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Educational Technology Gap Theory

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ABSTRACT

Using an adaptation of Oliver's (1977, 1980) Expectation Confirmation Theory as a framework, we develop a "technology road map" as suggested by McKeen and Smith (2006) for a professional development college (referred to as "The College") at a large federal university ("The University") with the goal of providing a state-of-the-art learning environment. Survey responses and comments provided key results and a starting point for future research. The major finding from this study is an Educational Technology (ET) "way ahead" criterion list. Study results led to fiscal year-end purchasing decisions to enhance the learning environment at The College. Additional analysis is required to devise an action plan for increasing levels of faculty expertise in emerging education technologies to develop and maintain a "state of the art" learning environment.

Keywords

Knowledge Management, Expectation Confirmation Theory, Education Technology

INTRODUCTION

In the middle of the last century, Drucker (1969) maintained that one of the reasons for Britain's economic woes was due to skilled labor shortages caused by an insufficient number of surplus farmers to shift from agricultural to emerging urban industries. However, the United States did have extra workers to move from field to factory, a contributing to its explosive economic development. In 2009, the United States confronts its own crisis because of a new kind of labor shortage. Innovations in information technology (IT) during the 1980s and 1990s have changed the rules of the game; industrialized nations are now in desperate need of knowledge workers as the information age matures, but our educational systems lag in adapting to this new environment.

In 2001, in a survey entitled "Loyalty and Commitment: A Survey on Attracting and Retaining Workers," 77% of human resource professional from large reported that it was difficult or very difficult to attract key talent, and 59c of the respondents indicated that it was difficult or very difficult to retain key personnel (Jamrog, 2002). The competition for knowledge workers has become a national issue. A call for increasing overall workforce skills in 2001 (Porter and Van Opstal, 2001) specified that the United States needs to:

- Improve math and science education
- Provide access to IT for all students
- Raise post-secondary enrollment rates for underrepresented minorities
- Increase access to higher education for students from low-income households
- Extend training opportunities to more workers

The knowledge worker shortage directly affects the federal workforce. Current research indicates a future shortage of workers with engineering, science, and technical skills. For example, the number of engineering doctorate degrees awarded annually has declined 15% in the last ten years (GAO, 2006). As one of the largest employers in the country, the Department of Defense (DOD) must remain attractive to potential employees, but struggles to remain competitive in compensation and quality of life issues, making recruitment and retention more challenging. Coupled with the impending retirements of an aging workforce, many defense related organizations will experience a loss of institutional knowledge, valuable experience, and technical talent (GAO, 2006). Thus, it is critical that DOD resources be spent as effectively and efficiently as possible to properly train and educate the future DOD workforce that will enable national security.

The university at the center of our study created a strategic planning team comprised of a diverse group of members from the various colleges that are part of the university. Their mission statement was to become, "A functionally diverse college providing the highest quality, multi-disciplined professional continuing education, and technical training to DOD and international students." The team also shaped an empowering vision to be an "Internationally recognized DOD center of excellence for professional development and consultation services." To support this mission, and to fulfill the vision, the planning team identified four strategic goals as of October, 2005:

1. Develop and maintain a state of the art learning environment.
2. Develop and present curricula that is operationally relevant, current and academically credible.
3. Attract and nurture the highest quality faculty and staff.
4. Improve partnerships through improved communications to encourage and facilitate more effective accomplishment of the mission.

In July of 2006, the team added a fifth goal to "Conduct and collaborate on responsive influential research" to support the university mission.

Lead proponents oversaw the process of realizing each of the above goals, and managed his or her team selected for each goal. The goals were broken into smaller, achievable elements and assigned to a team member for action. Strategic Goal number 1 is comprised of three elements: A) Incorporate relevant technology into the college learning environment; B) Ensure effective college facilities; and C) Ensure effective and efficient support operations. Thus, one purpose of this study is to report on how Strategic Planning Team 1A established a foundation for an action plan incorporating relevant technology into the ECPD learning environment and developing a technology roadmap (McKeen and Smith, 2006) for education.

