EXAMINING ENGINEERING & TECHNOLOGY STUDENTS' ACCEPTANCE OF NETWORK VIRTUALIZATION TECHNOLOGY USING THE TECHNOLOGY ACCEPTANCE MODEL

by

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A dissertation submitted in partial fulfillment of the requirements
for the degree of Doctor of Education
in the Department of Educational Research, Technology, and Leadership
in the College of Education
at the University of Central Florida
Orlando, Florida

Spring Term
2010

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ABSTRACT

This causal and correlational study was designed to extend the Technology Acceptance Model (TAM) and to test its applicability to Valencia Community College (VCC) Engineering and Technology students as the target user group when investigating the factors influencing their decision to adopt and to utilize VMware as the target technology. In addition to the primary three indigenous factors: perceived ease of use, perceived usefulness, and intention toward utilization, the model was also extended with enjoyment, external control, and computer self-efficacy as antecedents to perceived ease of use. In an attempt to further increase the explanatory power of the model, the Task-Technology Fit constructs (TTF) were included as antecedents to perceived usefulness. The model was also expanded with subjective norms and voluntariness to assess the degree to which social influences affect students' decision for adoption and utilization.

This study was conducted during the fall term of 2009, using 11 instruments: (1) VMware Tools' Functions Instrument; (2) Computer Networking Tasks Characteristics Instrument; (3) Perceived Usefulness Instrument; (4) Voluntariness Instrument; (5) Subjective Norms Instrument; (6) Perceived Enjoyment Instrument; (7) Computer Self-Efficacy Instrument; (8) Perception of External Control Instrument; (9) Perceived Ease of Use Instrument; (10) Intention Instrument; and (11) a Utilization Instrument. The 11 instruments collectively contained 58 items. Additionally, a demographics instrument of six items was included to investigate the influence of age, prior experience with the technology, prior experience in computer networking, academic enrollment status, and employment status on student intentions and behavior with regard to VMware as a network virtualization technology.

Data were analyzed using path analysis, regressions, and univariate analysis of variance in SPSS and AMOS for Windows. The results suggest that perceived ease of use was found to be the strongest determinant of student intention. The analysis also suggested that external control, measuring the facilitating conditions (knowledge, resources, etc) necessary for adoption was the highest predictor of perceived ease of use. Consistent with previous studies, perceived ease of use was found to be the strongest predictor of perceived usefulness followed by subjective norms as students continued to use the technology. Even though the integration of the task-technology fit construct was not helpful in explaining the variance in student perceived usefulness of the target technology, it was statistically significant in predicting student perception of ease of use.

The study concluded with recommendations to investigate other factors (such as service quality and ease of implementation) that might contribute to explaining the variance in perceived ease of use as the primary driving force in influencing student decision for adoption. A recommendation was also made to modify the task-technology fit construct instruments to improve the articulation and the specificity of the task. The need for further examination of the influence of the instructor on student decision for adoption of a target technology was also emphasized.

To my wife Jennifer and to my son Christian, you are my rock of stability and the sunshine in my life. Your support and unconditional love were my source of strength throughout this dissertation project. I am forever grateful for the sacrifices you made for me, and thankful to the Lord for the blessing of sharing this moment with you. Mom, you have always been my role model. Thank you for being a dependable source of comfort. I will always count on your prayers for me. Dad, I am certain of your love. My beloved uncle Nabiel, thank you for sharing your passion for mathematics with me. More than you know you have influenced my life. My uncle Sami and my aunt Samia, I am indebted to you for all the sacrifices you made for me. I will always remember that you opened your house to me and made me part of your family; if it wasn’t for your support then, I would haven’t made it to this point.

May God continue to bless our family!

ACKNOWLEGMENTS

I am truly grateful to my committee members: Dr. Stephen Sivo, Dr. David Boote, Dr. Glenda Gunter, and Dr. Kelvin Thompson for the time and effort they invested in me. Dr. Sivo, I shared with you how I have always been fascinated by the world of cryptography. Watching you scripting with SAS was like witnessing a forensics analyst decrypting data, detecting patterns, and revealing the truth in the most fascinating way. I also agree with you that statistics is like Chinese food; you are very full when you have it, but shortly after you stop, you get hungry again! Dr. Boote, you taught me the power of asking questions, and about the significance of framing an existing question in a new way. I am grateful to you for introducing the world of technology acceptance research to me. Dr. Thompson, I am grateful to you for opening my eyes on the world of open-source education. You have planted the seed and now it is growing! You have always inspired me with your organization, dedication, and commitment to your students. Dr. Gunter, I am grateful to you for reminding me with the fact that at the end of the day we are measured by how much we helped others. I am both proud and honored to have you all as members of my committee, and I sincerely wish you all the success in everything you do. Thank You!

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LIST OF ACRONYMS/ABBREVIATIONS

AU	Actual Utilization
AT	Intention
CET	Computer Engineering Technology
CSE	Computer Self-Efficacy
EC	Perception of External Control
ENJ	Perceived Enjoyment
IA	Information Assurance
NVT	Network Virtualization Technology
PEU	Perceived Ease of Use
PUS	Perceived Usefulness
SN	Subjective Norms
TC	Task Characteristics
TF	Tool Functionality
TTF	Task-Technology Fit
VCC	Valencia Community College
VM	Voluntary Moderator
VOL	Voluntariness

CHAPTER ONE: INTRODUCTION

Introduction and Background of the Study

Network Virtualization Technology (NVT) was developed to help realize the objectives of reducing the cost of building physical networked communication systems, facilitating the administration and maintenance of networks and creating greener data centers. Several institutes of higher education have recently integrated NVT in designing and building laboratory environments to be utilized by computer engineering students for the purpose of practicing the technical skills of the discipline (Armstrong, Jayaratna, & Dodge, 2007).

Computer networking education requires an academic institute to make a tremendous investment in network equipment, providing a physical laboratory equipped with various physical network security appliances for learners to practice various configuration tasks, and to learn troubleshooting techniques. Students often need more time with the equipment, outside the class scheduled meetings (Anisetti et al., 2007). Since the majority of Engineering and Technology students are full-time employed, it is extremely difficult for them to be on campus outside scheduled class meetings to practice with the equipment. Network virtualization technology allows the student to create a virtual version of the laboratory environment provided on campus with the added portability feature, allowing students to roam off campus with such a virtual environment, and to practice configurations at home (Bishop & Frincke, 2008).

No empirical research has been conducted to examine the set of factors affecting users' beliefs and intentions toward NVT as precursors to their actual utilization of the technology. In this study, a hypothesized model based on the Technology Acceptance Model (TAM) (Davis, 1989), and extended with the Technology-Task Fit (TTF) constructs (Dishaw & Strong, 1999) is used to explicate, from a student's prospective, the factors deriving or determining their adoption and utilization of VMware software as a network virtualization technology.

The importance of conducting such a study has already been advocated in the literature based on the belief that the success of a new system or technology is primarily measured by users' acceptance and adequate use of the target system or technology (Karahanna, Straub, & Chervany, 1999). Consequently, several models have been proposed to explain the causal relationship and the correlations between beliefs, attitudes, intentions, and behaviors toward a new technology and with the ultimate objective of understanding the major factors affecting users' actual utilization of a new technology (Icek Ajzen & Fishbein, 1973; Davis, 1989). Several researchers (Paul J. Hu, Chau, Liu Sheng, & Kar Yan, 1999; Tulu, Horan, & Hurkhard, 2005) warned that failing to gain such an understanding, could lead to the detrimental problem of underutilized system, leading to a failed implementation, and waste of valuable resources.

Understanding user acceptance, adoption, and usage of new technologies has been a high priority for researchers and practitioners to ensure a successful investment in technology and to consequently realize the intended increase in productivity. The same concern has been voiced in educational settings. This is clearly echoed in the debate over the use of technology in education and training, and for the purpose of learning and teaching. Kozma (1994) explained that the unique attributes of a technology in conjunction with the methods that illuminate or capitalize on its capabilities together afford the learner new interactive opportunities with the content, leading to higher motivation and learning.

The “attributes” argument (Kozma, 1994) provides the foundation for understanding how the attributes of a certain learning technology influence learners’ actual utilization of the target technology, underscoring the importance of the purposeful use of the technology (Reiser, 1994). The ability of technology to support learning is expressed by the formal construct known as task-technology fit, which implies matching of the capabilities of the technology to supporting the tasks or activities necessary to acquire the target skills.

In this study, the acceptance of VMware as network virtualization technology for the purpose of learning computer networking related skills was examined from the student’s prospective. The results from this study may help Engineering and Technology educators to understand the factors essential for student’s adoption and utilization of VMware. In addition to the three anchoring factors (perceived ease of use, perceived usefulness, and intention toward utilization), the model was also extended with enjoyment, external control, and computer self-efficacy as exogenous variables to perceived ease of use. The Task-Technology Fit constructs (TTF) were included as antecedents to perceived usefulness. Social influences were also accounted for in the model by integrating subjective norms and voluntariness as exogenous variables on intention and perceived usefulness.

Purpose and Objectives of the Study

The purpose of this path analysis study was to investigate the casual relationship between student intention to use VMware as a network virtualization technology and their actual use of the technology. Previous studies have indicated that the use of various technologies has fallen below expectations (Brown & Venkatesh, 2003). In an attempt to prevent this possible problem of underutilization when implementing VMware for students to use in practicing computer networking skills, an expanded version of the Technology Acceptance Model (TAM) was proposed. The model was then tested for its ability to explicate student's beliefs and intentions toward VMware, and how those beliefs and intentions ultimately influence the actual utilization of the technology. Even though the proposed model was tested by Valencia's engineering and technology students, it should provide some guidance when consulted in understanding the facilitating conditions and other precursor factors necessary to adopt the technology by other users groups and in different settings.

Research Questions

The researcher sought to answer the following questions in this correlational inquiry:

1. How does the proposed expanded Technology Acceptance Model (TAM) explain the variance in students' actual use of VMware as a network virtualization technology?
2. What is the inter-relationship among perceived usefulness, perceived ease of use, and student intention toward using VMware?
3. What is the role of subjective norms in the proposed model in explaining students' behaviors

and intentions towards VMware?

4. What are the effects of the constructs of the Task-Technology Fit variable (task characteristics and tool functionality) on student's perception of usefulness?
5. How do the antecedents of perceived ease of use enjoyment, external control, and computer self-efficacy) affect students' perceived ease of use of VMware?
6. Does voluntariness moderate the effect of subjective norms on intention?
7. What are other variables (i.e., prior experience, age, employment, academic enrollment, and major) can contribute to the proposed model?

The proposed expanded TAM model, depicting the constructs and determinants under examination is illustrated in Figure 1.

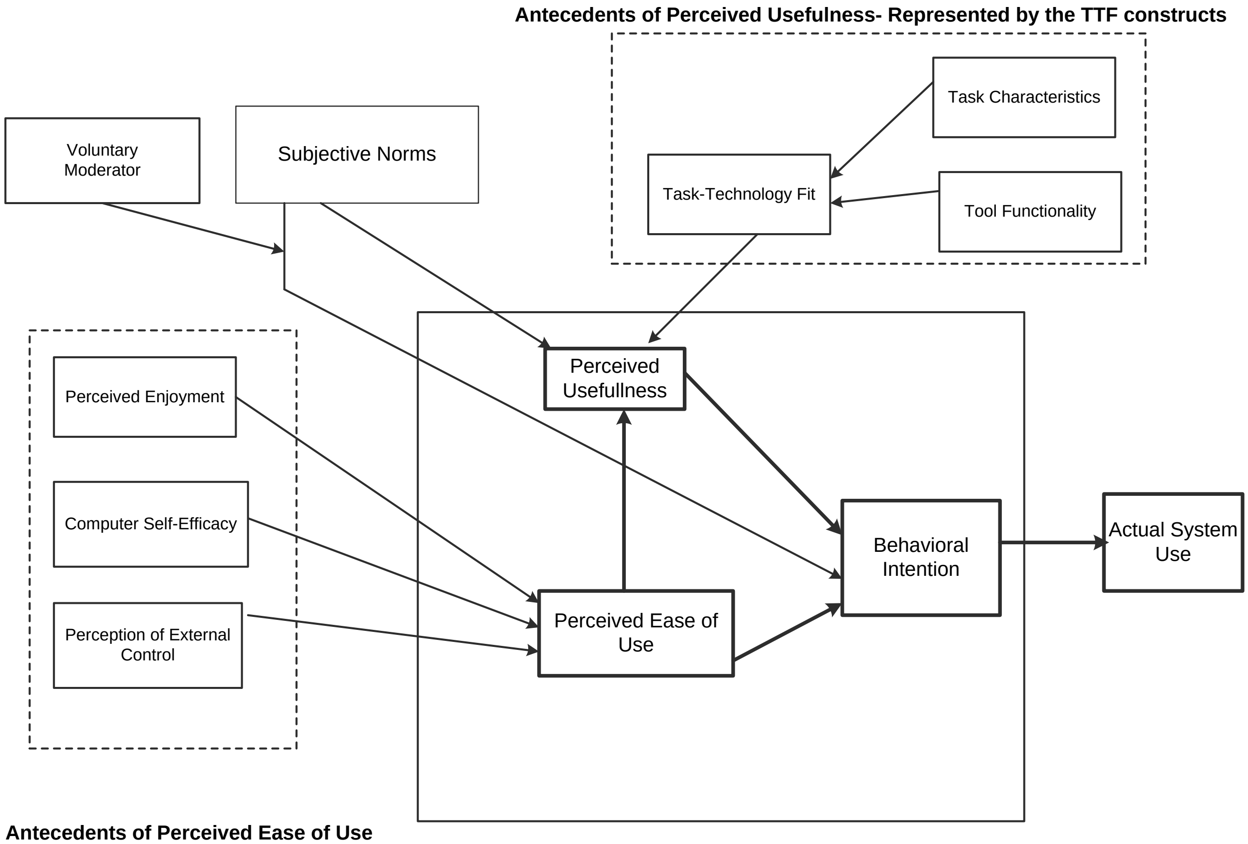

Figure 1: The Expanded Technology Acceptance Model Hypothesized

Each one of the arrows depicted in the model indicates a causal relationship between two factors. The relationship can be direct such as that between perception of external control and perceived ease of use or indirect such as the effect of perceived ease of use on intention through perceived usefulness. Ease latent factor in the model is measured using different observed variables. For example, perceived ease of use is measured using five variables (i.e., PEU1, PEU2, PEU3, PEU4, and PEU5).

Relevance of the Study

The intent of this study was to assist Valencia Community College, Engineering and Technology division in providing an alternate, off-campus arrangement for students to practice computer networking skills. Due to the high cost of equipment, students could not replicate the on-campus laboratory environment at home. This limitation, restricted students access to the tools they need to practice the hands-on skills to times when open-lab hours were scheduled. This arrangement proved to be too inconvenient for the very busy life style of Valencia's Technology students with the majority holding full-time employments. Based on this explanation, Engineering and Technology instructors have limited homework assignments to conceptual and theoretical objectives, avoiding the need for access to equipment.

The significance of this study my provide educators, and laboratory managers with insights about students reactions to, and perceptions of implementing and utilizing VMware as a network virtualization tool which could possibly provide the student with the opportunity to replicate the on-campus laboratory environment at home, and ultimately allowing them to practice computer networking hands-on skills when and where suitable to their busy schedules. By the same logic, instructors may also find it more reasonable to use practical homework assignments, given students access to network virtualization technology.

Limitations and Assumptions of the Study

1. Participation in the study was limited to students who were enrolled in CET2486 Local Area Networks. They were a convenience sample to the researcher and the results might not be applicable to other domains, settings, or groups.
2. Only two instructors participated in this research study. The researcher accounted for one of them. The researcher's attitudes, believes, experience, and motivation may have significantly influenced the participants in this technology acceptance study.
3. This study was a self-reported study and as is the case with other studies of the same nature, its validity is dependent on the participants' understanding and honest response to the survey questions.
4. Even though Valencia's students had free access to VMware through a college-wide academic license, other users will have to purchase the software at a cost of $100.
5. It was assumed that each student enrolled in CET2486 owned a PC with the hardware configuration and capabilities required to install and run VMware.
6. This self-reported study may not provide a complete explanation of users' acceptance of the target technology as there may be other factors not included in the hypothesized model, but affecting users believes, intentions and subsequently behaviors toward VMware.

