studies on knowledge retention in CBTs. Kulik and Kulik’s (1991) meta-analysis included twenty studies that examined knowledge retention differences, as measured by percentage correct on follow-up examinations between CBT and traditional classroom instruction. They found an improvement for knowledge retention from traditional to CBT from a 50th to approximately a 57th percentile. More recent research by Williams and Zahed (1996) involved just one evaluation, but the study was between CBT and traditional classroom instruction. This study measured student performance directly following coursework and one month after using an identical multiple-choice 33-item exam. Differences between treatments in initial posttest performance directly following coursework were found to be
nonsignificant. However, there was significant CBT advantage on the retention test given one month later (Williams and Zahed, 1996) Thus, there exists at least some evidence that the use of CBT can affect knowledge retention. George et al., (2004) demonstrated that increasing levels of interactivity in deception detection training improve subject knowledge acquisition. As such, we propose that among CBTs, varying levels of interactivity will have a significant effect on knowledge retention, as measured by relative retained knowledge.

This study will also explore possible effects of job on knowledge retention. Biros et al., (2002) demonstrated that experience in the knowledge domain was associated with a subject’s ability to detect deception in that domain. Therefore, we propose that individuals reporting communications as their job field will possess a higher level of baseline knowledge regarding the network security content of the central and base-specific courses. This belief in a higher level of baseline knowledge is rooted in the assumption of a background in the communications field, either obtained through training or experience in the communications field to include aspects of network and information security. Typical duties for individuals in this field include network administration, information systems security, computer help desk tasks and other information technology responsibilities. Those working in this career field also receive basic communications training at the time they enter the service, refresher training after they have had a few years of practical experience and continuous on-the-job training. Because of this higher level of baseline knowledge, it is proposed that when compared to individuals in non-communications job fields, individuals in the communications job field will exhibit higher levels of knowledge retention.

In summary, this study will test the following hypotheses:

H1: Knowledge Retention will negatively correlate with time.
H2: Overall interactivity will positively correlate with knowledge retention as measured by relative retained knowledge
H3: Job field will have a significant effect on knowledge retention

Methods

This study analyzed two network user CBTs. Each CBTs objectives and end-of-course exams were nearly identical. Both courses contain three primary course sections consisting of (1) Authorized and Unauthorized Activities, (2) Virus Detection and Protection, and (3) Backup Strategy. The base-specific course contains an additional section on Computer Security Controls containing material on User Responsibilities and Password Policies. One primary exam difference is the pass/fail thresholds; users of the central program must obtain at least 16 out of 23 questions (≥ 70%) correct in order to pass while users of the base-specific program must obtain at least 19 out of 23 questions (≥ 83%) correct in order to pass.

The first stage of this research consisted of a content analysis of the level of interactivity present in the two programs. This content analysis was used to determine the treatment
differences as experienced by those subjects who indicated they first reviewed the CBT course prior to taking the initial exam. The content analysis covered the four main components of overall interactivity: (1) multimedia, (2) programmed instruction, (3) frequency of interactivity, (4) range of interactivity. The classification system used for the content analysis was constructed in order to limit the amount of categories per construct and minimize subjectivity. For multimedia, the category was single, dual, or multi. Although multimedia suggests the use of more than two implemented media, neither CBT exhibited more than two types with the base-specific CBT implementing text only (single) and central CBT implementing text and line drawings (dual). For programmed instruction, the category was either yes (programmed instruction was implemented) or no (programmed instruction was not implemented). The frequency and range content analysis was based upon Kettanurak et al.’s (2001) Interactivity Measurement Matrix. The frequency analysis involved a raw count of the number of instances a student had the opportunity to interact (provide input in some form/manner) with the CBT during the course and also considered course navigation control features. The range analysis involved a count of the number of input choices and a description of the range of outcomes that may occur as a result of a student’s choices at each interaction opportunity.

The second quasi-experimental stage utilized a web-based retest/survey assessment tool. This tool was administered to two graduate military student sample groups, representing the two training programs. Both CBT programs have their own information gathering databases (DB), which track student information by course. Each student’s initial (archival) test score percentage was recorded by the DBs. The archival segment of data for both samples was independently collected prior our undertaking this study. Determination of CBT program used was based on the students’ previous assignment locations.