In order to develop this roadmap, a "gap analysis" of ET needs was required. Figure 1 below provides an illustration of the gap between current technology and perceptions of future technology need:

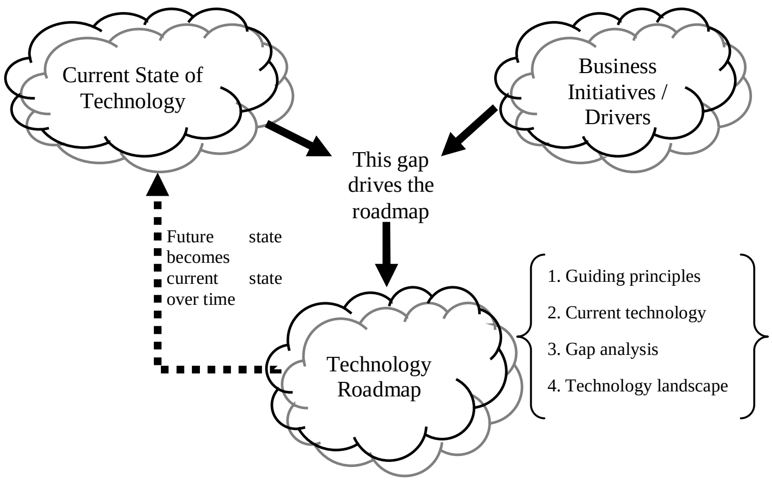

Figure 1. The Process of Developing a Technology Roadmap (McKeen and Smith, 2006)

Thus, it was determined that an assessment of the current state of ET within The College would be needed to identify if there were "gaps" between ET available in The College and ET available and being used outside of the university and DOD. To measure a possible gap, an adaptation of Expectation Confirmation Theory (ECT) (Oliver, 1977, 1980) is used, exchanging "Expected Educational Technology Need" for "Expectations" and "Current ET Usage" for "Perceived Performance."

The following sections of this study contain a literature review of recent articles focusing on ET issues and ECT; a section describing data collection and analysis; a summarized analysis; a discussion of the implications of the assessment, limitations of this study, and its implications for The College specifically and further generalizability to other educational venues. Finally, the conclusion section summarizes the results of the study and provides topics for future research.

LITERATURE REVIEW

To understand the challenges of creating an ET system, an initial analysis of the factors required for an information system is needed. Systems analysis is a study of the "problems and needs of an organization to determine how people, data, processes, and IT can best accomplish improvements of the business" (Whitten, Bentley and Dittman, 2003). For this study, the "business" is education, so a complete analysis would look at the people, data, processes, and IT from an educational perspective. However, the data in question would be specific to each individual school within the university, and the processes are the focus of the other strategic teams; therefore, the balance of this study will be concerned with the people and IT affecting the university's strategic goals.

People

The diverse ET needs of faculty and students are presented in many ways, but most are visible along generational boundaries. Members of the "Greatest Generation" born before 1945 have been retired from the DoD and no longer influence The College's ET needs. However, the three remaining generations have significantly different interaction with contemporary information and ET.

Baby Boomers

Children born from 1945 to 1964 were the first generation to grow up with television, but there was only one in the house. Citizen's band (CB) radios extended their mobile "virtual" reach to tens of miles, but were not practical as business or mobile computing tools. Computers were mainframes costing millions of dollars and requiring housing in large, environmentally-controlled rooms. Personal computers, while just being introduced in the latter part of the baby boom era, were cost-prohibitive to all but businesses or the wealthy. Many of the faculties of The College are members of this generation.

Generation X

The next generation, Generation X, was born from 1965 to 1980. Many grew up with multiple televisions in their household, and VCR's, CD players, etc. defined their environment. Access to IT continued to increase, changing how these young people dealt with the world around them. Cell phones were available, but because of the infancy of the cellular network, they were expensive and had limited range. The majority of The College's continuing professional development students are members of this generation.

Net Generation (Generation Y)

The older members of this generation born from 1981 to 1999 have been in the professional workforce for only a few years. Many will not remember a time when there was not an Internet. Their best friends may be people that they have only chatted with online. They were practically born with cell phones in their hands. With the advent of social networking websites, we are raising a generation of people who will keep their childhood friends intimate for the duration of their lives. With the affordable internet and cellular telecommunications, their mobile "virtual" reach is global. They expect any organization to which they belong to use modern IT. The older members of this generation are just beginning to enter the phase of their careers requiring continuing professional development and represent a great future challenge to DoD educational systems. Although not present in large numbers yet, these students will become a critical driver of educational changes for The College.