Organization of the Dissertation

This dissertation is organized into five chapters. Chapter one is the introduction which provides the direction of the study. Chapter two is the review of the literature, and provides the theoretical basis of the study, detailing the basis upon which the expanded TAM model was structured. Methodology-related issues including sampling, subjects, data collection and data analysis are included in chapter three. Chapter four focuses on interpreting the results as produced from the data analysis phase, using the proper statistical tests. Based on the findings from chapter four, chapter five suggests recommendations for future research. Appendices A through L present the 11 questionnaire scales used in the online survey. References are then listed at the end of the dissertation.

Definition of Terms

The following definitions are used in this study:

Endogenous Variables: endogenous variables are synonymous with dependant variables and, as such, are influenced by the exogenous variables in a model (Byrne, 2001).

Exogenous Variable: exogenous variables are synonymous with independent variables; they cause fluctuations in the values of other latent variables (Byrne, 2001).

Network Virtualization (NV): NV is establishing network connections amongst a set of virtual machines coexisting in the same host operating system. For the purpose of this research, a virtual network is a one or more groups of virtual operating systems and virtual switches, residing on the same host operating system and connected to form one or more networks for the purpose of generating, analyzing and testing network traffic. Figure 2, illustrates an example of a virtual network using VMware.

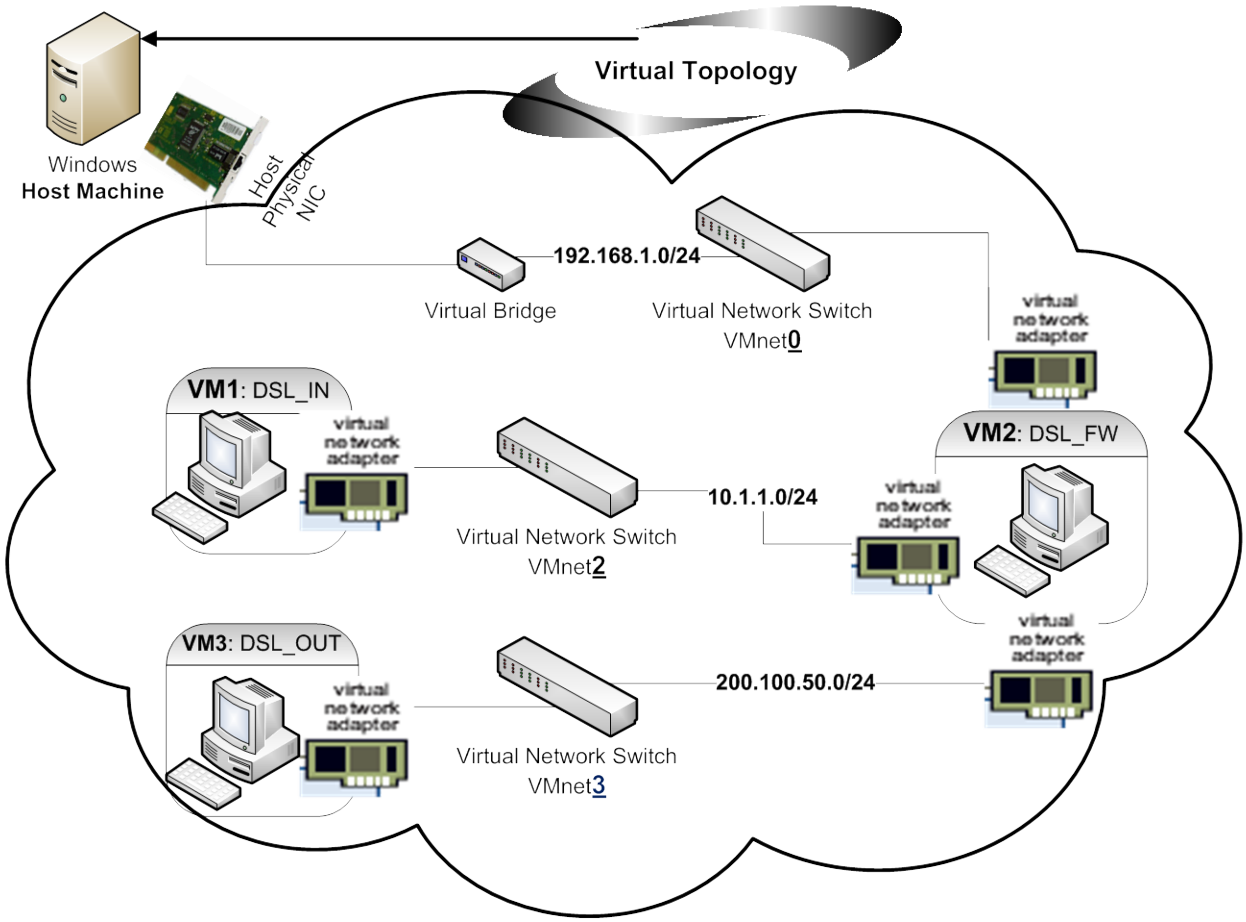

Figure 2: Network Virtualization Technology Using VMWare

Path Analysis: A mathematical representation whereby a set of equations relate dependent variables to their explanatory variables (Byrne, 2001).

PC Virtualization: is the technology used to start an operating system (Guest Operating System) within an existing operating system (Host Operating System). For example, through virtualization, a learner with a windows XP operating system at home, desiring to learn Apple Mac, would be able to do so by loading an Apple Mac virtual machine on their existing Windows host machine. The virtualization Technology enables the gust operating system to borrow the hardware resources (hard drive, memory, keyboard, etc…) from the host operating system. Furthermore, several guest operating systems could, concurrently be started on the same host operating system as depicted in Figure 3.

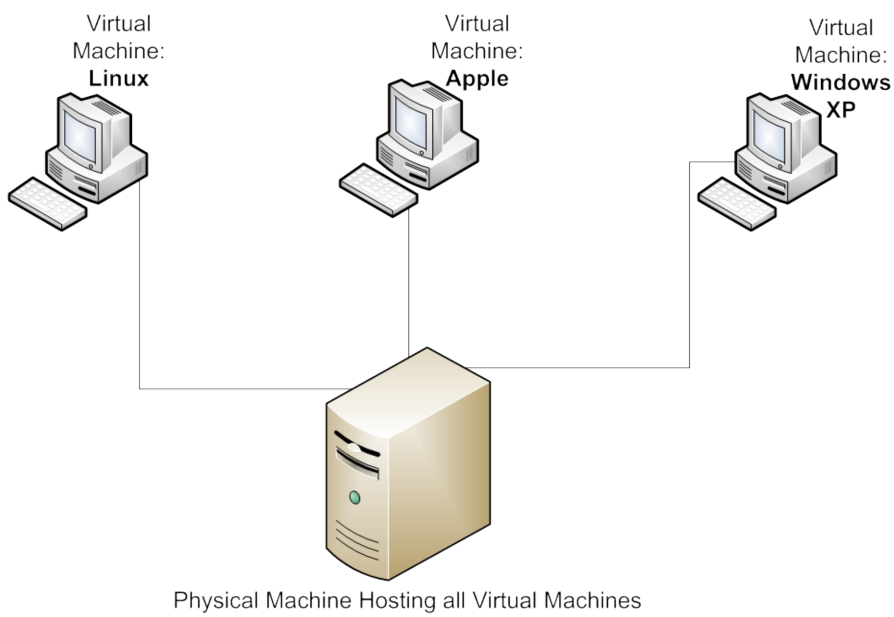

Figure 3: Operating System Virtualization

VMware Workstation: an operating system virtualization program with networking capability which can be utilized to design and build one or more virtual networks connecting a group of virtual operating systems.

CHAPTER 2: REVIEW OF LITERATURE

This study builds on and contributes to earlier studies related to examining the factors leading to users' acceptance and adoption of a new technology or a new system. Although earlier studies (I. Ajzen, 1991; Taylor & Todd, 1995; Wiener, 1993) have examined how user's perception of ease of use and perception of usefulness led to the formation of intention to use and in return predicted actual use, many researchers; however, explained that the studying of how perceptions formed was only meaningful when contextualized for a specific technology and a specific user group (McFarland & Hamilton, 2006; Venkatesh & Davis, 1996). Unique to this study, the researcher contextualized the Technology Acceptance Model (TAM) for network virtualization technology when studying its acceptance by Engineering and Technology students at the community college level. As such, this study provides additional insight into the factors affecting engineering and technology student's decision for adoption and utilization of VMware as a network virtualization technology. Moreover, little analytical attention has been paid to the role of the user in implementing a target technology. While most of the previous studies focused on studying user's perception of ease of use, implying that the burden of implementation fell outside the responsibilities of the user (Venkatesh, Morris, Davis, & Davis, 2003), in this study; however, the user was, primarily, responsible for implementing the technology in their home system. Therefore, this study addressed this issue by analyzing the effect of user's perception of external control over the resources necessary to implement and use the technology and how such perception affected behavioral intention and actual utilization. Additionally, the theoretical insights from the Task-Technology Fit (TTF) model provided another contribution to acceptance research by illuminating the importance of understanding how user's perception of the usefulness of the technology formed (Goodhue & Thompson, 1995). Even though that the theory of the Task-Technology Fit predicted that, in general, an increased perception of fit between the technology and the task caused an increased perception of the usefulness of the technology and in turn led to increased utilization of the technology; however, prior studies explained the difficulty of clearly articulating the tasks and functions to users when measuring their perception of fit using survey items. Unique to this study, the researcher addressed this issue by developing two authentic instruments: (1) Tool Functions (TF) instrument with items specific to measuring students' perception of the available functions of VMware; and (2) task characteristics instrument (TC) measuring student's perception of various required computer networking related tasks. Additionally, since previous studies reported mixed results on the influence of subjective norms on user's acceptance of (Anandarajan, Igbaria, & Anakwe, 2000), this study investigated whether subjective norms influenced students' intention and utilization toward VMware.

To further explain the theoretical foundation of this study, this review of the literature is composed of six major sections (1) Network Virtualization Technology; (2) the Technology Acceptance Model; (3) Antecedents of Perceived Ease of Use (Enjoyment, Computer Self-Efficacy, and External Control); (4) Task-Technology Fit; (5); Social Influences (Subjective Norms, and Voluntariness); and (6) Individual Differences.

Network Virtualization Technology

In Information and Communication Technology (ICT) undergraduate curricula, learning network configuration, management, and security-related skills involves hands-on experience with a number of different devices which may be unavailable or too costly to provide for institutions under budget constraints. A number of software tools and environments have been developed to help users to share distributed laboratory resources and realize virtual experiments. Still, ongoing discussions about offering lab-based courses via distance education show that most university instructors consider this option impossible or ineffective, consequently, relatively few universities offer lab-based courses to remote ICT students (Anisetti et al., 2007; Vaughn & Dampier, 2008).

One of the challenges for instructors during the lab elements of courses taught is that students have a broad spectrum of previously gained knowledge and practical understanding of the subject matter. Laboratory elements in turn are difficult to plan and schedule, as the time needed to perform individual tasks varies greatly among individual students and student groups (Armstrong et al., 2007).

Computer Networking Technology education programs are normally designed with focus on providing direct first-hand experience with the configurations and connections of various network equipment with different platforms. Building and maintaining such an environment is very costly, making it impossible for institutes with limited resources to implement such programs (Nedic, Machotka, & Nafalski, 2003).

Some of the proposed solutions to this problem included using simulations, remote access technologies and/or virtualization technologies; however, each has been proved to be deficient in remedying the problem. For example, simulation is a software-based application which is designed to mimic the behavior of certain network equipment. Even though a relatively affordable solution; however, simulation programs recognize only a certain pre-configurable way to answering a given question or solving a given problem. This contradicts real practices in production environments where there are almost always multiple ways of accomplishing any given task. It has been reported in the literature that the use of simulation in cyber security education while, provides a feasible solution, it negatively impacts the quality of a training program and limits students critical thinking skills by restricting students' experiential learning (Bishop & Frincke, 2008).

Similarly, using remote access technologies have posed many impediments to learning in cyber security education. Remote access technologies, in addition to opening access to physical lab equipment to students off-campus, they also allow an academic institute to share their equipment and lab environment with other schools and outside partners, reducing the need, logistically, to duplicate the same costly lab environment individually at each site. The problem however lies in scheduling – there is a limited number of devices for learners to practice whether through traditional access in physical labs or through remote access by means of the internet via a Secure Shell Session (SSH). Simply, if a piece of equipment is used by a remote user, access to the same device will be denied to anyone else. A student would have to wait for that device to be released back to the pool of available resources to access it. The scheduling limitation has proved to be very frustrating to students in a cyber security program (Nedic et al., 2003).

A more effective solution was needed and was found in the use of Virtualization Technologies in Computer Networking education. This was done by using both open source and commercial software to create virtual machines with different operating systems such as Windows, Linux, and Apple. Virtualization was much more effective compared to simulation since virtualization afforded the learner the opportunity to try any given solution(s) to any given problem(s) with no restrictions in terms of supported configurations and/ or commands, hence supporting experiential learning, and critical thinking (Bishop & Frincke, 2008; Hoffman & Ragsdale, 2004).

The Technology Acceptance Model

The technology acceptance model (TAM) by Davis (1989) was founded upon Ajzen’s (1973) Theory of Reasoned Action (TRA) from the social psychology domain. TRA focused on the casual relationships between beliefs, intentions and behaviors with the objective of measuring behavior-relevant components of attitudes such as actual utilization (Fishbein & Ajzen, 1975; Venkatesh, Morris et al., 2003). Furthermore, TRA explained the difference between individuals’ attitudes toward an object, and their attitude toward the utilization of the object.

With the clear trend of increased integration of technology in various business processes, TAM was proposed as a parsimonious model focusing on understanding user’s reactions to the adoption of a proposed technology or an electronic system specifically in a corporate environment, and on explicating the constructs affecting individuals' attitude and intention toward actual utilization (Anandarajan et al., 2000; McFarland & Hamilton, 2006). TAM predicted that users' attitude and intentions toward using a system mediated their actual utilization of the system.

The original TAM model (Figure 5) introduced three main variables as precursors affecting the actual utilization of a system or a technology: Perceived Ease of use, Perceived Usefulness, and Attitude toward using the target system. Both perceived ease of use and perceived usefulness were loading factors on attitude toward using a system or a technology with the outcome variable being the actual utilization of a system (Taylor & Todd, 1995). The original TAM model also suggested that perceived ease of use explained a very significant percentage of the variance is perceived usefulness (Venkatesh, 1999). Perceived ease of use was defined as the degree to which the individual believed the use of the target system to be free of mental and physical efforts. Perceived usefulness was defined as the degree to which an individual believes that the use of the target system could help them improve their performance on the job. Attitude toward the use of a target system was defined as the degree to which an individual associated positive feelings with the target system. And, actual system use was defined as overt response, measured by the individual's action in reality in terms of intensity and/or the amount of time for which they have actually utilized the system under examination (Davis, 1989).

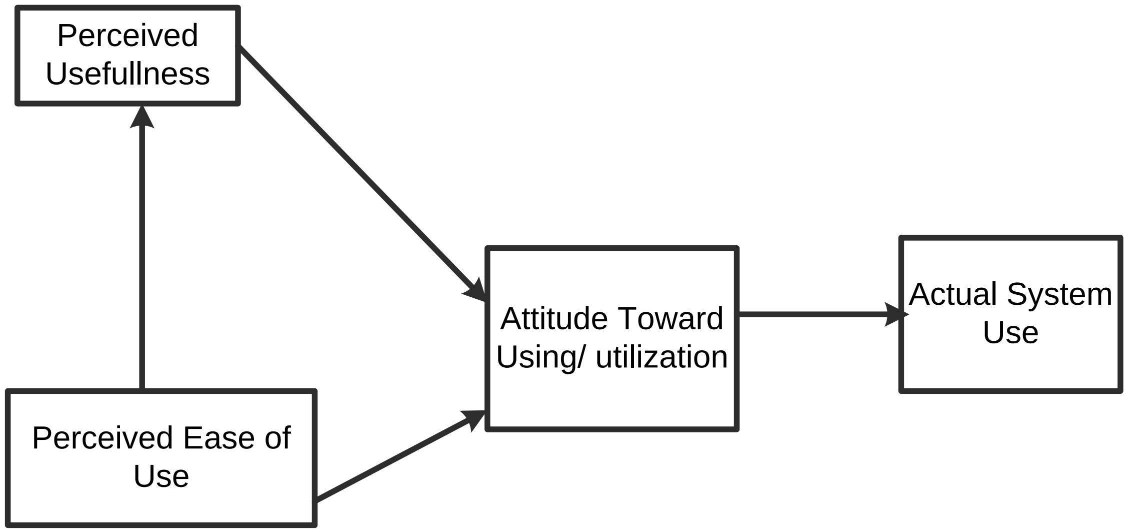

Figure 5: The Original TAM

Davis (1989) posited that perceived usefulness was 50% more influential than ease of use in determining the actual usage of a proposed system or a technology. His findings underscored the importance of incorporating the appropriate functionalities in a new system or technology. A construct for system design features was included in the model to explain the external stimulus, triggering the cognitive response (perceived usefulness, and perceived ease of use), mediating the affective response (attitude toward using), and ultimately affecting the behavioral response of the actual utilization of the system.