Throughout academic literature, knowledge retention has consistently been measured by the amount of course material recalled by students who previously completed a training course (Haynie, 1997; Roberts, 2001; Sanders et al., 2002; Williams and Zahed, 1996; Wisher et al., 2001; Yildrem et al., 2001). Knowledge retention studies have typically used uniform follow-up intervals (all subjects were retested X amount of time following initial end-of-course test). This study differs in design in that knowledge retention is measured across various follow-up intervals ranging from 0 to 9 months. Knowledge retention is operationalized as relative retained knowledge, defined as performance on a retention exam relative to performance on an initial exam, and has a formula of: \([T2/T1] \cdot 100\). Knowledge retention analyses performed in this study used the relative retained knowledge formula and reference time by either number of days passed since initial test or by parsing users in month groups. Since the number of days passed is available, this allows knowledge retention to be viewed in a longitudinal manner, allowing the rate at which knowledge is lost to be calculated.
Population

The population of interest is network end-users. At the time of this study, the Air Force was one of the few organizations that had a recurring IA training program. A subset of these users were selected for this study, composed of two groups: (1) network end-users that took the central CBT and (2) network end-users that took the base-specific CBT.

The data was collected in December 2002. The sample included subjects that had previously completed one of the two CBTs between the months of January and November 2002 in its entirety. Actual subjects in this study were network end-users currently authorized and licensed to utilize the organization’s networks.

There was a sizeable difference in the number of trainees for each month sampled. Therefore, the data was first grouped by months, and subjects were randomly sampled from each month’s data. Expectations were for a response rate of approximately 30%. Since a sample size of 1,000 per CBT group was desired, 500 base-specific users were sampled from each month (3,500 total) and 450 central CBT users were sampled from each month (3,600 total) and a survey was delivered to these users via email. Of the 7100 emails sent, 5384 were successfully delivered, 2784 to central users and 2600 to base-specific CBT users. The overall response rate for the emails successfully delivered was 13.8%, or 744 usable responses. Responses were divided into treatment and control groups for each CBT. Treatment groups reported that they reviewed CBT courses prior to taking initial test. Control groups reported that they did not review courses prior to taking initial test. This data collection approach provided the needed input for the survey phase of the study.

Analysis

The interactivity content analysis included four components of overall interactivity: frequency, range, multimedia, and programmed instruction. The goal of this analysis was to determine the difference in interactivity between the two types of CBT. Based on the analysis of each CBT using the four criteria above, it was determined that the central CBT could be characterized as having LOW interactivity, while the base-Specific CBT could be characterized as having NO interactivity. The single media text of the base-specific CBT can be likened to no more than a plain online text book and as such is believed to have a negligible effect on interactivity. Statistical techniques employed in this study included: independent sample t-tests in both equal and unequal variances form, traditional analysis of variance (ANOVA), Welch ANOVA for unequal variance samples, and simple linear regression.

Hypothesis 1: Time and Knowledge Retention

The negative effect of time on knowledge retention has been cited throughout literature and exhibited across various academic studies. In order to test this relationship of time and knowledge retention in this study, a simple linear regression (SLR) analysis between time (days passed) and knowledge retention (relative retained knowledge) was performed...
among sample and aggregated sample groupings. The results of that analysis are found in Table 1.

Table 1
Time Effect (Days Passed) on Knowledge Retention
(Relative Retained Knowledge) Using SLR and Single Parameter t-tests

<table>
<thead>
<tr>
<th>Sample Group</th>
<th>R^2</th>
<th>pValue</th>
</tr>
</thead>
<tbody>
<tr>
<td>Central Treatment, n=252</td>
<td>0.048</td>
<td>0.0004</td>
</tr>
<tr>
<td>Base-Specific Treatment, n=314</td>
<td>0.01</td>
<td>0.0756</td>
</tr>
<tr>
<td>Both Treatment, n=566</td>
<td>0.032</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Central Treatment and Control, n=360</td>
<td>0.043</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Base-Specific Treatment and Control, n=384</td>
<td>0.018</td>
<td>0.0079</td>
</tr>
<tr>
<td>All Groups including Control</td>
<td>0.039</td>
<td>&lt;0.0001</td>
</tr>
</tbody>
</table>

As expected, the one-tailed t-test performed for each sample grouping (alpha=0.1) indicates that there is a significant negative relationship between time and knowledge retention. The SLR analysis produces linear equations for each sample grouping. The linear equations, minus the error term, produced from the SLR analyses for relative retained knowledge in each sample grouping are given in Table 2. Using these equations, the number of days that will pass before the knowledge level falls below the acceptable threshold can be calculated. For the central users, the threshold is 70%, while a higher threshold of 83% is used for the base-specific training.