Theoretical Model

Oliver's (1977, 1980) Expectation Confirmation Theory (ECT), which is used in marketing and consumer behavior, provides a theoretical foundation for this study. Oliver's model (see Figure 2 below) states that expectations and perceived performance of a product or service can predict satisfaction with that product or service. Positive or negative disconfirmation due to better or worse performance respectively, can moderate the degree of satisfaction. Noe (2005) identified six characteristics to consider when using technology to enhance learning: Content, Link to Resources, Learner Control, Collaboration & Sharing, Administration, and Delivery.

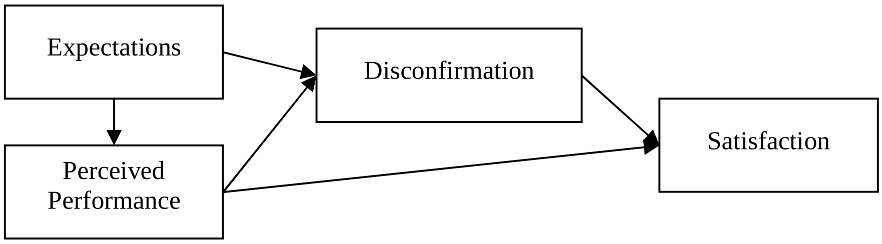

Figure 2. Oliver's Expected Confirmation Theory

The literature review identified seven categories to include in a study of ET. These categories include current ET use for course work and non-related administrative work; future technology needs for course work and non-related administrative work; current student use of ET in other academic courses; and faculty training – actual ET training received versus perception of how much ET training is needed.

Adapting the ECT framework to reflect the dissonance between current and expected ET usage would allow study of the factors affecting each category and provide input into an "ET roadmap," using as a dependent construct the concept of "Satisfaction with Technology Roadmap," shown in Figure 3 below with the constructs and adaptation of the ECT model. Note that feedback to the "Satisfaction" construct is in the opposite direction than the Technology Roadmap model, but is relevant to the ECT model.

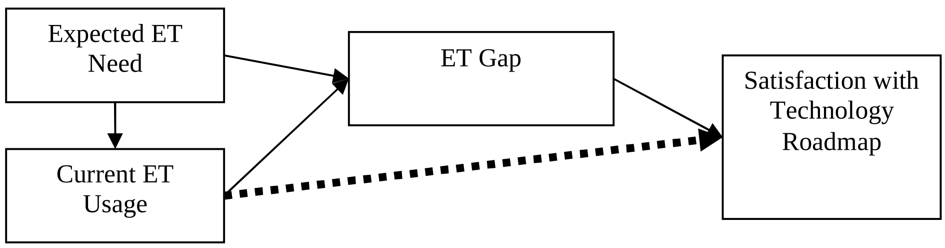

Figure 3. Educational Technology Gap Model

In this proposed model, indicators for the "Educational Technology Gap" construct would measure faculty beliefs and attitudes regarding the ET use in the organization.

METHODOLOGY

A survey, "Technology Projection Survey," attempting to identify the current ET usage of the faculty and staff of The College was developed to establish a starting point for the ET roadmap. The survey contained both quantitative and qualitative sections that allowed respondents to answer with scalar responses and comments.

Participants

The survey was sent out to 114 people (both faculty and staff) currently employed at The College with an invitation from the lead proponent to participate. The population included federal faculty and staff, with time in the organization ranging from newly arrived to over 30 years of service at The College. The average time in the organization for respondents was just over 52 months. Some people perform administrative duties; others perform both administrative and instructional duties, but all are considered knowledge workers who may have input on the technology roadmap.

The Survey

Quantitative and qualitative responses were collected from respondents. Seven questions, with up to 14 stubs each, were asked along with limited demographic data. Survey questions relating to training are listed in Table 2 below. Participants were invited to take the web survey via e-mail; all employees of The College are required to use e-mail. The e-mail included the reason for the study, the authorization for the study, and a hyperlink to the actual survey. Fifty-four results were received in the initial response period for a 47.4% response rate; a reminder e-mail garnered six more responses for a final response rate of 52.6%. The respondent comments were analyzed using content analysis, a methodology for studying the content of different forms of communication (Krippendorff, 2003).