Venkatesh (2001) explained the parsimonious nature of the TAM as a strong advantage. The original TAM was designed with few broad non-system specific constructs, increasing its applicability to various systems and technologies. TAM was tested in both academic and corporate environments. Examples include: testing TAM with physician acceptance of telemedicine (Paul J. Hu et al., 1999); measuring students' perceptions of WebCT (Martinez-Torres et al., 2008; C. Pan, Gunter, Sivo, & Cornell, 2005; C. C. Pan, Sivo, Gunter, & Cornell, 2005);studying consumer acceptance of Radio Frequency Identification Technology (RFID) (Hossain & Prybutok, 2008); testing the applicability of TAM to predicting consumers' reactions to Internet TV (Dong Hee, 2009); and using TAM to investigate students' perceptions of learning objects (Siong-Hoe & Peter, 2008). On average TAM explained 35% to 45% of the variance in users' actual utilization.

HU and Chau (1999) examined physicians' acceptance of telemedicine and found that perceived ease of use and perceived usefulness together explained 53% of the variance in doctor's behavioral intention to use telemedicine. The study (P. J. Hu & Chau, 1999) also reported that perceived ease of use explained 10% of the variance in perceived usefulness and that perceived usefulness had the strongest explanatory power and accounted for 45% of the changes in behavioral intention suggesting that physicians are relatively pragmatic and tend to focus on the usefulness of the technology itself.

Researchers (Tulu et al., 2005; Venkatesh, 2000; Venkatesh, Brown, Maruping, & Bala, 2008; Venkatesh, Ramesh, & Massey, 2003; Wiener, 1993); however, explained how the explanatory power of TAM could possibly increase with the inclusion of other constructs or the delineation of the original constructs with antecedents specific to the system or the technology under examination. This triggered the second phase of TAM where studies focused on understanding how perceptions of usefulness and perceptions of ease of use formed and changed over time when contextualized for certain technology and for a specific users group; TAM was expanded with variables such as ,to name a few, subjective norms, intrinsic motivations, users characteristics (age, gender, etc..), facilitating conditions, enjoyment, self-efficacy, social embeddedness, culture, convenience, privacy, and object characteristics.

Social Influences

Anandarajan (2000) expanded the TAM with the construct of subjective norms and defined subjective norms as perceived external pressures to use the system. The external pressures could be from superiors and is also defined as vertical pressure or from peers which is also known as horizontal pressure. Andarajan's experiment on a bank employees' adoption of a new technology concluded that there is a high correlation between subjective norms and the actual utilization of a system: Those who were characterized as high subjective-norms employees were more likely to adopt and utilize the system. The rational for this relationship is that people may choose to perform a behavior, even if they are not themselves favorable toward the behavior, if they believe that someone or a group of people who are important to them think they should, and they are sufficiently motivated to please them.

Pan et al. (2005) confirmed the same correlation when he examined the effect of including subjective norms on the TAM's overall ability to explain students' grades and behavioral attitudes toward WebCT in online or hybrid courses. The results suggested that subjective norms impacted student attitude toward WebCT. Subjective norms were also found to be high predictors of student perceived ease of use and perceived usefulness.

Dong Hee (2009) in extending the TAM model to studying consumers' reactions to Internet TV, expanded the model with social influences. His findings further confirmed the strong relationship between social influences and intention to use the technology. Consumers in the Asian markets who marked highly when responding to questions such as "people important to me think I should use IPTV", intended to use the technology more. Dong Hee, however, cautioned that the results of his findings might be culture-dependant, explaining that in Asian markets, social influences of the group tend to be higher than in individualistic Western societies.

Venkatesh (2001) explained the interrelated nature between subjective norms and voluntaries. In a longitudinal study examining users' reactions to implementing four different technologies in four different organizations, voluntariness was found to be a strong mediating factor on subjective norms when affecting intention to use. The study organized users groups in two different contexts; one was voluntary while the other was mandatory. Venkatesh hypothesized that users are more likely to confirm to subjective norms in mandatory usage settings and when the authority in question has the ability to reward the behavior and punish nonbehavior. The findings suggested that voluntariness significantly affected users' perception of subjective norms which in turn affected perceived usefulness, behavioral intention, and actual utilization of the target systems.

The impact of subjective norms was also tested through the examination of social networks and the ability of co-workers to influence each other through their interactions within the social network (Sykes, Venkatesh, & Gosain, 2009). The findings from a study involving 87 employees over a period of three months suggested that the more an employee was embedded in the social network the more they felt supported, and in return complied more with social norms. Active and meaningful participation in the social network was a significant high predictor of adoption and actual utilization of the target technology.

For the purpose of this research, the TAM model was expanded with the subjective-norms construct as the researcher, based on findings from previous studies, expected it to be of significant importance in explaining the variance in students' intentions and behaviors toward VMware. The interrelatedness between subjective norms and voluntariness was also considered in this study by separating research participants into both mandatory and voluntary contexts to ultimately test the ability of voluntariness to mediate the influence of subjective norms on students' behavioral intentions and usage.

Determinants of Perceived Ease of Use

Perceived ease of use originally focused on system characteristics for the purpose of informing system developers to enhance the system features and make them friendlier to the users by simplifying the user interface of the target system (Venkatesh & Davis, 1996). Taylor and Todd (1995), however, assessed how the availability of knowledge, resources, and opportunities to use the system, and support staff (external consultants) influenced user's perception of ease of use. The findings suggested that the extent to which the user perceived the resources, training, and opportunities necessary to use the system or technology under examination to be available to them significantly impacted their perceived ease of use and their attitude toward the system. Taylor and Todd (1995) findings add to the robustness of the Theory of Planned Behavior (I. Ajzen, 1991), confirming that as a general rule, the greater the perceived behavioral control, the more likely an individual will perform the behavior under consideration.

Venkatesh (2000) posited that perceived ease of use is a strong determinant of intention, delineating the determinants of the construct of perceived ease of use to include: computer self-efficacy, perception of external control, computer anxiety, computer playfulness; perceived enjoyment, and objective usability. Venkatesh postulated that some of the determinants changed over time with increasing experience and direct interactions with the system. Accordingly, Venkatesh determinants of perceived ease of use were divided into anchors and adjustments.

Anchors specified the set of factors influencing users' attitudes prior to direct experience with the target system. Those factors highlighted the individual differences in technology adoption and included internal control (computer self-efficacy), intrinsic motivation (playfulness and satisfaction), and emotion (anxiety and stress). Those anchors explained individual differences and their role in influencing users' perceived ease of use in the very early stages of using the target system and before any concrete, direct interaction with the system through objective usability.

Those initial perceptions, however, were adjusted with the experience of direct interaction with the proposed system. Venkatesh (2000) explained those adjustments as objective usability (experience), external control (facilitating conditions), and perceived enjoyment. For the participants in his study, Venkatesh concluded that computer self-efficacy and external control were the strongest determinants of perceived ease of use.

The bidimensional conceptualization of control as intrinsic and extrinsic, and the impact of both on user's perception of ease of use was contextualized for educational Wikis (Liu, 2010). Liu reported that Wiki self-efficacy (internal control) significantly correlated with user's perception of ease of use and with the actual utilization of Wikis. However, the path from perceived behavioral control (external control) to wikis' ease of use and actual utilization was not significant for his research participants. In selecting Wiki self-efficacy as opposed to general computer self-efficacy, Liu explained that as it is problematic to define a single measure of sports efficacy, it is as problematic to define one measure of computer-efficacy, encouraging researchers to consider contextually relevant characteristics of the specific technology or system under examination.

The role of intrinsic motivation in explaining the variance in user's perception of ease of use was also studied (Compeau & Higgins, 1995; Shang, Chen, & Shen, 2005). Shang et al. defined intrinsic motivation as the performance of an activity for no reason other than the enjoyment or satisfaction realized from the process of performing it. In analyzing consumers' reactions to on-line shopping, findings suggested that enjoyment had a significant effect on perceived ease of use and explained 58% of the variation in behavioral intentions. Perceived usefulness; however, for online shoppers had a modest effect on behavior intention and actual usage.

Perceived playfulness was also tested as an exogenous variable on perceived ease of use (Liao, Tsou, & Huang, 2007) of 3G mobile services in Taiwan. In studying the factors affecting adoption of mobile information devices, Liao, et al., found mobile service compatibility to significantly mediate the relationship between Mobil service quality and perceived playfulness. Perceived playfulness then explained the variance in perceived ease of use to a significant degree. Unique to the context of mobile information services and to the participants in this research study, perceived playfulness also contributed significantly to the variance in perceived usefulness of the technology.

To build on those research findings, this study investigated the role of the following constructs on affecting over all perception of ease of use: (1) perceived enjoyment of using the target system (VMware), (2) learner's computer self-efficacy, and (3) perceived external control over the target system.

Task-Technology Fit

While the study by Davis (1993) of the affect of adding the system design construct on users' actual utilization of a system is relevant for the purpose of new system development in corporate environment, and specifically during early design phases to ensure that system developers, and designers are including all the features desired by users. In academic training settings; however, adopting a technology for the purpose of teaching and learning has been largely a question of media with the focus on investigating the attributes of a proposed technology and how it could be used purposefully to increase students learning. In the case of adapting certain pre-packaged technology where there is no opportunity to change the system characteristics, the more valuable question becomes: How fit the technology is in achieving the learning objectives intended for the students? In the TAM model that was excluded; however, acknowledged as complex and contextual.

Dishaw (1999) examined this issue, and proposed the expansion of the TAM model with the Task-Technology Fit (TTF) constructs (Goodhue & Thompson, 1995). The Task-Technology Fit model originated from information systems research and was supported by the idea that users' decision to adopt a technology specially in a workplace setting is primarily derived by the extent to which they perceive the system or technology to be a good fit for the task it supports; as the gap between the requirements of a task and functionalities of a technology widens, TTF is reduced(Klobas, 2009).

Dishaw (2009) reiterated that while TAM focused on attitudes toward using a particular system or a technology based on the perceived usefulness and the ease of use of the system or the technology TTF; however, focused on the match between user task needs and the available functionality of the technology. The results from Dishaw's study of programmers' acceptance of software engineering tools suggested that the explanatory power of TAM increased significantly when expanded with the TTF constructs as antecedents to user's perceived usefulness; however, TTF failed to explain the variance in perceived usefulness.

The expansion of the Technology Acceptance Model (TAM) with the Task-Technology Fit constructs (TTF) was also tested in Policemen acceptance of FINDER (Scott Jr, 2006). Scott examined a combination of measurable influences in the FINDER (a Florida system that shared low-level data among 121 police agencies) environment that best predicted user-level success, and actual utilization of the system. Task-Technology fit loaded directly on Actual system use and explained 35% of the variance in actual system use. User-Level Success was also another outcome variable and was proven to be highly correlated with TTF. The Task-Technology Fit construct explained almost 41% of the variations in User-Level Success (making an arrest, finding a missing person, recovering stolen property, or locating a witness).

The importance of the compatibility between the task and the technology was also tested in the medical field (Tulu et al., 2005). The responses of 97 physicians who self-reported on their reactions to an online disability evaluation system indicated that perception of fit predicted both initial use and sustained use of the system. The analysis of the results further suggested that physician's perception of the degree to which the technology fit the task derived their perceptions of the usefulness of the technology, and subsequently, significantly loaded on their decision to use the technology.

Task-Technology Fit (TTF) was also tested against consumers' acceptance of E-Commerce (Klopping & McKinney, 2004). In his study, Klopping, removed the path from perceived ease of use to perceived usefulness, and hypnotized the fit between the task and the technology to be the primary predictor of perceived usefulness. The findings indicated that consumers who answered favorably to questions such as "the online product information maintained at websites is pretty much what I need to carry out my tasks" reported a high level of perceived usefulness of E-Commerce. Kopping (2004) explained that in the context of E-Commerce it seemed that it was relatively easier to articulate the shopping tasks defined in the study; that clearer definition led to better understanding and perception of the fit. Extending the Technology Acceptance Model (TAM) with the Task-Technology Fit (TTF) items led to increasing the explanatory power of the model from 47% of the variance in actual utilization to 52%.

The impact of the task on usability was mediated by other variables in a study attempting to predict users reactions to wireless Internet (Fang, Chan, Brzezinski, & Xu, 2006). Perceived ease of use, perceived usefulness, and perceived enjoyment were found to mediating effects on tasks. Fang et al. (2006) classified the wireless Internet tasks into gaming & entertainment, research, shopping. The results clearly showed that gaming and entertainment task were mediated by perceived enjoyment. Online shopping was mediated by perceived safety. And, online research was mediated by perceived usefulness. The findings further emphasized the importance of categorizing the tasks into coherent and clear categorizes as an important prerequisite to correctly assessing the role of the task in user's decision for adoption.

The Task-Technology Fit was presented in a new view (Zigurs & Khazanchi, 2008) for collaboration technologies. When the task is more abstract, it was argued that using patterns to organize tasks was more suitable than using taxonomies for the same purpose. For example, Zigurs and Khazanchi (2008) in studying online groups reactions to online collaboration tools, organized collaboration tasks using patterns. A communication problem was identified first such as “How do you create synergy in your team and increase shared understanding of project’s goals?” From there, the next step was to form the solution in a list of patterns of tasks such as “Use face-to-face video conferencing to socialize; and, communicate often on project’s goals” The results indicated that using patterns to group tasks was more integrative, allowing for a clear understanding of the tasks and in return higher perception of fit between the technology and the task.

Based on the above anecdotal discussion, several researches sought to define the determinants of perceived usefulness and argued that TTF should be one important determinant of whether systems are believed or perceived to be useful. To build on the previous research findings, this research expanded the Technology Acceptance Model (TAM) with the Task-Technology Fit (TTF) constructs to examine from a learner’s prospective the extent to which VMware as a network virtualization technology fits the tasks performed (configuration, design, troubleshooting, etc..) for the purpose of learning computer networking. The model also examined the ability of TTF to predict student’s perceived usefulness of VMware.

Individual Differences

While the Technology Acceptance Model (TAM) was gaining significant popularity and support, a stream of research emerged, testing the importance of incorporating the effect of individual differences in technology acceptance studies (Morris, Venkatesh, & Ackerman, 2005; Ritu & Jayesh, 1999). Five individual differences including: role with regard to technology; tenure in workforce, level of education, prior similar experience, and participation in training were considered. With exception to tenure and training, individual differences accounted for the variance in users' perceptions, intentions, and actual utilization. Ritu & Jayesh (1999) posited that users with higher education, similar prior experience, and greater familiarity with technology in general are likely to have more positive believes about the technology.

The role of gender on technology acceptance was also investigated in the workplace (Venkatesh & Morris, 2000). 342 users were introduced to new software, and users' reactions were collected on two different time occasions. Analyzing the results, Venkatesh & Morris (2000), suggested that perceived usefulness was the deriving factor for adoption for men. However, for women, ease of use, was the highest contributor to the variance in intensions and utilization even over time. The results also suggested that for the participants in this study, women were more influenced by subjective norms in decision for adoption than men.

The ability of perceived ease of use and perceived usefulness to fully mediate intentions without considerations to individual differences was further questioned and investigated (Burton-Jones & Hubona, 2005). In a study assessing the reaction of IT employees toward email and word processing applications, individual differences such as age, seniority and education were tested for their ability to explain the variance in user's intentions and behaviors. Jones & Hubona (2005) found that age significantly influenced ease of use; younger users fond the technology to be easier to use. Seniority and education influenced perceived ease of use; higher education and more seniority led to increased perception of usefulness. In addition to individual differences moderating effect on beliefs, individual differences also directly loaded on actual utilization. All three variable in investigation: age, education, and seniority significantly affected usage frequency. The study concluded with further emphasizing the importance of accounting for individual differences in technology acceptance studies.

Based on the aforementioned findings from previous studies, this study included a demographics instrument to test for the influence of age, prior experience, employment, and academic enrollment status on student's acceptance and utilization of VMware as a computer networking virtualization tool.