Table 2
Linear Equations for Relative Retained Knowledge by Days Passed

<table>
<thead>
<tr>
<th>Sample Group</th>
<th>Linear Equation</th>
<th>Days until Knowledge equals threshold</th>
</tr>
</thead>
<tbody>
<tr>
<td>Central Treatment</td>
<td>E(Relative Retained)=95.2-(0.05*Days Passed)</td>
<td>504</td>
</tr>
<tr>
<td>Base-Specific Treatment</td>
<td>E(Relative Retained)=88.1-(0.02*Days Passed)</td>
<td>255</td>
</tr>
<tr>
<td>Both Treatment</td>
<td>E(Relative Retained)=92.0-(0.04*Days Passed)</td>
<td>*</td>
</tr>
<tr>
<td>Central Treatment and Control</td>
<td>E(Relative Retained)=94.9-(0.04*Days Passed)</td>
<td>622.5</td>
</tr>
<tr>
<td>Base-Specific Treatment and Control</td>
<td>E(Relative Retained)=88.6-(0.04*Days Passed)</td>
<td>140</td>
</tr>
<tr>
<td>All Groups Including Control</td>
<td>E(Relative Retained)=92.5-(0.04*Days Passed)</td>
<td>*</td>
</tr>
</tbody>
</table>

*Cannot be calculated due to differing guidelines

The associated negative days passed slope values in the linear equations given above demonstrate that for each one day that passes, the estimate for relative retained knowledge drops from between 0.02% to 0.05% depending upon sample grouping.
Hypothesis 2, Overall Interactivity and Knowledge Retention

In order to determine the effects of overall interactivity on knowledge retention, values for new test score percentage, relative retained knowledge, and relative knowledge loss were computed for each treatment group. It is appropriate to use just the treatment groups since it is only these groups which experienced different levels of overall interactivity. The control group did not experience differing levels of interactivity since they did not review the CBT prior to testing. In an attempt to compare similar retention intervals, the data sets were parsed into month groups, where each group spanned a one-month period ranging from 1-2 months to 8-9 months. For the central treatment group, from one month to eight months had passed since training. This was divided into seven groups, each consisting of one month’s data. Similarly, for the base-specific treatment group, two to nine months had passed since training. This was also split into seven subgroups, each containing the data for a different month.

As previously demonstrated, time (days passed) has a significant negative effect on knowledge retention, as measured by relative retained knowledge. It was for this reason that an attempt to control for the time distribution between treatment groups was made prior to comparing treatment groups.

To determine if there was a significant difference in the days passed since training between the two groups, an ANOVA was performed. The results showed that a mean of 129 days since training for the central treatment group and 150.5 days since training for the base-specific treatment group (p-value < 0.0001). As noted above, for the central group, data was available for the period one month to eight months after training. For the base-specific CBT group, the data reflected two to nine months post training. In order to minimize the difference between the groups in days passed, the data was filtered to remove the first month of data for the central group and the last month for the base-specific group. Only data for overlapping time periods was retained. The resulting data covered six months of records, including those who had received training anywhere from two to eight months prior. As described above, the data for these six months was categorized into groups for each month in the six-month interval. After removing the data for the first and ninth months, 485 records remained, 210 central treatment and 275 base-specific treatment.

Though there was a significant difference in days passed using the full set of data, when filtered to include only overlapping retention groups, no significant difference was found. Using a 99% confidence level (â = 0.01), there was no significant difference between the average number of days passed (p-value = 0.03) with an average of 146.5 days passed for the central treatment group and 136.2 days passed for the base-specific treatment group. Given these results, it was deemed appropriate to compare the level of knowledge retention for the 2-3 month through 7-8 month intervals for both groups.
Independent one-tailed t-tests were conducted for relative retained knowledge between treatment groups for each retention/month groups. A 90% confidence level was set for the t-test. A lower confidence level was deemed appropriate since the days passed average favored the base-specific treatment group (no interactivity). The results of the t-tests are shown in Table 3.