Content Analysis

Themes identified from the literature review of ET issues were used to construct a spreadsheet allowing coders to observe alignment of comments from respondents with ET issues to facilitate content analysis. Three coders, (two Ph.D. students, and one MBA student) coded the 99 respondent comments captured by the ECPD Technology Projection Survey. Definitions of the categories and examples were hyperlinked to the spreadsheet used for recording the ratings of the comments. No coder training was conducted on how to rate comments other than the instruction sheet provided to each coder. The coders assigned comments using the categories identified in the literature review (software, connectivity, hardware, security, reliability, learning, training, and technical issues), or to an "Other" category as applicable.

Quantitative Analysis

Quantitative responses from the survey were analyzed using paired samples t test. Questions 6 and 7 are related to current training and required training. Questions 3 and 4 are related to the current and future use of educational related technology with a software perspective, and questions 1 and 2 are related to the current and future use of educational related technology from a hardware perspective. Question 5 is concerned with the current use of emerging educational technologies in ECPD courses.

Results

The results listed in Table 1 below, in descending order of appearance, provide an indication of the relative percentage of comments for each category and the associated Krippendorff's alpha (Krippendorff, 2003). A comment was retained if at least two reviewers coded the comment for that respective category. Krippendorff's alpha is a proportion of the observed to expected above-chance agreement of the coders (Krippendorff, 2003). The sum of the percentages exceeds 100% as some comments were placed in multiple categories. Only one category, (Security), meets the minimum alpha of 0.667 at the 0.05 level of significance (as suggested by Krippendorff) to draw substantive conclusions about the respondent's comments, but as the respondents work where network security is paramount, this is not surprising. Upon reviewing comments coded as related to security (14.1%), a majority of the comments were actually connectivity problems caused by network security protocols. Thus, for this study, security issues will not be considered. Three other categories (software, connectivity, and hardware) have a Krippendorff's alpha above 0.60 and will be considered in this study.

Category	Relative number of comments (%)	Krippendorff's Alpha (%)
Software	38.4	63.9
Learning	29.3	55.2
Connectivity	25.3	62.4
Training	17.2	55.7
Hardware	16.2	65.7
Tech Issues	15.2	39.1
Security	14.1	73.1
Other Issues	6.1	55.7
Reliability	2.0	38.6

Table 1. Content Analysis on Survey Comments

Table 2 below lists IT related to instruction. Respondents were asked how often they were receiving training on these topics. Responses were scored as follows: Often = 3, Rarely = 2, Never = 1, Not Sure = 0. Next, respondents were asked how much instruction they feel they would need on the related instruction related technology. Responses were scored as follows: Extensive = 3, A Lot = 2, Some = 1, None = 0. The mean difference (current training minus needed training) for the $n = 60$ respondents is listed by topic. A negative mean score would indicate that the respondent felt that they should be getting more training on the associated IT than they are currently receiving. Topics in bold type had a significant difference at alpha = 0.05 and a negative mean score.

Instructional related IT	Mean	*t*	Sig. (2 tailed)
Advanced Input / Output Devices (Scanner, Digital Camera)	-.117	-.866	0.390
Art/Graphic Development	**-.333**	**-2.575**	**0.013**
Basic Operating System Techniques (Windows)	.450	3.015	0.004
Curriculum specific applications (Simulations, spreadsheets, etc.)	.033	.248	0.805
Database/Spreadsheet use or development	.050	.375	0.709
Desktop Publishing	-.133	-1.090	0.280
Electronic Presentations (PowerPoint, for example)	.450	3.095	0.003
Electronic Research (On-line)	.383	2.762	0.008
E-mail (Any type)	.783	5.271	0.000
Information retrieval (Research methods, University Library, etc.)	.183	1.212	0.230
Internet access (Telecommunications)	.600	3.886	0.000
School Management (Budgets, Scheduling, People)	.167	1.166	0.248
Storage devices (Thumb drives, external hard drives, etc.)	.567	4.557	0.000
Telecommunications (E-Mail, Bulletin Boards, Internet Access)	.517	3.598	0.001
TV/Audio, Video (Camcorder, Projection Devices)	-.033	-.248	0.805
Web Page Development	**-.483**	**-2.951**	**0.005**
Word Processing	.683	5.044	0.000

* Note: Paired Samples *t* test using Question 6 and Question 7. (df = 59)