Summary

Among the models that were developed to explain and predict technology usage, the Technology acceptance model (TAM) is arguably one of the most widely adopted and tested across organizational contexts, technologies and cultures. The main goal of the TAM is to describe the influence of users' beliefs and attitudes on their intention to use technology and, subsequently, to predict the usage of technology itself. In the TAM, two variables, perceived usefulness (PU) and perceived ease of use (PEU), were hypothesized to be fundamental determinants of user acceptance and fully mediated utilization. Furthermore, the TAM postulated that users' perception of the usefulness and ease of use relative to a particular technology shapes their attitude towards its use and affects their behavioral intention to make use of that technology. This causality of the technology acceptance model makes it a good theoretical foundation for this research study, investigating Engineering and Technology student's reactions to VMware as a network virtualization technology at Valencia Community College.

CHAPTER 3: RESEARCH METHODOLOGY

Introduction

The research design and method of data collection are discussed in this chapter. Additionally data analysis procedures are presented. Details about student population and sample selection, survey instruments, and data collection procedures are all explained in this chapter.

This technology-acceptance study is a correlational investigation where path analysis, regressions, correlations, and analysis of variance (ANOVA) are used to examine factors affecting Engineering & Technology students' use of VMware as a network virtualization tool. A proposed model was expanded from Davis'(1989) Technology Acceptance Model (TAM) to investigate the ability of perceived enjoyment, external control and computer self-efficacy to explain the variance in student perceived ease of use. Those constructs are included in the model as antecedents to perceived ease of use. The original model is also expanded with task characteristics and tool functionality as antecedents to perceived usefulness. Task-Technology Fit (TTF) was then calculated as the interaction between task characteristics (TC) and tool functionality (TF) with the purpose of investigating the ability of the TTF construct to explain the variance in student perceived usefulness of VMware.

Two more constructs were added to the original TAM, namely, subjective norms and voluntariness to investigate the impact of social influences on student's intention and behavior toward network virtualization technology using VMware. Actual system use was selected as the single outcome to the model in its entirety including original constructs (perceived ease of use, perceived usefulness, and intentions), and expanded constructs (perceived enjoyment, perceived external control, computer self-efficacy, task-technology fit, subjective norms, and voluntariness). In attempting to investigate the expanded model's ability to explain the variance in student actual utilization of VMware as a network virtualization tool, seven guiding questions were utilized:

1. How does the proposed expanded technology acceptance model explain the variance in student's actual use of VMware?
2. What is the inter-relationship among perceived usefulness, perceived ease of use, and student intention toward using VMware?
3. What is the role of subjective norms in the proposed model in explaining student intention and behavior toward VMware?
4. What are the effects of the constructs of the Task-Technology Fit variable (task characteristics and tool functionality on student's perception of VMware usefulness?
5. How do the antecedents of perceived ease of use (Enjoyment, External Control, and Computer Self-Efficacy) affect student perceived ease of use of VMware?
6. Does voluntariness moderate the effect of subjective norms on intention?
7. What are other variables (age, specialization, employment, experience,) that can contribute to the proposed model and possibly increase its power of explaining the variance in student's actual utilization of VMware?

Design of the Study

Valencia Community College is the third largest community college in the nation, offering Pre-Major and Associate in Art (A.A.) degrees. Valencia also offers 33 Associate in Science (A.S.) career programs, leading directly to new careers with a job placement rate of 93% to 95%. Valencia serves students through eight physical campuses and centers and a well-established virtual campus through Second Life. The department of Computer Engineering Technology (Networking) was established in 1999, and since then offered two specializations; one in Server Administration & Network Infrastructure, and the second in Internet Routing and Switching. There are around 600 students currently enrolled in the program. Due to the high cost of equipment, a decision was made for the program to be housed at the west campus, avoiding the prohibitive cost of duplicating the lab environment in other campuses. Currently, students with a declared major in computer networking travel from different areas such as Osceola, East Orlando, and Lack Nona to attend classes at the West Orlando campus. None of the courses offered under the computer networking specialization is offered in online mode.

Generally, instructors organize class time to focus on hands-on activities and laboratory experiments knowing that students will not have access off-campus to the equipment they need to practice. Homework assignments and other off-campus activities; therefore, focused only on the conceptual acknowledge of the discipline while on-campus assignments focused on procedural and hands-on skills.

Recently the Department of Computer Engineering Technology (Networking) at Valencia Community College (VCC) was funded by the National Science Foundation (NSF) to develop and offer a new specialization in Cyber Security. Research in Information Assurance (IA) education stressed the need for increased practice and hands-on exercises to prepare future Cyber security professionals for the demands of the workplace. With the addition of the Cyber Security specialization, the search for a solution to provide students with an off-campus laboratory environment to practice at their convenience when their schedule allowed was made more urgent.

Based on findings from Information Assurance education and training in both corporate and military settings, VMware as a virtualization tool was selected to mitigate the problem of students' lack of access to network equipment off-campus. VMware technology was implemented on-campus by lab managers to virtualize operating systems; however the implementation was never transparent to students, but to the contrary students were made to believe that they were using physical operating systems in the lab while in reality they were using virtual operating systems. The network virtualization function of VMware was never implemented on-campus. Necessary to the success of this solution is student's ability to implement the technology at home, and to utilize it for the purpose of studying computer networking skills.

The VMware project was rolled out for the first time in the fall term of 2009 when this research study was conducted. The Local Area Networks (LAN) course was selected because it is one of the first courses students take under the computer networking specialization and the researcher was interested in understanding students' reactions to the technology from as early as the first term they entered into the program.

Two instructors participated in this research study. To ensure fidelity of implementation and to increase inter-instructor reliability, the same WebCT course shell was used in all four sections where all assignments, case studies, and lecture notes were hosted. This was done to ensure consistency in instruction and in availability of resources. The Two participating instructors met biweekly face-to-face to ensure consistency in instructional activities and to discuss implementation problems as reported by students and how support could be provided to students during their implementation of the technology on their home system. Each section met once a week for three and half hours (four credit-hours) course. Each instructor supported all four sections during their office hours. Instructor 1's office hours were utilized by his and instructor 2's students and the same was true for instructor 2's office hours. Additional each instructor implemented the technology in both voluntary and mandatory contexts.

In this research project, the causality issue in the belief-intention-behavior relationship as reported by participating students was investigated. Casual pathways among students' perception of Task-Technology Fit, perceived enjoyment, perceived external control, computer self-efficacy, perceived ease of use, perceived usefulness, subjective norms, voluntariness, intentions, and actual utilization with regard of VMware were investigated and measured.

Study Population and Sample Selection

The target population of this study was students enrolled in the Computer Engineering Technology (Networking) program at Valencia Community College (VCC). Specifically, students enrolled in CET2486C –Local Area Networks (LAN), voluntarily participated in this research study by completing the questionnaire. It was projected that a total of four sections, each with possible enrollment of 24 students, would be offered during the fall term of 2009, when this study was conducted. The four sections were taught by two different instructors (the researcher was one of them). To increase students' participation, each instructor agreed to award extra points at the end of the term to students who chose to complete the online questionnaire. An alternative extra-credit assignment was made available to nonparticipants.

Additionally, each instructor implemented VMware in both voluntary and mandatory contexts (Table 1). Students in all four groups were trained on how to use VMware by Instructor 1 during the first four weeks of the term. Additionally, for the same four-week period, Instructor 1 equally motivated all students both those enrolled in his two sections and those who were enrolled in Instructor 2's two sections. For the first four weeks of the term, Instructor 1 was invited as a guest speaker to the two sections taught by instructor 2 in addition to teaching and motivating his two groups. Some of the methods that Instructor 1 used to motivate students included using case studies to illustrate the importance of VMware in various production environments and how knowledge of VMware could be used to increase students' employability. For example, Instructor 1, among other case studies, provided a case study which explained how the US Air Force cut back hardware related costs by 180,000; created a leaner Information

Technology infrastructure; and reduced carbon emission by more than 50% by implementing network virtualization technologies. Instructor 1 also provided proof of how the VMware technology was under implementation by the entire Department of Defense space-related programs. Other ways of motivating students were by explaining how VMware administrators earning power could reach up to $73,000 with VMware Certified Professional (VCP) certification. Moreover, Instructor1 provided data which explained how the VMware certification proved to be highly valuable and how that 80% of the jobs in the field cited VMware in their description. All case studies and data mentioned above were also shared with Instructor 2, and used to motivate students about VMware.

Table 1: Participants and Treatments

Group	Instructor	Voluntariness	Treatment
Group 1	Instructor 1	Mandatory	Use of VMware on-campus or off-campus (if students were successful at implementing the technology at home) is required to complete all four homework assignments.
Group 2	Instructor 1	Voluntary	Use of VMware is required to complete the first homework assignment. Students in this group can then voluntarily use VMware on-campus or off-campus (if they were successful at implementing the technology at home) to complete the other three homework assignments, or opt for using the traditional laboratory equipment on-campus.
Group 3	Instructor 2	Mandatory	Use of VMware on-campus or off-campus (if students were successful at implementing the technology at home) is required to complete all four homework assignments.
Group 4	Instructor 2	Voluntary	Use of VMware is required to complete the first homework assignment. Students in this group can then voluntarily use VMware on-campus or off-campus (if they were successful at implementing the technology at home) to complete the other three homework assignments, or opt for using the traditional laboratory equipment on-campus.

Instructor 1 = the researcher in this study; Instructor 2 = another computer networking faculty

Four identical homework assignments accounting for 20% of students overall grade were required from students in all groups. Teaching and learning VMware along with the four homework assignment were part of the normal course activities. Each of the four assignments covered certain hands-on objectives with respect to network configurations and troubleshooting.

To learn the objectives, master the skills and ultimately complete the assignments a student could equally use either the physical equipment on-campus or VMware off-campus. The assignments were purposefully designed as such to practically demonstrate to the students how VMware was in computer networking in production environments. The complexity of the homework assignments increased, progressively from assignment one to assignment four, covering more objectives and providing the students with both the opportunities to practice the necessary computer networking skills and to increase their direct interaction with VMware. Students must be successful at implementing VMware at home to be able to complete the homework assignments off-campus. Students in all groups were required to use VMware when completing assignment one. For the remaining three assignments the use of VMware varied, depending on the context; voluntary versus mandatory as described in Table 1.

It is worthy to note here that for students, problems with implementing VMware on their home systems were two folds. First software problems included operating systems compatibility issues and interoperability with other applications already installed on the user's system. For example, the installation of VMware on Windows XP was slightly different from that on Windows 7. After a successful install, in some instances, the firewall installed on a user's system denied VMware access to system resources. The instructors had to provide customized instructions to deal with the implementation in this highly heterogeneous environment.

The second and more complex obstacle was insufficient hardware resources on some of the students' home systems. To maximize the benefit of VMware, a Personal Computer (PC) needs to be equipped with a certain amount of Random Access Memory (RAM) Also the processor has to support virtualization technology. While some students were able to complete the necessary hardware upgrades, others couldn't. A blog was created to provide technical support in questions-answers format for students in all four sections

In summary, participants in this research study (those who completed the online questionnaire) were recruited from four sections of an introductory-level course, CET 2486 Local Area Networks (LAN). Purposefully, the usage of the system was mandatory in two sections and voluntary in the other two to examine the theorized moderating role of voluntariness on subjective norms. Total of 79 students were registered in all four sections combined. The first measurement took place at the end of the fourth week, and 71 out of possible 79 students enrolled then completed the questionnaire as shown in Table 2. By the time the survey was administered the second time which was the last week before the final exam, ten students had dropped out and the total students enrolled went down to 69. During the second measurement, 61 students out of the possible 69 still enrolled participated by completing the survey successfully as shown in Table 3.

Table 2: Participants by Section on Time 1

Section (Group)	Enrolled-Time 1	Participated-Time1	Percent %
Instructor 1 - Mandatory	20	18	25.4
Instructor 2 - Mandatory	20	19	26.8
Instructor 1 - Voluntary	20	18	25.4
Instructor 2 - Voluntary	19	16	22.5
Total	79	71	100

Table 3: Participants by Section on Time 2

Section (Group)	Enrolled-Time 2	Participated-Time 2	Percent %
Instructor 1 - Mandatory	19	17	27.9
Instructor 2 - Mandatory	15	11	18.0
Instructor 1 - Voluntary	19	18	29.5
Instructor 2 - Voluntary	16	15	24.6
Total	69	61	100

Student's participation in this study was totally voluntary. Students' Atlas email accounts which are provided by Valencia Community College were used to send the survey link, and to track the completion status of the survey. With an addendum approved by the UCFIRB (See Appendix N), the students were awarded extra points to their final course grade for completing the survey over the two measurement points. The consent letter was disclosed as the introductory page of the survey through the survey management web site (SurveyMonkey). The consent form included human subjects' rights pertaining to the VMware study, and ensuring participants that there was no detrimental effect on their relationship with the instructor whether or not they participated in the study (See Appendix M). Furthermore the voluntariness, confidentiality, and anonymity aspects were stressed and explained verbally in class.

Data Collection Instrument

An online survey with five varied scales was administered to participants in all four sections. The survey was comprised of eleven instruments each aimed to operationalize and to measure a specific variable in the proposed model. Specifically, the instruments included (1) VMware Tools' Functions Instrument; (2) Computer Networking Tasks Characteristics Instrument; (3) Perceived Usefulness Instrument; (4) Voluntariness Instrument; (5) Subjective Norms Instrument; (6) Perceived Enjoyment Instrument; (7) Computer Self-Efficacy Instrument; (8) Perception of External Control Instrument; (9) Perceived Ease of Use Instrument; (10) Intention to Use Instrument; and (11) Actual Utilization Instrument. The 11 instruments collectively contained 58 items. Additionally, a demographics instrument of six items was included to investigate the influence of individual differences such as age, prior experience with the technology, prior experience in computer networking, academic enrollment status, and employment status on student's beliefs and behavior with regard to VMware as a network virtualization technology.

VMware Tools' Functions Instrument

Scores on the Tools' Functions (TF) Instrument could range from five to 25 points. There were no scales readily adoptable for operationalizing and measuring tools' functions. Even though Goodhue (1995) had developed scales to measure the same construct, the questions were purposefully very general to cover many technologies. In this study, five new items were developed specifically for VMware as a network virtualization technology. VMware Tools' Functions questions were developed based on vendor's specifications, and documentation of possible configurations and functions as detailed in the product manual. The five items collectively attempted to measure the extent to which students believed VMWare tools to be capable of performing certain computer networking functions. All five items (see Apendix A) were measured on a five-point Likert scale with 1 as "Not at All", and 5 as "Very Large Extent". Reliability testing indicated that Cronbach coefficient alpha was .91 for the first measurement and .92 for the second measurement.

Task Characteristics Instrument

Scores on the Task Characteristics (TC) Instrument could range from ten to 50 points. There were no scales readily adoptable for operationalizing and measuring task characteristics. Even though Goodhue (1995) had developed scales to measure the same construct, the questions were purposefully very general to cover rudimentary computer skills. In this study, ten new items were developed to contextualize the task characteristics construct to computer networking (see Appendix B). Computer networking task characteristics questions were developed based on the measurable learning outcomes of the CET 2486 Local Area Network – the course in which research participants were enrolled and where the network virtualization technology using VMware was implemented. The ten items collectively attempted to measure the extent to which students believed to have performed certain computer networking tasks using either VMware or the physical equipment on-campus. All ten items were measured on a five-point Likert scale with 1 as "Not at All", and 5 as "Very Large Extent". Reliability testing indicated the Cronbach coefficient alpha was .88 for the first measurement and .94 for the second measurement. Included in the Task Characteristics instrument were questions such as "I installed an operating system." and "I analyzed network protocols." As consistent with the literature, Task-Technology Fit (TTF) was then computed as the interaction term (product) between the computer networking tasks and the VMware tool functionality variables (Dishaw & Strong, 1999).

Perceived Usefulness Instrument

The Perceived Usefulness (PUS) scale was adapted from Venkatesh (2000). The scale was very reliable in several prior studies with Cronbach alpha coefficients of 0.97. The four items in the scale were adjusted to fit in the context of learning. For example the original scale by Venkatesh included items such as "Using the system improves my performance in my job." Adjusted to fit the context of learning, the same item was stated as "Using VMware improves my understanding of various computer networking concepts." Scores on the perceived usefulness (PUS) Instrument could range from four to 20 points (see Appendix C). All four items were measured on a five-point Likert scale with 1 as "Strongly Disagree", and 5 as "Strongly Agree".