Table 3
Overall Interactivity Effect on Knowledge Retention: Relative Retained Knowledge Between Treatment Groups and Retention/Month Groups

<table>
<thead>
<tr>
<th>Retention/Month Group</th>
<th>pValue</th>
<th>Significant Difference per t-test (alpha=0.1)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2-3 mos</td>
<td>0.02</td>
<td>Yes</td>
</tr>
<tr>
<td>3-4 mos</td>
<td>0.12</td>
<td>No</td>
</tr>
<tr>
<td>4-5 mos*</td>
<td>0.87</td>
<td>No</td>
</tr>
<tr>
<td>5-6 mos*</td>
<td>0.59</td>
<td>No</td>
</tr>
<tr>
<td>6-7 mos</td>
<td>0.84</td>
<td>No</td>
</tr>
<tr>
<td>7-8 mos</td>
<td>0.026</td>
<td>Yes (Higher retained knowledge for central treatment)</td>
</tr>
<tr>
<td>(All Intervals Combined)</td>
<td>0.07</td>
<td>(Higher retained knowledge for central treatment)</td>
</tr>
</tbody>
</table>

* Indicates unequal variance t-test was used.

**H3: Job Field Effects on Knowledge Retention** The remaining hypothesis tested the effects of job field. Analyses for these parameters were conducted independently upon each CBT’s aggregated treatment and control groups. Independent analysis of CBT sample groups affords the opportunity to include the entire sample sets, in that the retention interval month groups that did not overlap can be analyzed. In the survey, users were required to select from one of fifteen job fields, such as communications, flying operations, or medical. Job field was analyzed by categorizing the data into communications and non-communications. Table 4 records the ANOVA analysis for time and knowledge retention between the remaining independent variables hypothesized on, in regards to knowledge retention. Significance in knowledge retention was exhibited for the job field demographic; however the time distribution was also shown to be significant between job fields.

Table 4
Knowledge Retention and Time ANOVAs, Central Treatment and Control Group

<table>
<thead>
<tr>
<th>Job Field</th>
<th>Sample Size</th>
<th>Days Passed Mean (alpha=0.1)</th>
<th>Relative Retained Knowledge, Mean % (alpha =0.1)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Communications</td>
<td>129</td>
<td>120.8</td>
<td>90.9</td>
</tr>
<tr>
<td>Non-Communications</td>
<td>231</td>
<td>132.8</td>
<td>87.7</td>
</tr>
<tr>
<td></td>
<td></td>
<td>p=.08</td>
<td>p=.04</td>
</tr>
</tbody>
</table>

**Discussion of Hypotheses Findings** The three primary hypotheses were: associating the construct of knowledge retention to time and interactivity, as well as associating job-field with knowledge retention. Results were mixed for the proposed hypotheses. As expected, there was support for a negative relationship between time and knowledge retention. There was support that overall interactivity within CBTs positively affects knowledge.
retention, as results showed that from 2-3 months, 7-8 months, and overall from 2-8 months, the interactive CBT showed greater knowledge retention. This finding is consistent with the reviewed literature and reinforces the well-documented link between social and engaging learning environments with positive learning outcomes (Jung et al., 2002; Muirhead, 2000; Oliver et al., 1996; Vygotsky, 1978).

Knowledge retention was the central learning outcome construct in this study. Also of interest were the effects of job field on knowledge retention. It was hypothesized that users in a communications job field, when compared to those not in a communications job field, would exhibit higher levels of knowledge retention. There was evidence for this proposed relationship. The logic behind job field effect is that users in the communications field are more likely to experience information and network security issues outside the training CBTs. However, there was also a significant different in the days passed between the different job fields. Future research should seek to minimize this difference, or adjust for it, so that the rate of knowledge loss can be isolated. Table 5 summarizes the results of testing each hypothesis.