Table 2. Comparison of Training Topics

Instructional related IT (Software)	Mean	*t*	Sig. (2 tailed)
Art/Graphic Development Software & Hardware	-.233	-1.753	0.085
Authoring/Multimedia Software	**-.267**	**-2.250**	**0.028**
Computerized Testing (Blackboard, WebCT)	**-.383**	**-2.762**	**0.008**
Desktop Publishing (MS Publisher, etc.)	**-.417**	**-3.085**	**0.003**
E-mail (Any type)	.000	.000	1.000
Instructional Demonstrations, Tutorials	**-.433**	**-3.550**	**0.001**
Notebook Computers that allow the user the "write" notes	**-.717**	**-4.704**	**0.000**
Spreadsheets/Database	-.017	-.299	0.766
Student Information Systems (Records, Billeting, contact info)	-.133	-1.734	0.088
Student Management (Grading, Attendance, Assessments)	**-.233**	**-2.231**	**0.030**
Web Page Development	-.233	-1.675	0.099
Word Processing	2.550	16.873	0.000

* Note: Paired Samples *t* test using Question 3 and Question 4. (df = 59)

Table 3. Comparison of Current and Future Technology Usage (SW)

The next comparison involves the current use of technology and the expected future use of technology.

Table 3 above is a listing of educational information technologies that might be used at ECPD. Respondents were asked, “Do you currently use any of the following technologies in work-related activities?” Responses were scored as often = 3, rarely = 2, never = 1, not sure = 0.

Next, respondents were asked, “Do you plan to use any of the following technologies in work-related activities? ” Responses were scored as the same as the previous question. The mean difference (current usage minus expected usage) for the n = 60 respondents is listed by topic. A negative mean score would indicate that the respondent felt that they expected to be using the associated technology more in the future. Topics in bold type had a significant difference at alpha = 0.05 and a negative mean score.

The next comparison involves the current use of ET hardware and the expected future use of ET hardware. Table 4 below is a listing of hardware items relating to educational technologies that might be used at The College. Respondents were asked, “Are you currently using any of the following technologies in your course?” Responses were scored as follows: Often = 3, Rarely = 2, Never = 1, Not Sure = 0. Next, respondents were asked, “What types of technology do you think you will need in the next three years to provide quality instruction?” Responses were scored as the same as the previous question.

Comparison of current and expected future use of ET (ET)	Mean	t	Sig. (2-tailed)
Computer Networks (e-mail, intranet, etc.)	.033	.814	0.419
Digital Camera (Photograph)	**-.217**	**-2.143**	**0.036**
Digital Camera (Video)	**-.417**	**-3.632**	**0.001**
Digital Sender (scanner plus .PDF maker)	**-.317**	**-2.268**	**0.027**
Laptop Computers	-.200	-1.762	0.083
Mobile Computer Devices (PDAs, Blackberries, etc.)	**-.550**	**-4.002**	**0.000**
Music and Video Devices (IPods, Jukebox, DVD Players)	-.083	-.760	0.450
Notebook Computers that allow the user the "write" notes	**-.983**	**-6.202**	**0.000**
Overhead LCD Projectors	-.133	-1.475	0.146
Scanners	-.017	-.119	0.905

* Note: Paired Samples *t* test using Question 1 and Question 2. (df = 59)

Table 4. Comparison of Current and Future ET Usage (HW)

The mean difference (current usage minus expected usage) for the n = 60 respondents is listed by topic. A negative mean score would indicate that the respondent felt that they expected to be using the associated technology more in the future. Topics in bold type had a significant difference at alpha = 0.05 and a negative mean score.

The final comparison involves the faculty and staff evaluation of student use of educational technologies courses compared to the faculty and staff evaluation of student usage of e-mail.

Table 5 below is a listing of educational technologies that might be used by students of The College in the future. Respondents were asked, "Do your students currently use any computer-aided instruction (CAI) in University related activities?" The term University was used as opposed to The College to include any distance learning or other school use of educational technologies. Responses were scored as follows: Often = 3, Rarely = 2, Never = 1, Not Sure = 0. Using the student use of e-mail (n = 60, mean = 2.40, standard deviation = 1.153) as the standard of comparison, the mean difference (student ET usage minus student e-mail usage) for the n = 60 respondents is listed by topic. A negative mean score indicates that the student usage is less than that of e-mail. All topics were significant at the alpha = 0.05 level when compared to e-mail usage.