The perceived usefulness instrument attempted to measure the extent to which students perceived VMware, as network virtualization tool, to be useful to them in learning computer networking concepts and in practicing computer networking skills. Reliability testing indicated the Cronbach coefficient alpha was .91 for the first measurement and .87 for the second measurement.

Perceived Enjoyment Instrument

The Perceived Enjoyment (ENJ) scale was adapted from Venkatesh and Davis (1996). In several prior studies about the determinants of perceived ease of use, the scale was very reliable with Cronbach alpha coefficient of 0.90. Scores on the perceived enjoyment (ENJ) instrument could range from three to 15 points, and included items such as "I find using VMware to be enjoyable." All three items were measured on a five-point Likert scale with 1 as "Strongly Disagree", and 5 as "Strongly Agree". The Perceived Enjoyment instrument attempted to measure the degree to which students perceived their interaction with VMware to be enjoyable (see Appendix F). Reliability testing indicated the Cronbach coefficient alpha was .99 for the first measurement and .97 for the second measurement.

Computer Self-Efficacy Instrument

Computer Self-Efficacy (CSE) was measured by adapting the scale of Compeau and Higgins (1995) and consistent with previous work on the determinants of perceived ease of use

(Venkatesh & Davis 1996). Scores on the Computer Self-Efficacy (CSE) Instrument could range from ten to 50 points (see Appendix G). All ten items were measured on a five-point Likert scale with 1 as “Strongly Disagree”, and 5 as “Strongly Agree”. The Computer Self-Efficacy scale attempted to measure the degree to which a student perceived his or her ability to perform a non system-specific computer related task. The scale included items such as “I could complete a task if someone showed me how to do it first.” Reliability testing indicated the Cronbach coefficient alpha was .87 for the first measurement and .93 for the second measurement.

Perception of External Control Instrument

The Perceived External Control (EC) scale was adapted from Venkatesh and Davis (1996). In several prior studies about the determinants of perceived ease of Use, the scale was very reliable with Cronbach alpha coefficient of 0.82. Scores on the Perception of External Control (EC) Instrument could range from six to 30 points (see Appendix H). All six items were measured on a five-point Likert scale with 1 as “Strongly Disagree”, and 5 as “Strongly Agree”. The scale attempted to measure the degree to which a student felt that he or she had the opportunities, resources, and knowledge necessary to use VMware. Items in the scale were adjusted to fit in the context of learning, and to measure the availability of resources both on-campus and off-campus with respect to the specific technology under examination. An example of the times in that scale is: “I have the resources necessary to use VMware off-campus.” Reliability testing indicated the Cronbach coefficient alpha was .84 for the first measurement and .89 for the second measurement.

Perceived Ease of Use Instrument

The Perceived Ease of Use (PEU) scale was adapted from Davis (1989) with a Cronbach alpha coefficient of .91. The five items in the instrument were slightly modified to specifically address VMware as the technology or system under examination (see Appendix I). Scores on the Perceived ease of use (PEU) Instrument could range from five to 25 points. All five items were measured on a five-point Likert scale with 1 as "Strongly Disagree", and 5 as "Strongly Agree". An example of the items included in the Perceived Ease of use scale is "My interaction with VMware is clear." Reliability testing indicated the Cronbach coefficient alpha was .94 for both measurement points.

Intention to Use Instrument

The Intention to Use scale attempted to measure student behavioral intention toward using VMware as a network virtualization technology. The scale was adopted from Venkatesh (2000) with a Cronbach alpha coefficient of .91. Scores on the Intention to Use (AT) Instrument could range from 2 to 10 points (see Appendix J). Two items were measured on a five-point Likert scale with 1 as "Strongly Disagree", and 5 as "Strongly Agree". Example of an item on the scale is "Assuming I had access to VMware, I intend to use it to practice computer networking skills". Reliability testing indicated the Cronbach coefficient alpha was .72 for the first measurement and .95 for the second measurement.

Actual Utilization Instrument

The instrument specific to measuring actual use of VMware was operationalized with questions that assessed the amount of time spent and the frequency of using VMware to practice various computer networking skills. Davis (1989) argued that frequency of use and amount of time spent using a target technology are typical usage metrics in Management Information Systems (MIS) research. According to Davis (1989), the instrument is moderately reliable with a Cronbach Alpha coefficient of 0.70. The three items in the original scale were slightly modified to be specific to the use of VMware. An example of an actual utilization item is: “In general how many times did you use VMware both on-campus and off-campus?” Additionally, two items were included to assess student experiential use of the technology for purposes outside course work and classroom assignments (see Appendix K). An example question is “I used VMware to perform other tasks not required by my course work.” Actual Utilization (AU) Instrument could range from five to 25 points. Five items were measured on a five-point Likert scale with 1 as “Strongly Disagree”, and 5 as “Strongly Agree”. Reliability testing indicated the Cronbach coefficient alpha was .75 for the first measurement and .81 for the second measurement.

Subjective Norms Instrument

The Subjective Norms (SN) Instrument was adopted from Venkatesh and Davis (2000) with Cronbach alpha of .81. Subjective Norms (SN) Instrument could range from five to 25 points. Five items were measured on a five-point Likert scale with 1 as “Strongly Disagree”, and 5 as “Strongly Agree”. Reliability testing indicated the Cronbach coefficient alpha was .82 for the first measurement and .85 for the second measurement. The scale attempted to measure the degree to which a student believed that someone important to him/her thought that he or she should or should not use VMware (see Appendix D). Example of the items on the scale is: “I am usually inclined to do what my instructor thinks I should do”.

Voluntariness Instrument

The Voluntariness (VOL) Instrument was adopted from Venkatesh and Davis (2000) with Cronbach alpha of .82. Voluntariness (VOL) Instrument could range from 3 to 15 points (see Appendix E). Three items were measured on a five-point Likert scale with 1 as “Strongly Disagree”, and 5 as “Strongly Agree”. Reliability testing indicated the Cronbach coefficient alpha was .83 for the first measurement and .86 for the second measurement. The voluntary moderator factor was then computed as the product of subjective norms and voluntariness.

Student Demographic Instrument

Additionally, a demographics instrument of six items was included to investigate the influence of age, prior experience with the technology, prior experience in computer networking, academic enrollment status, and employment status on student intention and behavior with regard to VMware as a network virtualization technology (see Appendix L).

Data Collection Procedures

Prior to participation, students were asked to review the informed consent letter which was posted online (see Appendix M). Students' participation or lack thereof had no detrimental effect on their relationship with their instructors. Security and confidentiality were practiced in storing students' responses. Using Survey Monkey, an email invitation collector was sent to students in all four sections to their Valencia's Atlas email account. Students email addresses were obtained as part of the course registration information. An announcement was made in class by the two participating instructors when the survey became available, asking students to login to their Atlas email account. Additionally, an announcement was made using WebCT's announcement feature, and asking students to login to their Valencia's Atlas email account to access the email invitation.

The email had a link to the consent form which stressed the voluntariness of participation; however, encouraged participation by awarding participants 10 points out of a total of 500 points (2% of the overall grade) toward their final course grade for a complete participation. Alternatively, an extra credit assignment, requiring the same time and effort as required for completing the survey was also available to nonparticipants. The consent form also explained that students could opt out of the survey study at any point. At the end of the consent form, if a student indicated that he/she is (1) at least 18 years old, and (2) agreed to the consent form, then the survey page was displayed, using a Secured Hyper Text Transfer Protocol

(HTTPS) session with Secure Socket Layer (SSL) encryption. However, if a student answers in the negative to one or both of these questions, then the information about the alternative extra-credit assignment was made available to the student. An HTTPS session was used to collect and store students' responses. The option to "Not save the email address" in the survey results was selected; with the activation of this feature, the researcher was able to track the status of the email in the recipients list and verify who did or did not respond for the purpose of awarding extra credit. The email addresses; however, were not visible when the responses were downloaded for analysis, keeping the survey anonymous. Please see Figure 4 for a flowchart of the data collection process.

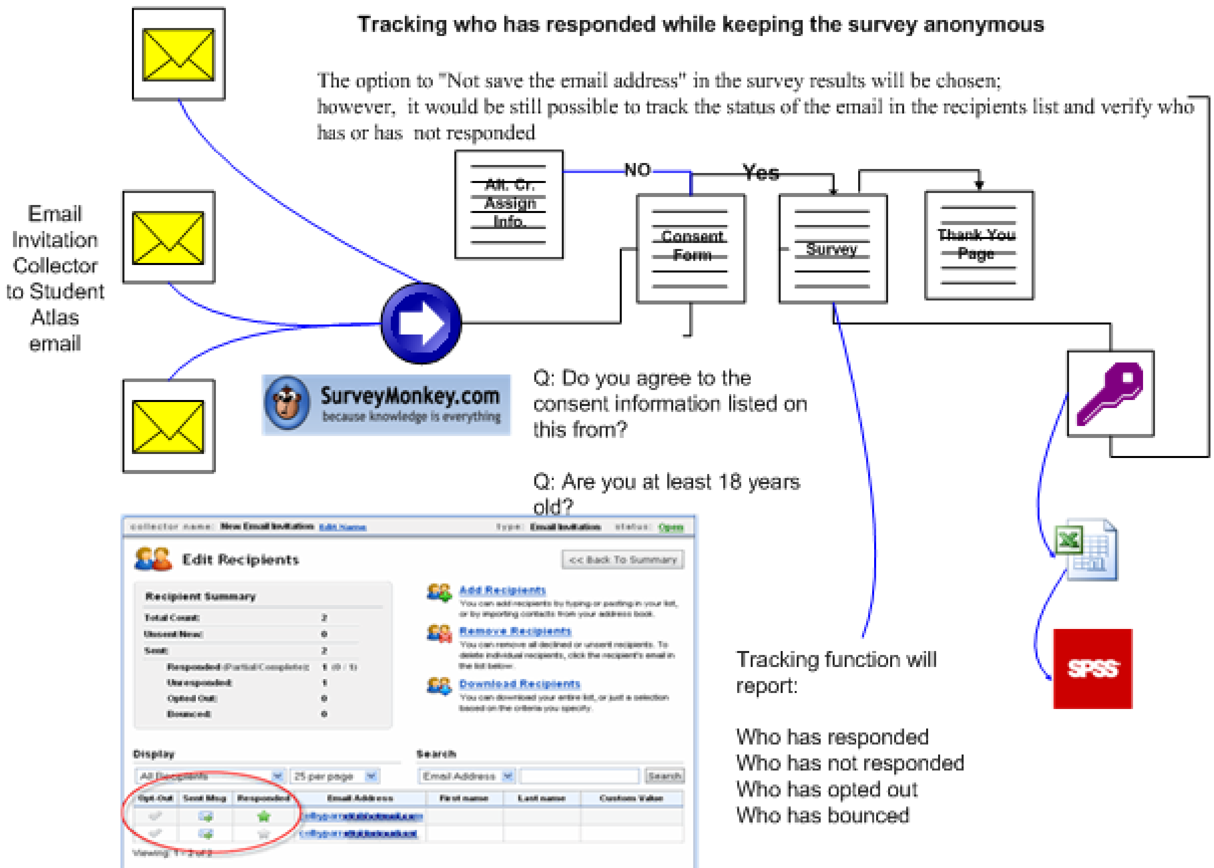

Figure 4: A Flow Chart of the Data Collection Process

Data Analysis Procedures

In this statistical model, a set of manifest variables were related to a set of latent variables, where it is assumed that the responses on the indicators or manifest variables are the result of an individual's position on the latent variables. Ultimately, the data were analyzed to determine the plausibility of the proposed model in predicting usability of VMware as the outcome variable.

Specifically, questionnaire data were downloaded from a secured web server. Data anonymization techniques, ensuring that personal identity couldn't be reconstructed from existing data were followed. The data were then entered into SPSS for Windows and used as an input source into AMOS for the propose of performing path analysis and regressions and to explore and measure causal pathways among students' perceived ease of use, perceived usefulness, intentions, subjective norms, and students' actual utilization of network virtualization technology.

Validity and reliability of instruments were tested by conducting exploratory factor analysis, and internal consistency reliability analysis. An internal consistency Cronbach alpha coefficient of each of the eleven instruments was generated using the data reduction procedure in SPSS. The proposed model was tested using both Time 1, and Time 2 data. For each set of data model fit indices were generated to determine the plausibility of the proposed model. Analysis of variance was then conducted using ANOVA in SPSS for Windows to test the influences of individual differences (experience, academic enrollment status, and employment status) on student intentions and actual utilization of VMware.

CHAPTER 4: RESEARCH RESULTS

Introduction

The analysis report for the current research was based on outputs from both statistics software packages SPSS for Windows and AMOS for Windows. The first section provides the basic statistic descriptions of the participants' demographics information (i.e., major; age; academic enrollment; and employment status). Next, the issues of validity, and reliability of the survey instruments is discussed. The last section of this chapter is dedicated to answering the following research questions using path analysis, regressions, and univariate analysis of variance using both Time 1, and Time 2 data sets.

1. How does the proposed expanded technology acceptance model explain the variance in student's actual use of VMware?
2. What is the inter-relationship among perceived usefulness, perceived ease of use, and student intention toward using VMware?
3. What is the role of subjective norms in the proposed model in explaining student intention and behavior toward VMware?
4. What are the effects of the constructs of the Task-Technology Fit variable (Task Characteristics and Tool Functionality) on student's perception of VMware usefulness?
5. How do the antecedents of perceived ease of use (Enjoyment, External Control, and Computer Self-Efficacy) affect student perceived ease of use of VMware?
6. Does voluntariness moderate the effect of subjective norms on intention?

7. What are other variables (age, specialization, employment, experience,) that can contribute to the proposed model and possibly increase its power of explaining the variance in student's actual utilization of VMware?

Participant Demographics

A total of 56 (as shown in Table 4) valid participants were assessed in four sections of CET 2486C Local Area Networks (LAN). In Time 1, total of 79 students were enrolled and 71 participated (see Table 2). In Time 2, total of 69 students were enrolled and 61 participated (see Table 4). Fifty-Six valid participants completed the survey on both times. Fifty-five percent of the participants came from the two sections taught by Instructor 1, and 45% came from the two sections taught by Instructor 2.

Table 4: Valid Participants by Section

Section (Group)	Participants	Percent %
Instructor 1 - Mandatory	14	25
Instructor 2 - Mandatory	11	20
Instructor 1 - Voluntary	17	30
Instructor 2 - Voluntary	14	25
Total	56	100

Table 5 shows the distribution of the participants by age. Forty-two percent of the participants were between 20 and 25 years old. The majority of the participants (60%) were between 18 and 25 years old. Seven of the participants were at least 40 years old. Figure 5 shows a bar chart representation of the age distribution of the participants.