### Table 5
Hypothesis Testing Results Summary

<table>
<thead>
<tr>
<th>Hypothesis</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>H1: Knowledge Retention will negatively correlate with time.</td>
<td>Supported</td>
</tr>
</tbody>
</table>
| H2: Overall interactivity will positively correlate with knowledge retention as measured by relative retained knowledge: 
  \[ (retest score / initial test score) \cdot 100 \] | Partially Supported |
| H3: Job field will have a significant effect on knowledge retention        | Supported        |

**Limitations**

The time-sensitive nature of knowledge retention and the large range of retention intervals studied made it difficult to compare sample groups with exact retention interval distributions. The sample was adjusted so that similar intervals could be compared. A critical piece in studying learning outcomes over time is an evaluation of knowledge levels prior to initial training. This study was unable to measure this part of the time series and therefore could not provide a baseline level of knowledge prior to course treatment. Without such evidence, conclusions about course effect on learning are limited. Though the ideal baseline was not available, the treatment groups which reviewed the course prior to the exam were able to be compared to users who had not reviewed the course materials, providing some level of control. Knowledge retention values at all time periods were found to occur across a wide range of values. This variance had an effect on the explanatory power of the models. It is clear that there are other factors significantly affecting the construct of knowledge retention.
Implications for Academia and Future Research

This study involved the comparison of one CBT with no interactivity and one with low interactivity. CBTs exist that employ a much higher level of interactivity than present between the two courses studied (None and Low). In that interactivity was shown to have a significant positive effect on knowledge retention, future studies may search for learning outcome differences among a wider range of interactive CBTs to include those courses evaluated as having medium and high interactivity. Statements from several users indicated the presence of stale and extremely familiar course content. It is important not only to assess whether or not training material is effective, but whether or not it is relevant and current as well. An in depth study into whether or not the course content is current and relevant for today’s network security environment and end-user experiences would prove to be a worthwhile research effort.

Implications and Recommendations for Practitioners

This study has several implications for Information Assurance practitioners. Findings should help to shape future versions of CBT design and implementation, as well as network end-user training policy and management. This study found evidence linking interactivity and knowledge retention. This study also analyzed user knowledge levels over time in relation to pass/fail thresholds and the current retraining timeline of one year. By examining knowledge retention levels over time, we are able to calculate the knowledge retention at the current retraining timeline of one year, as well as calculate when the knowledge retention level drops below pass/fail thresholds. For the central CBT the pass/fail threshold at the time of data collection was 70%. According to the regression equations calculated in this study, at the time of retraining, knowledge retention will be 80.3%, well above the required level. Therefore, with the current central CBT threshold of 70% in place, it appears that the current retraining timeline is appropriate in that the average user score continues to be above the threshold at the time that training recurs. For the base-specific CBT, knowledge retention will drop below the 83% level after about 140 days. At the time of retraining, this level will drop to 73.9%. Therefore, with the current base-specific threshold of 83%, a one-year retraining timeline does not seem adequate in that the average new test score is predicted to drop below the threshold around 7 ½ months before retraining. To remedy this, one possibility in preventing the average score from dropping below the current threshold would be to shift the retraining timeline from annually to every 4 ½ months. It may be unrealistic to impose the burden of such frequent training on the organization. Other, perhaps more preferable options, include adjusting the threshold to a lower level or improving the training so that the content is retained for a longer period.

At the time that this study was conducted, there was no central authority for IA training. MAJCOMS could either use the centrally-developed program or create their own. They could also determine their own pass/fail threshold. The training has since been centralized and a standard pass/fail threshold has been set at 80 percent. The current training is also more interactive by providing end of section quizzes with feedback, self-paced study, and more real world scenarios and examples.
Conclusion

We cannot stress enough how important a good personnel training program is to an organization’s IA readiness poster. This study demonstrated that even with a good training program, employee IA knowledge retention degrades over time. One can imagine the vulnerabilities present in organizations that do not properly train their employees. CBT can provide effective network user training. However, the knowledge gained through this training decreases over time. Therefore, training must be repeated at appropriate intervals to minimize IA threats. Training should also incorporate interactivity and other tools that decrease the rate at which knowledge is lost. Network end-user training must remain current with changing technologies and evolving threats. If the aim of the network user training mandate is to promote awareness, increase knowledge, and improve skills in the arena of information and network security, then the training content must remain fresh, current, and engaging, as well as relevant for user experiences. These training content characteristics should be prevalent in all training programs. By creating an adaptable computer learning environment more conducive to expanding individual knowledge, personnel may show gains in knowledge retention. These gains in retention for network security training can help fortify the defense of information/network assets by improving the most critical piece of an organization’s information security architecture — the people.

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