Faculty/staff evaluation of student course related use of ET	Mean	*t*	Sig. (2-tailed)
Art/Graphic Development Software & Hardware	-1.167	-8.654	.000
Blogs (Web Logs)	-1.333	-9.527	.000
CAI - Drill and Practice/Tutorial	-1.233	-8.270	.000
CAI - Simulation/Educational Games	-1.150	-7.572	.000
Database/Spreadsheet use or development	-.783	-5.020	.000
Desktop Publishing	-1.117	-7.241	.000
Electronic Presentations (PowerPoint, for example)	-.200	-1.541	.129
E-mail (Any type)	.200	2.053	.045
Information Retrieval (Library, Internet, other...)	-.200	-1.725	.090
Internet Access (Telecommunications)			
Podcast (Content downloads)	1.400	-2.053	.000
Problem Solving	.833	-11.037	.000
Web Page Development	1.367	-6.877	.000
Word Processing	.000	-11.769	1.000

* Note: Paired Samples *t* test using Questions 5-X and Question 5-10: Mean = 2.20, standard deviation = 1.260. (df = 59)

Table 5. Student Use of ET in College Courses

DISCUSSION

Based on the results of the content analysis of the survey comments, the training topic comparison, expected usage comparison, and literature review, the following topics were identified for further consideration in the future development of a technology roadmap and are pertinent to the future research.

Technology Roadmap Factors

Software

The training question analysis summarized in Table 2 identified only two application software related topics significant at alpha = 0.05 level. Respondents felt more training with Art/Graphic Development, and Web Page Development is required. On the other hand, there were several topics listed where the respondent felt that they did not need additional training (using Windows and the Internet for example). Perhaps training resources should be shifted from basic computer skills to advanced training in the areas identified. Five software applications: Authoring/Multimedia Software; Computerized Testing (Blackboard, WebCT); Desktop Publishing (MS Publisher, etc.); Instructional Demonstrations, and Tutorials; Student Management Systems (Grading, Attendance, Assessments) were identified by respondents (Table 3) as software applications that they expected to use more in the near future than in current use (significant at alpha = 0.05). The technology roadmap should include plans to acquire and provide training for these applications.

Connectivity

The content analysis of comments revealed that 16.2% of the comments related to hardware related topics. Krippendorff's alpha for hardware was below the suggested threshold of 0.667, so the comments are questionable. However, one of the most significant hardware items listed in

Table 3 was the "Notebook Computers that allow the user the "write" notes," with a mean difference of -0.717 and significant at the alpha = 0.05 level. In Table 4, the difference is even more significant. The respondents identified five different hardware items that they felt would be used more in the next three years to provide instruction. Three of the items are concerned with digitizing images (photograph, video, documents), and the last two Mobile Computer Devices (PDAs, Blackberries, etc.) and notebook computers that allow the user to "write" notes) enable mobility. Additionally, the mobile computer devices allow greater connectivity. Each of these items were significant at the alpha = 0.05 level.

Satisfaction with Technology Roadmap

Ely (1999) identified eight conditions that facilitate implementation of ET: dissatisfaction with the status quo, time, resources, rewards and incentives, skills and knowledge, commitment, leadership, and participation. Additionally, Mumtaz (2005) compiled a list of factors that affect teachers' use of IT: teacher motivation and commitment to their students' learning; their own development as teachers; support from their schools; and access to technology. By using several of these factors, an indicator for faculty and staff satisfaction regarding the use of ET can be created in a future study. Currently, the indicator of faculty/staff satisfaction with current technology use is determined by comparing the use of ET against a standard. In

Table 5, a comparison of the current use of education related technologies with the student use of e-mail revealed that all of the other technologies were significantly underused. What this analysis illustrates is that if The College truly wants to "develop and maintain a state of the art learning environment," these results provide a metric for measuring improvement.

Limitations

There are several limitations to the generalizability of the study. First, The College represents a unique environment, even within the DOD educational system as it has a very diverse student population comprised of civilian employees and military members. Second, the responses were not distinguishable by school or by position (faculty or admin) which may affect the validity of the some of the quantitative analysis. Third, the low response rate is a concern because there is no data available to determine a non-response bias. Fourth, this study did not collect any data from students, whose perspective would provide valuable insight into their ET needs.