Table 5: Description of Participants' Age

Age	Participants	Percent (%)	Valid Percent (%)	Cumulative Percent %
18-20	10	18	18	18
20-25	24	42	42	60
25-30	2	4	4	64
30-35	9	16	16	80
35-40	10	7	7	87
Over 40	7	13	13	100
Total	56	100	100	

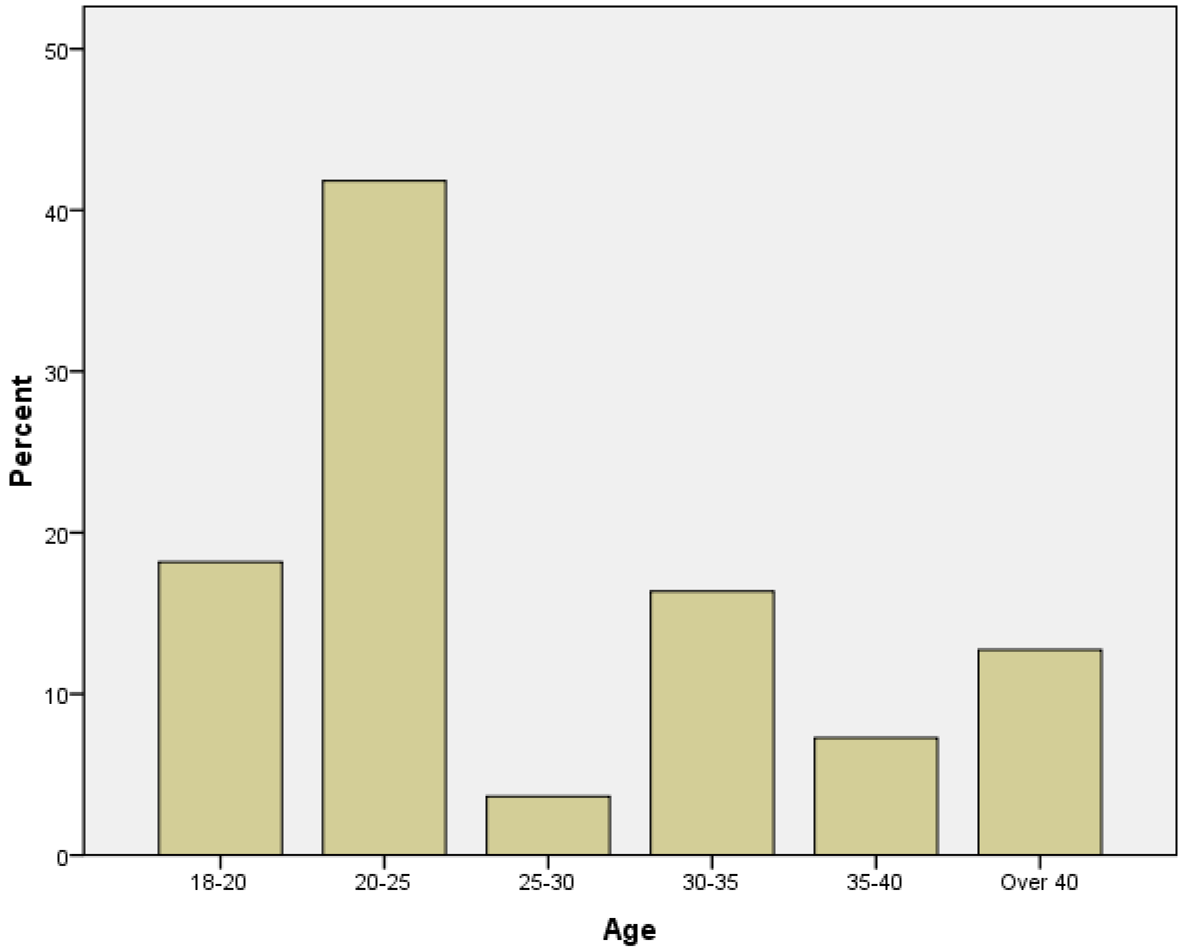

Figure 5: Bar Chart of Participants' Age

The CET 2486C Local Area Networks (LAN) course in which our research participants were enrolled is a prerequisite class for various majors in the Engineering and Technology division at Valencia Community College (VCC). Table 6 shows that over half of the participants were Computer Engineering Technology major. During the first class meetings and time for introductions, it was clear to the researcher that students from many majors and fields of study were enrolled in the Local Area Networks class as part of their degree electives. Those included computer programming and analysis students, Database Technology students, Lather and Photonics students and many others. However students represented in each of those were very few and the researcher though it would be appropriate to group them under “Other”.

Table 6: Description of Participants’ Major

Major	Participants	Percent (%)	Valid Percent (%)	Cumulative Percent (%)
CET	31	55	55	55
EET	12	21	21	77
CIS	2	4	4	80
PD	1	2	2	82
Other	10	18	18	100.0
Total	56	100	100	

CET: Computer Engineering Technology; EET: Electronics Engineering Technology; CIS: Computer Information Systems; PD: Professional Development

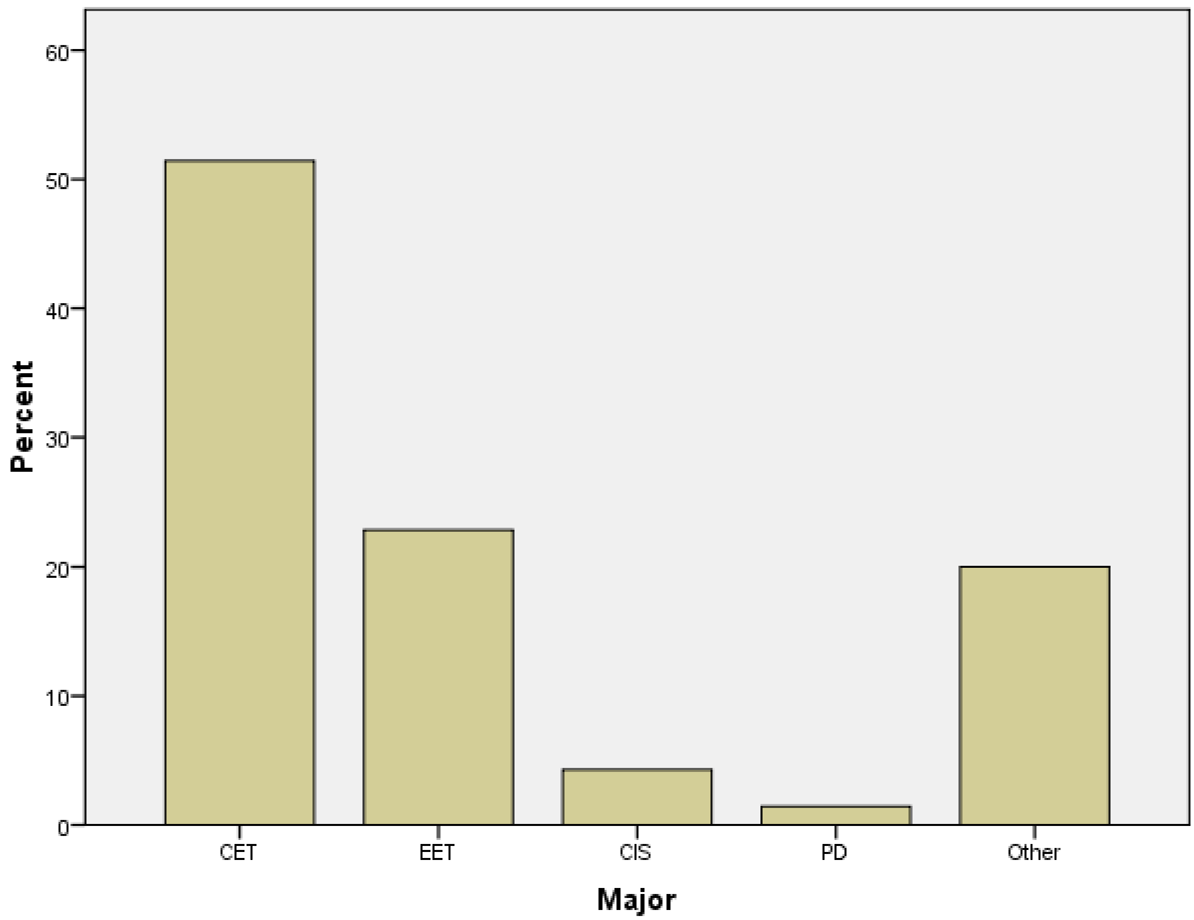

Figure 6: Bar Chart of Participants' Major

Participants were also asked to report on their prior experience with VMware as the target technology. Table 7 shows that 82% of the participants indicated that they were not familiar with VMware at all prior to their enrollment in the Local Area Networks (LAN) course. Only one student indicated that he/she was very experienced with the technology. Table 7 shows the distribution of the participants by their prior VMware experience. Figure 7 shows a bar chart representation of participants' VMware experience.

Table 7: Description of Participants' VMware Experience

VMware Experience	Participants	Percent %	Valid Percent %	Cumulative Percent %
Not familiar at all	46	82	82	82
Heard about it	5	9	9	89
Used it to some extent	4	7	7	98
Use it to a great extent	1	2	2	100.0
Total	56	100	100	

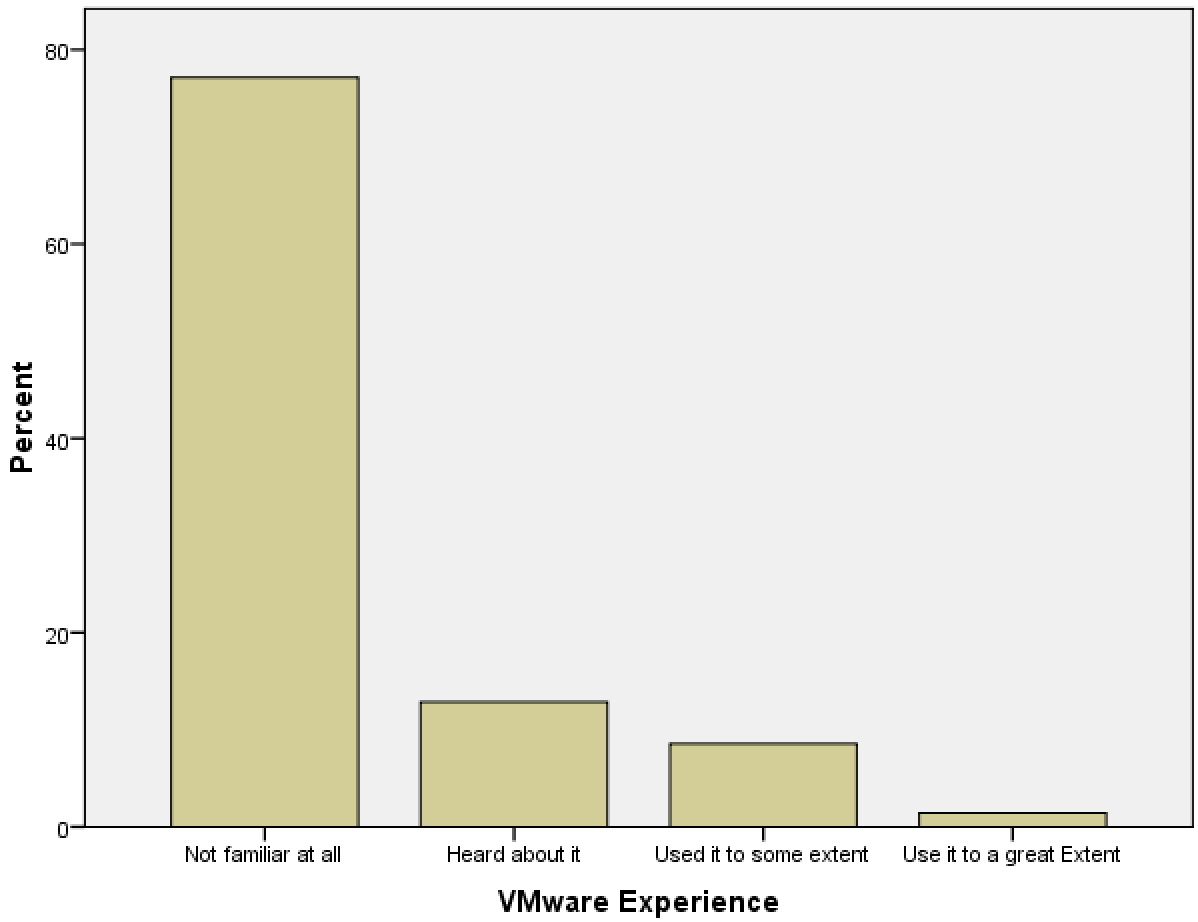

Figure 7: Bar Chart of Participants VMware Experience

Participants' prior experience in computer networking is represented in Table 8. The majority of the students (70%) indicated that they had some prior computer networking experience before attending the Local Area Networks (LAN) course. Fewer than 10% of the participants indicated that they came to the LAN class with extensive experience in computer networking. Figure 8 shows a bar chart representation of participants' prior computer networking experience.

Table 8: Description of Participants' Computer Networking Experience

Computer Networking Experience	Participants	Percent %	Valid Percent %	Cumulative Percent %
No experience at all	12	21	21	21
Some experience	39	70	70	91
A lot of experience	5	9	9	100.0
Total	56	100	100	

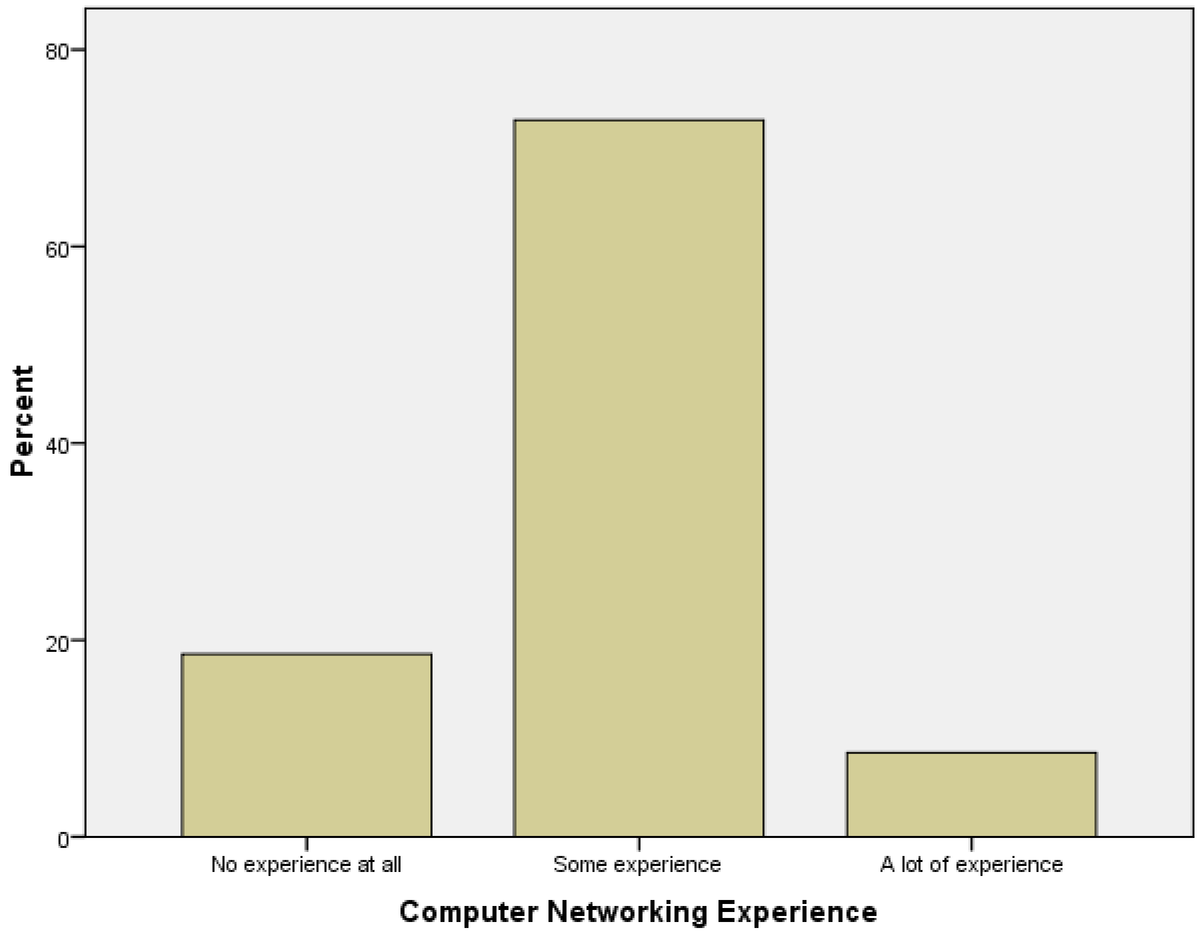

Figure 8: Bar Chart of Participants' Computer Networking Experience

The majority of the participants were employed either as full-time (41%) or as part-time (23%). A significant percentage of the students were unemployed as shown in Table 9. A bar chart representation of participants' employment status is shown in Figure 9.

Table 9: Description of Participants' Employment Status

Employment Status	Participants	Percent %	Valid Percent %	Cumulative Percent %
Full-Time	23	41	41	41
Part-Time	13	23	23	64
Unemployed	20	36	36	100
Total	56	100	100	

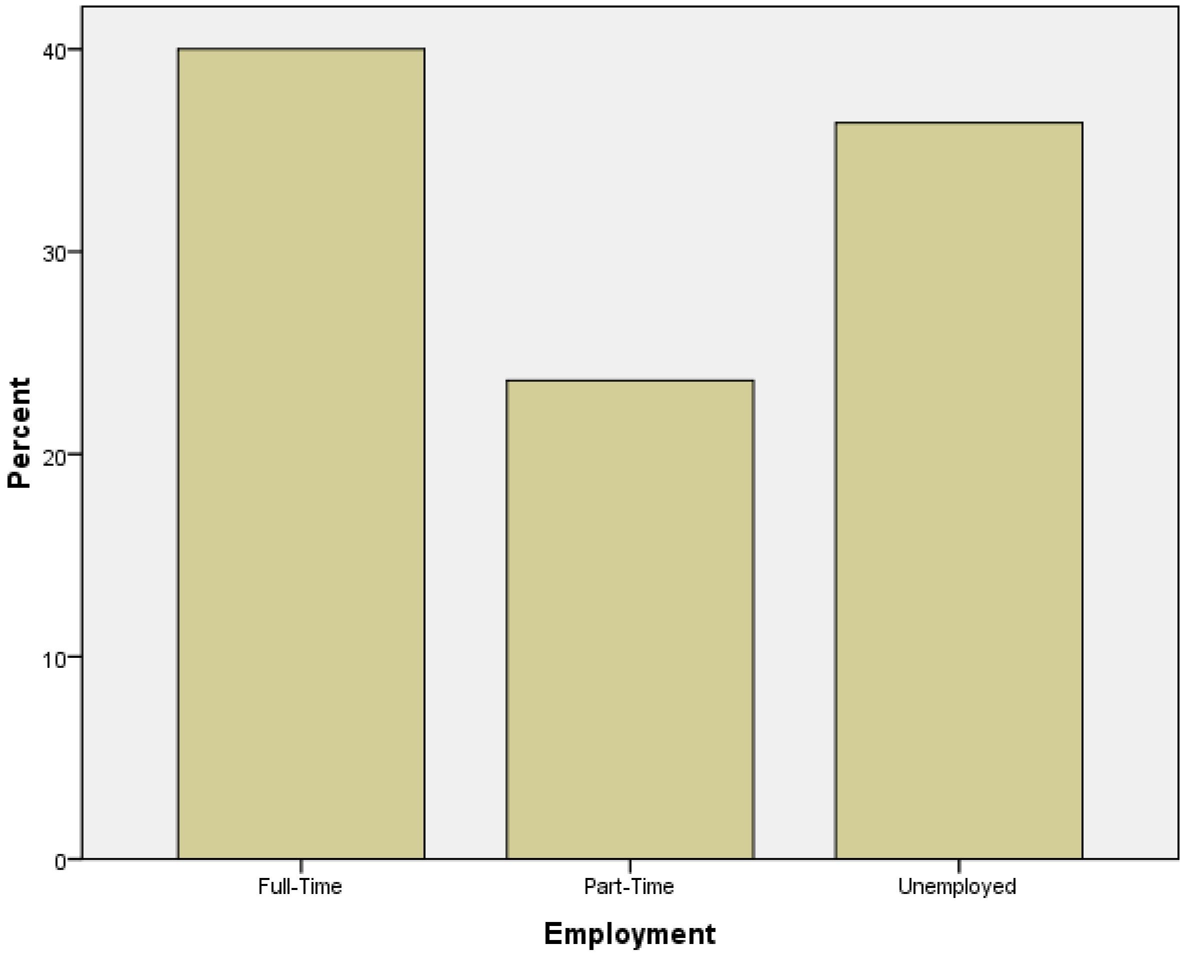

Figure 9: Bar Chart of Participants' Employment Status

The Majority of the participants were degree-seeking students either as full-time (57%), or as part-time (37%). Only 6% of the participants were attending the Local Area Networks (LAN) as non-degree seeking as shown in Table 10. A bar chart representation of participants academic enrollment status is shown in Figure 10.

Table 10: Description of Participants' Academic Enrollment

Academic Enrollment Status	Participants	Percent %	Valid Percent %	Cumulative Percent %
Full-Time, Degree-Seeking	32	57	57	57
Part-Time, Degree-Seeking	22	37	37	94
Full-Time, Non-Degree-Seeking	1	2	2	96
Part-Time, Non-Degree-Seeking	2	4	4	100
Total	56	100	100	

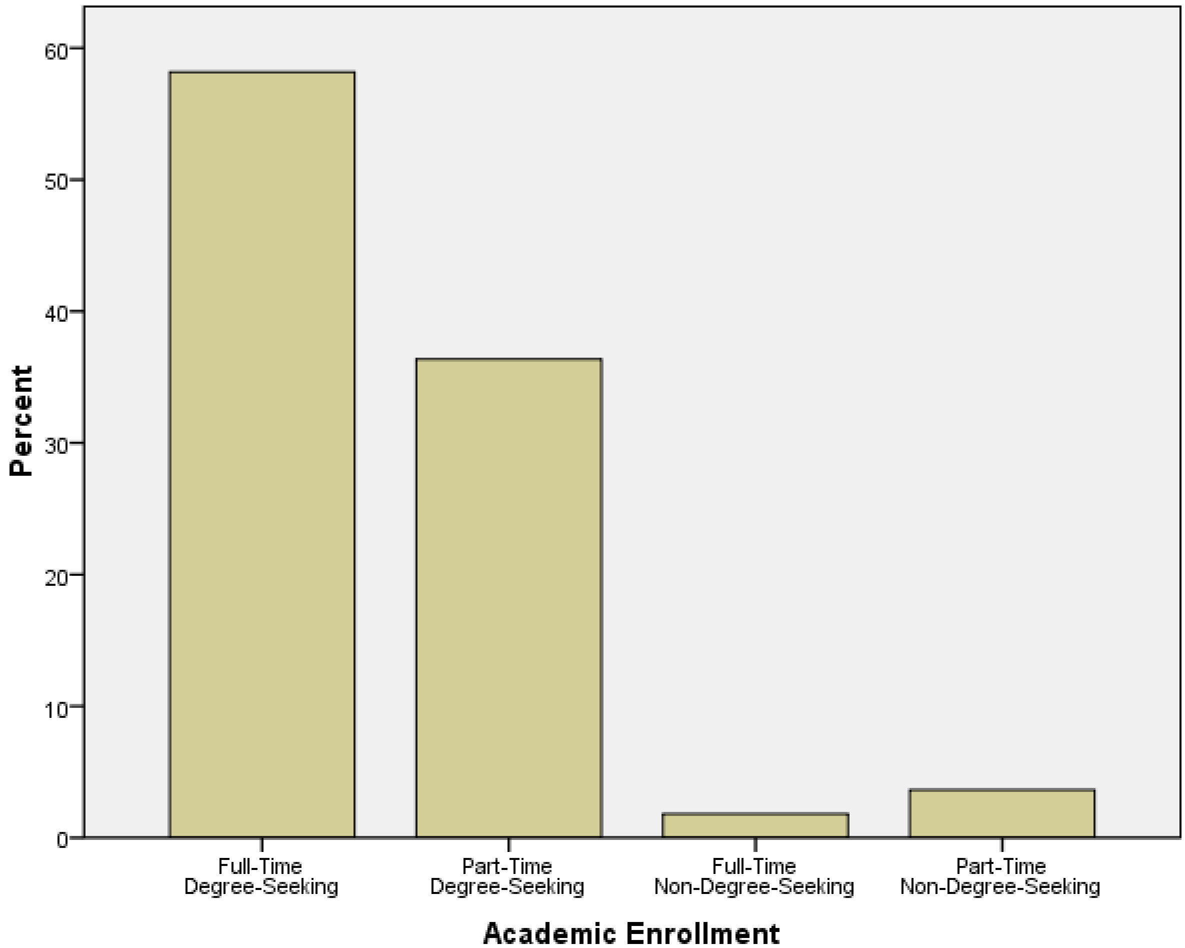

Figure 10: Bar Chart of Participants' Academic Enrollment Status

Data Characteristics

Descriptive Statistics of the Model's Variables

The survey was comprised of eleven instruments each aimed to operationalize and to measure a specific variable in the proposed model. Specifically, the instruments included (1) VMware Tools' Functions Instrument; (2) Computer Networking Tasks Characteristics Instrument; (3) Perceived Usefulness Instrument; (4) Voluntariness Instrument; (5) Subjective Norms Instrument; (6) Perceived Enjoyment Instrument; (7) Computer Self-Efficacy Instrument; (8) Perception of External Control Instrument; (9) Perceived Ease of Use Instrument; (10) Intention to Use Instrument; and (11) Actual Utilization Instrument. The 11 instruments collectively contained 58 items. Participants' responses to each of the instruments were then averaged and reported in Table 11 for Time 1 data and in Table 12 for Time 2 data. Additionally, the descriptive statistics for the Task-Technology Fit (TTF) construct were included. There was no specific instrument to operationalize the TTF construct; however TTF was calculated as the interaction between the Tool Functionality (TF) variable and the Task Characteristics (TC) variable. Similarly, no specific instrument was included for the voluntary moderator variable. The voluntary moderator variable was calculated as the product of subjective norms and voluntariness.

Table 11: Descriptive Statistics of Variables on Time1

Variable	Mean	Std. Deviation
TF	21.58	4.146
TC	41.58	7.262
TTF	911.79	266.85
SN	16.72	3.071
VOL	3.89	1.248
VM	64.76	24.20
PUS	13.99	2.039
ENJ	13.48	3.061
CSE	32.90	5.814
EC	21.89	3.808
PEU	16.99	3.694
AT	9.03	1.603
AU	13.13	4.021

TF: tool functionality; TC: task characteristics; TTF: task-technology fit; NS: subjective norms; VOL; voluntariness; VM: voluntary moderator; PUS= perceived usefulness; ENJ; enjoyment; CSE; computer self-efficacy; EC: external control; PEU; perceived ease of use; AT; intension toward using; AU: actual utilization

Table 12: Descriptive Statistics of Variables on Time2

Variable	Mean	Std. Deviation
TF	21.84	3.28
TC	43.36	6.16
TTF	954.23	229.30
SN	16.66	3.35
VOL	3.89	1.20
VM	65.25	25.43
PUS	18.31	2.61
ENJ	13.15	3.08
CSE	41.48	7.43
EC	17.30	3.08
PEU	17.02	3.35
AT	8.90	1.90
AU	14.64	4.29

TF: tool functionality; TC: task characteristics; TTF: task-technology fit; NS: subjective norms; VOL; voluntariness; VM: voluntary moderator; PUS= perceived usefulness; ENJ; enjoyment; CSE; computer self-efficacy; EC: external control; PEU; perceived ease of use; AT; intentions toward using; AU: actual utilization

Comparing the variables over time, the data suggested that participants' perception of the usefulness of VMware as a network virtualization tool increased from Time 1 to Time2. Also, as time progressed, student's perception of fit between the computer networking tasks and the VMware tools increased. Students' perception of external control; however, decreased over time. Also, worthy of mentioning is that student's perception of ease of use as well as student's intention and actual utilization of VMware were all almost the same from Time 1 to Time 2.

Reliability

The value of the 11 variables were summed from their corresponding measurement items (i.e., five items for tool functionality, ten items for task characteristics, four items for perceived ease of use, etc..) In spite of the high reliability suggested by previous studies, the current study conducted reliability analysis to validate the internal consistency on the 12 sets of measurement items. Table 13 shows Cronbach's' alpha generated by SPSS for both times. To achieve this level of reliability, item SN5 was removed from the subjective norms instrument; items VOL2, and VOL3 were removed from the voluntariness instrument; item PEU3 was removed from the perceived ease of use instrument; and item AU3 was removed from the actual utilization instrument.

Table 13: Cronbach's Reliability Analysis

Instrument	Time 1	Time 2
Tool Function (TF)	.910	.921
Task Characteristics (TC)	.884	.939
Perceived Usefulness (PU)	.906	.872
Subjective Norms (SN)	.818	.832
Voluntariness (VOL)	.830	.856
Perceived Enjoyment (ENJ)	.985	.974
Computer Self-Efficacy (CSE)	.874	.928
External Control (EC)	.840	.893
Perceived Ease of Use (PEU)	.935	.943
Intention to Use (AT)	.717	.950
Actual Utilization (AU)	.747	.814

Fit Statistics Report

According to the fit statistics report as shown in Table 14, Time 1 data fitted the model more than Time 2 data did. In general, a chi-square probability value (*p*) of .05 or higher is needed to accept the null hypothesis that the model fits the data. Root mean square error of approximation (RMSEA), comparative fit index (CFI), and normed-fit Index (NFI) are the alternative goodness of fit indexes to the chi-square test. All three alternative indexes are valued from 0 to 1. While RMSEA desires a value lower than 0.08 for a good model fit, both CFI and NFI values require 0.9 or larger to indicate an acceptable fit of the model.

Table 14: Fit Statistics Report on Time 1 and Time 2

Fit Index	Time 1	Time 2
Chi-Square	27.13	42.24
Chi-Square Degree of Freedom (df)	17	17
Chi-Square Probability Value (*p*)	.056	.001
Root Mean Square Error of Approximation (RMSEA)	.092	.157
Bentler's Comparative Fit Index (CFI)	.970	.939
Bentler & Bonett's Normed –fit Index (NFI)	.929	.908

Factors' Correlations

Analyzing the data from Time 1, strong correlations amongst the variables of the model were detected. Computer self-efficacy however did not correlate with any of the variables in the model. Both external control and enjoyment were very highly correlated with perceived ease of use. The data also suggested that the task-technology fit construct highly correlated with ease of use, and with usefulness. Also, as indicated in Table 15, actual utilization correlated the highest with perceived ease of use.

Table 15: Correlations Matrix on Time 1

	PUS	SN	ENJ	CSE	EC	PEU	AT	AU	TTF	VM
PUS	-									
SN	.335**	-								
ENJ	.718**	.331**	-							
CSE	.054	.180	.079	-						
EC	.521**	.265*	.615**	.087	-					
PEU	.704**	.268*	.811**	.015	.770**	-				
AT	.581**	.303*	.649**	.032	.529**	.572**	-			
AU	.431**	.149	.441**	.045	.483**	.553**	.334**	-		
TTF	.650**	.321**	.612**	.147	.655**	.758**	.584**	.470**	-	
VM	.312**	.447**	.299*	.189	.353**	.318**	.334**	.164	.290*	-

TTF: task-technology fit; NS: subjective norms; VM: voluntary moderator; PUS= perceived usefulness; ENJ; enjoyment; CSE; computer self-efficacy; EC: external control; PEU; perceived ease of use; AT; intentions toward using; AU: actual utilization

Analyzing the data from Time 2, perceived ease of use highly correlated with external control. Perceived usefulness highly correlated with both perceived ease of use and subjective norms. Intention correlated the highest with perceived ease of use and with its antecedents; external control and enjoyment. Actual utilization correlated the highest with intention and external control. Other correlations are presented in Table 16.

Table 16: Correlation Matrix on Time 2

	PUS	SN	ENJ	CSE	EC	PEU	AT	AU	TTF	VM
PUS	-									
SN	.647**	-								
ENJ	.602**	.560**	-							
CSE	.308*	.472**	.338**	-						
EC	.500**	.565**	.788**	.398**	-					
PEU	.666**	.581**	.771**	.402**	.801**	-				
AT	.647**	.598**	.825**	.344**	.806**	.845**	-			
AU	.415**	.526**	.569**	.334**	.576**	.502**	.587**	-		
TTF	.482**	.446**	.515**	.358**	.610**	.696**	.542**	.507**	-	
VM	.511**	.610**	.512**	.461**	.664**	.634**	.566**	.468**	.551**	-

TTF: task-technology fit; NS: subjective norms; VM: voluntary moderator; PUS= perceived usefulness; ENJ; enjoyment; CSE; computer self-efficacy; EC: external control; PEU; perceived ease of use; AT; intentions toward using; AU: actual utilization

Research Question 1

Research Question 1: How does the proposed expanded Technology Acceptance Model (TAM) explain the variance in student's actual use of VMware as a network virtualization technology?

Path analysis using AMOS was conducted to assess the relative importance of various direct and indirect causal paths to the dependent variables, Perceived Ease of Use (PEU), Perceived Usefulness (PU), Intention (AT), and Actual Utilization (AU). The model contained the following variables as observed, endogenous variables: Perceived Ease of Use (PEU), Perceived Usefulness (PU), Actual Utilization (AU), and Intention (AT) toward using VMware as a network virtualization technology. Six observed exogenous variables were represented in the model: Perceived Enjoyment (ENJ), Perceived External Control (EC), Computer Self-Efficacy (CSE), Task-Technology Fit (TTF), and Voluntary Moderator (VM). Four error terms (E1, E2, E3, and E4) were the unobserved, exogenous variables in the model. Exploratory analysis suggested the existence of a strong path between TTF and PEU, and another between PEU, and AU. The model, with path coefficients using Time 1 data is depicted in Figure 11.