Implications

Even with the aforementioned limitations, this study has provided a starting point for future research and a technology roadmap. The results regarding specific educational technologies are significant and can be used to formulate a preliminary technology roadmap. Additionally, The University has recently established an ET Work Group, which may be able to utilize portions of this research for creating a University Education Technology Roadmap. Dissemination of this research throughout DOD education related organizations might also initiate discussions on how these organizations plan to provide effective training and education to the next generation defending the United States.

CONCLUSION

This research supports The College's strategic plan, "Develop and maintain a state of the art learning environment," by establishing a baseline of current employee usage of ET. This first step is a critical part of developing a technology road map. Expectation Confirmation Theory provides a framework for understanding the factors affecting the perceived technology gap between what the faculty use and what they think they should be using to provide effective education of DOD students. The analysis of survey responses and comments indicated that The College faculty reported low levels of use and expertise in emerging educational IT. However, a list of topics to consider as The College develops an ET roadmap was created that will focus future research efforts. Additionally, there appears to be a need to provide technology training to the school's faculty and administrative support staff. All new people should be assigned an appropriate training/development plan. Lastly, The College should provide broader faculty development regarding ET topics. In essence, many faculty members "don't know what they don't know." Increasing the opportunities for faculty to visit other educational organizations may help heighten awareness of emerging ET capabilities. Additional analysis is necessary to formulate an action plan to help employees attain higher levels of expertise in emerging education technologies.

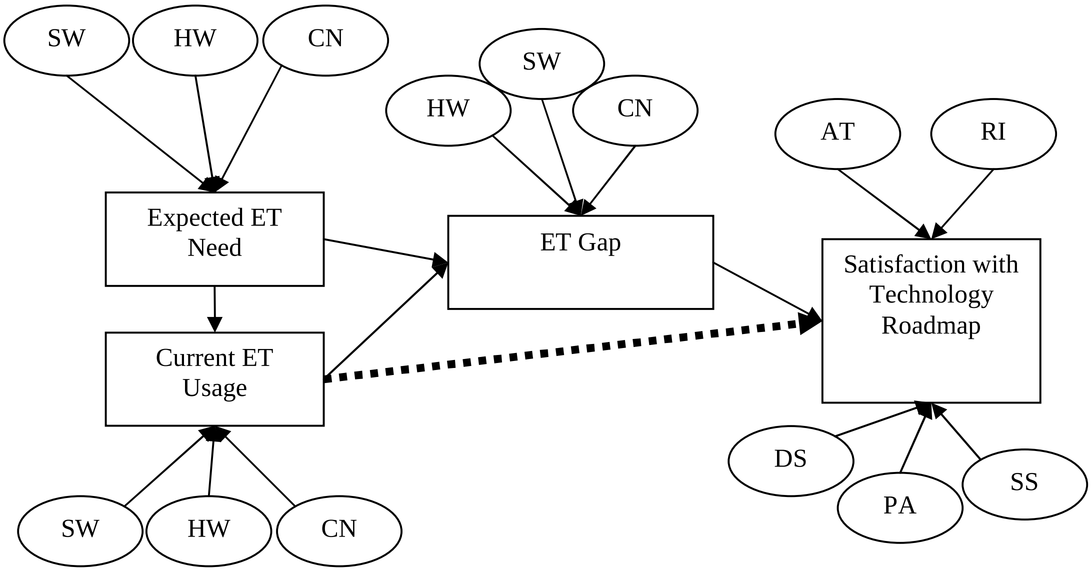

Figure 4. Proposed Model for Future Research

Abbreviation	Description
SW	Software (system and application)
HW	Hardware
CN	Connectivity
DS	Dissatisfaction with status quo
AT	Access to technology
RI	Rewards and incentives
PA	Participation
SS	School support

Table 6. Legend for Factors in Figure 4

Future Research

The proposed "Educational Technology Gap Model" is a starting point for the next phase of research, and an extension of the model (Figure 4) using factors identified in this research can determine the next phase of research. First, develop an instrument that specifically deals with software, connectivity, hardware, and satisfaction as they relate to ET issues. By focusing on the factors identified in this research, the data collected may be sufficient to use partial least squares analysis and build a valid model with predictive reliability. Using the results of the new survey, use quantitative analysis to determine the "Satisfaction with Technology Roadmap" construct to determine adjustment to the strategic plan.

Lastly, all of the data for this study was gathered from employees of The College. Future research should include input from students. As the ultimate consumer of the educational product produced, their perception of their needs may be the most relevant information available.

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