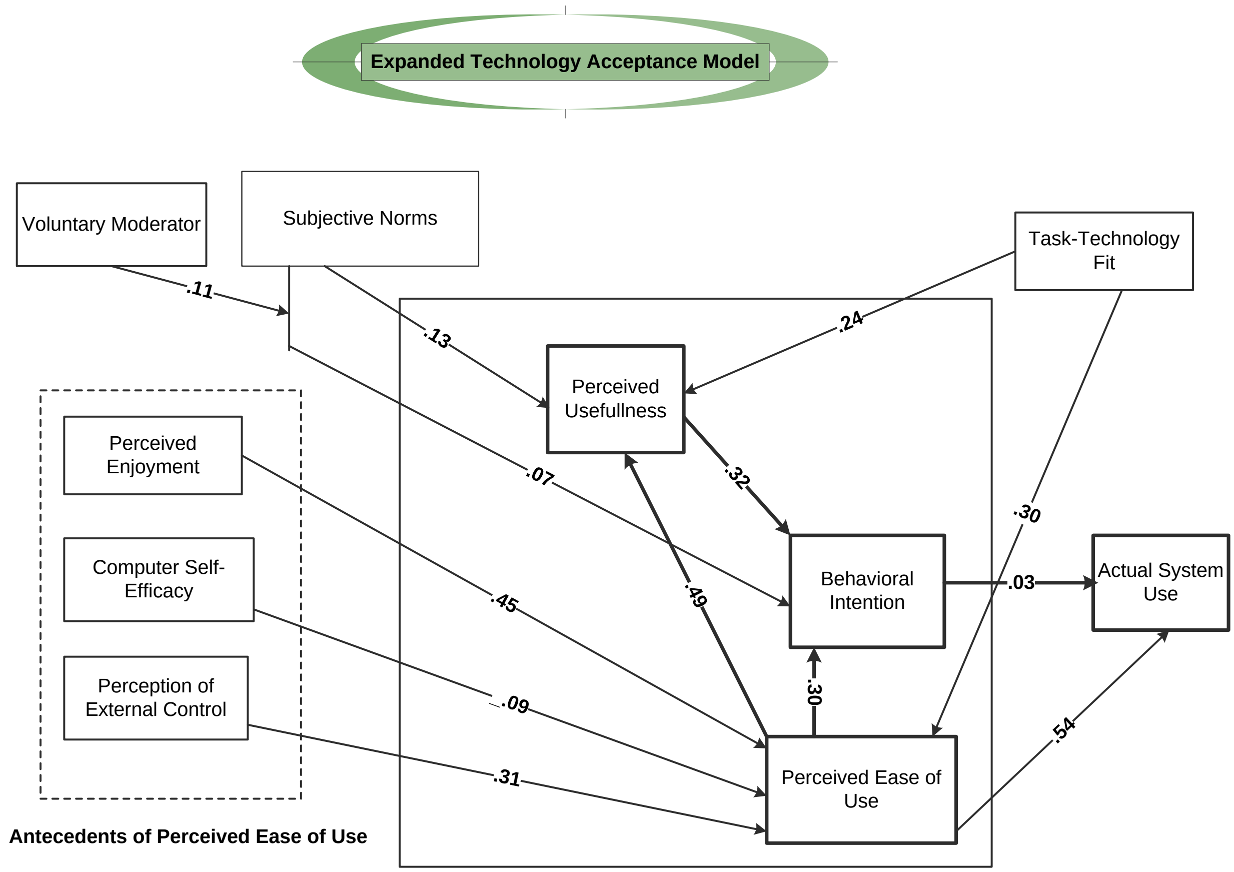

Figure 11: Path Diagram of the Expanded TAM on Time 1

Inspection of the squared multiple correlations suggested that 31% of the variance in Actual Utilization was explained by the model on Time 1 with Perceived Ease of Use being the highest contributor of this explanation. On Time 1, Enjoyment (.45), External Control (.31), and Task-Technology Fit (.30) significantly contributed to the variance in Perceived Ease of Use. Perceived Ease of Use (.49) was the most significant contributor to explaining the variance in Perceived Usefulness, followed by Task-Technology Fit (.24), and Subjective Norms (.13). Perceived Usefulness (.32) and Perceived Ease of Use (.30) contributed almost equally to intention. Voluntary Moderator contributed second most significantly to intention. Table 17 shows the equations with standard path coefficients for the expanded TAM model on the first measurement data.

Table 17: Path Equations on Time 1

1.	AU	=	.54PEU	+	.03AT						+	.43
2.	PUS	=	.49PEU	+	.24TTF	+	.13SN				+	.14
3.	AT	=	.32PUS	+	.30PEU	+	.11VM	+	.07 SN		+	.20
4.	PEU	=	.45ENJ	+	.31EC	+	.30TTF	-	.09CSE		+	.03

TTF: task-technology fit; NS: subjective norms; VM: voluntary moderator; PUS= perceived usefulness; ENJ; enjoyment; CSE; computer self-efficacy; EC: external control; PEU: perceived ease of use; AT: intentions toward using; AU: actual utilization

Examination of the squared multiple correlations (Table 18) indicates that 82% of variance in PEU, 54% of the variance in PUS, 41% of the variance in AT, and 31% of the variance in AU were explained by the model using Time 1 data.

Table 18: Squared Multiple Correlation on Time 1

Variables	PEU	PUS	AT	AU
R-squares	.82	.54	.41	.31

PEU: perceived ease of use; AT: intentions toward using; AU: actual utilization; PUS: perceived usefulness

The same model was then tested using Time 2 data. Inspection of the squared multiple correlations suggested that 34% of the variance in Actual Utilization was explained by the model on Time 2 with Intention being the highest contributor of this explanation. Figure 12 represents the expanded TAM model with path coefficients using Time 2 Data.

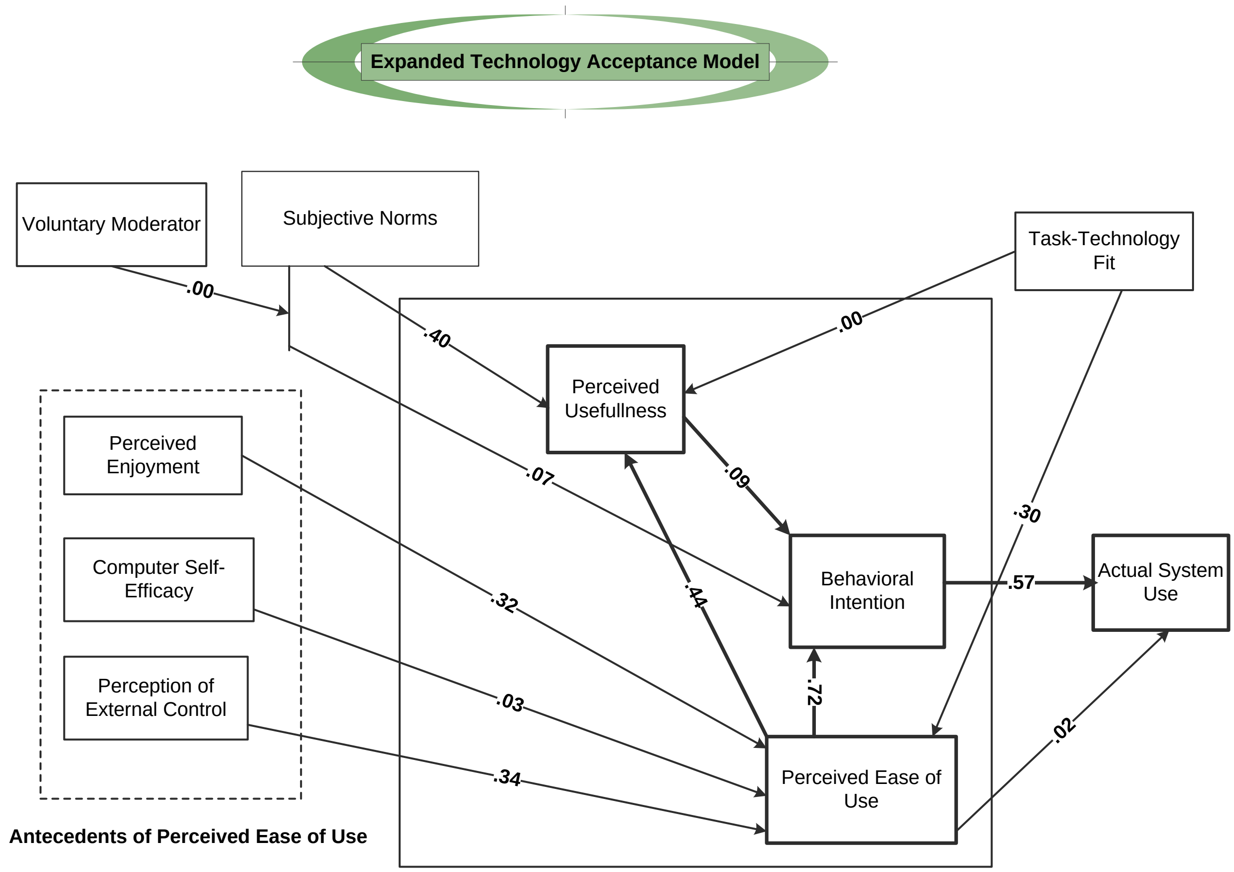

Figure 12: The Expanded Technology Acceptance Model on Time 2

On Time 2, Enjoyment (.34), External Control (.33), and Task-Technology Fit (.30) significantly contributed to the variance in Perceived Ease of Use. Perceived Ease of Use (.44) was the most significant contributor to explaining the variance in Perceived Usefulness, followed by Subjective Norms (.40). Perceived Ease of Use (.72) was the most significant contributor to Intention (AT), followed by Subjective Norms (.13), and Perceived Usefulness (.09). The path from Voluntary Moderator to intention was insignificant. Table 19 shows the equations with standard path coefficients for the expanded TAM model on the second measurement data.

Table 19: Path Equations on Time 2

1.	AU	=	.02PEU	+	.57AT						+	.41
2.	PUS	=	.44PEU	+	.004TTF	+	.40SN				+	.16
3.	AT	=	.09PUS	+	.72PEU	-	.02VM	+	.13 SN		+	.08
4.	PEU	=	.32ENJ	+	.34EC	+	.30TTF	+	.03CSE		+	.01

TTF: task-technology fit; NS: subjective norms; VM: voluntary moderator; PUS= perceived usefulness; ENJ; enjoyment; CSE; computer self-efficacy; EC: external control; PEU: perceived ease of use; AT: intentions toward using; AU: actual utilization

Examination of the squared multiple correlation (Table 20) indicates that 76% of variance in PEU, 54% of the variance in PUS, 73% of the variance in AT, and 34% of the variance in AU were explained by the model using Time 2 data.

Table 20: Squared Multiple Correlation on Time 2

Variables	PEU	PUS	AT	AU
R-squares	.76	.54	.73	.34

PEU: perceived ease of use; AT: intentions toward using; AU: actual utilization; PUS: perceived usefulness

Research Question 2

Research Question 2: What is the inter-relationship among perceived usefulness (PUS), perceived ease of use (PEU), and student's intention (AT) toward using VMWare as a network virtualization Technology?

Three core variables in the original TAM: perceived ease of use, perceived usefulness, and student intention toward using VMware, were examined in this section. As reflected in the results, relationships among those three variables on Time 1 were reported as follows using path analysis.

Perceived Ease of use → Perceived Usefulness, $\beta = .49$, $p = .01$

Perceived Usefulness → Student Intention toward VMWare, $\beta = .32$, $p = .02$

Perceived Ease of Use → Student Intention toward VMWare, $\beta = .30$, $p = .03$

Multiple regression analysis was conducted to predict Perceived Usefulness (PUS) from Perceived Ease of Use (PEU), Task-Technology Fit (TTF), and Subjective Norms (SN). Three predictors were entered simultaneously into the analysis: PEU, TTF, and SN. Standard multiple regression analysis revealed that the model statistically significantly predicted Perceived Usefulness of VMware as a network virtualization tool, $F_{3} = 26.41$, $p < .05$. The overall variance explained by the three predictors was 54%. Each predictor was positively related to the outcome variable; however, PEU ($\beta = .49$, $p < .005$), had the strongest load on PUS.

To understand how both Perceived Usefulness (PUS), and Perceived Ease of Use (PEU) affected student's Intention toward using VMware, the path coefficients were examined. Both PUS ($\beta = .32$, $p < .05$) and PEU ($\beta = .30$, $p < .05$), loaded heavily on AT. However, the total effect of one variable on another can be divided into direct effects with no intervening variables involved and indirect effects through one or more intervening variables. Accordingly, the total effect of PEU on AT is the sum of the direct effect (the path coefficient from PEU to AT) =.30 and the indirect effect, through PUS which is computed as the product of the path coefficient from PEU to PUS and the path coefficient from PUS to AT= (.49) (.32). The total effect is the sum of direct and indirect effects, .30 + .16 = .46.

Testing the model with Time 2 data, relationships among Perceived Ease of Use, Perceived Usefulness, and Intention were reported as follows using path analysis.

Perceived Ease of use → Perceived Usefulness, $\beta = .44$, $p = .01$

Perceived Usefulness → Student Intention toward VMware, $\beta = .09$, $p = .37$

Perceived Ease of Use → Student Intention toward VMware, $\beta = .72$, $p = .15$

Consistent with the results from Time 1, Perceived ease of use was the highest contributor to Perceived Usefulness. To understand how both Perceived Usefulness (PUS), and Perceived Ease of Use (PEU) affected student Intention toward using VMware, using Time 2 data, the path coefficients were examined. Consistent with Time 1, PEU ($\beta = .72$, $p < .05$), loaded heavily on AT in a direct path. PEU also loaded indirectly (.04) on AT through PU.

However, contrary to the results from Time 1 data, PUS ($\beta = .09$, $p > .05$) was not statistically significant in predicting he variance in AT. Even though students perception of the usefulness of VMware increased significantly from Time 1 to Time 2. It was no longer a predictor of their Intention about utilizing VMware in learning and practicing computer networking skills. Ease of Use; however, determined by External Control, Enjoyment, and Task-Technology fit was the highest predictor of student's intention towards utilizing VMware.

Research Question 3

Question 3: What is the role of subjective norms in the proposed model in explaining student's intention and usage of the technology?

Using Time 1 data, the path from Subjective Norms to Perceived Usefulness (β = .13, p > .05), was statistically insignificant. An even weaker path (β = .07, p > .05), was formed from Subjective Norms to Intention.

Subjective Norms → Perceived Usefulness, $\beta = .13$, p =.15

Subjective Norms → Intention, $\beta = .07$, p =.53

Testing the model with Time 2 data, the path from Subjective Norms to Perceived Usefulness (β = .40, p < .05), was statistically significant. The path formed from Subjective Norms to Intention. (β = .13, p > .05), was stronger than that measured in Time1; however, it was still statistically insignificant.

Subjective Norms → Perceived Usefulness, $\beta = .40$, p =.01

Subjective Norms → Intention, $\beta = .13$, p =.19

Subjective Norms had stronger load on Perceived Usefulness using Time 2 data. To test whether the instructor influenced students' sense of what the subjective norms were in class and how that might have shaped students' perception of the usefulness of VMware. Four data sets were created to separate participants based on the Instructor and point of measurement: Instructor 1- Time 1; Instructor 2 – Time 1; Instructor 1- Time 2; and Instructor 2 – Time 2. Path analysis was conducted for each set on both times and the results on Time 1were consistent with the findings from the comprehensive set: The paths from subjective norms to perceived usefulness and from subjective norms to intention were both insignificant. Using the two data sets from Time 2, the results indicated that for Instructor 1' participants, the path from subjective norms to perceived usefulness was significant and in that consistent with the results from the analysis of the comprehensive data set.

Subjective Norms → Perceived Usefulness, $\beta = .27$, p =.09

Subjective Norms → Intention, $\beta = .11$, p =.10

Analyzing the results from the Instructor 2- Time 2 data set, the results was inconsistent with that from analyzing the comprehensive data set: The path from subjective norms to perceived usefulness was insignificant. This might be attributed to the fact that after the first measurement, the two sections taught by the researcher continued to get the same exposure and motivation while the other two taught by Instructor 2, received a different message an developed a different sense of the social norms in the class room environment which is return affected their perception of the usefulness of VMware.

Subjective Norms → Perceived Usefulness, $\beta = .34$, p =.01

Subjective Norms → Intention, $\beta = .00$, p =.66

Research Question 4

Question 4: What are the effects of the constructs of the Task-Technology Fit variable on student's perception of usefulness?

To understand how the Task-Technology Fit construct (TTF) affected student perception of the usefulness of VMware as a network virtualization technology for the purpose of learning and practicing computer networking skills, the path coefficients were examined. TTF direct path (β = .24, p >.05) to PUS was not statistically significant. Accounting for the indirect effect of TTF on PUS through PEU (.15), the total effect of TTF on PUS (β = .39, p <.05) was more significant. Figure 13 shows both the direct and indirect paths to perceived usefulness.

Task-Technology Fit → Perceived Usefulness, $\beta = .24$, p = .07

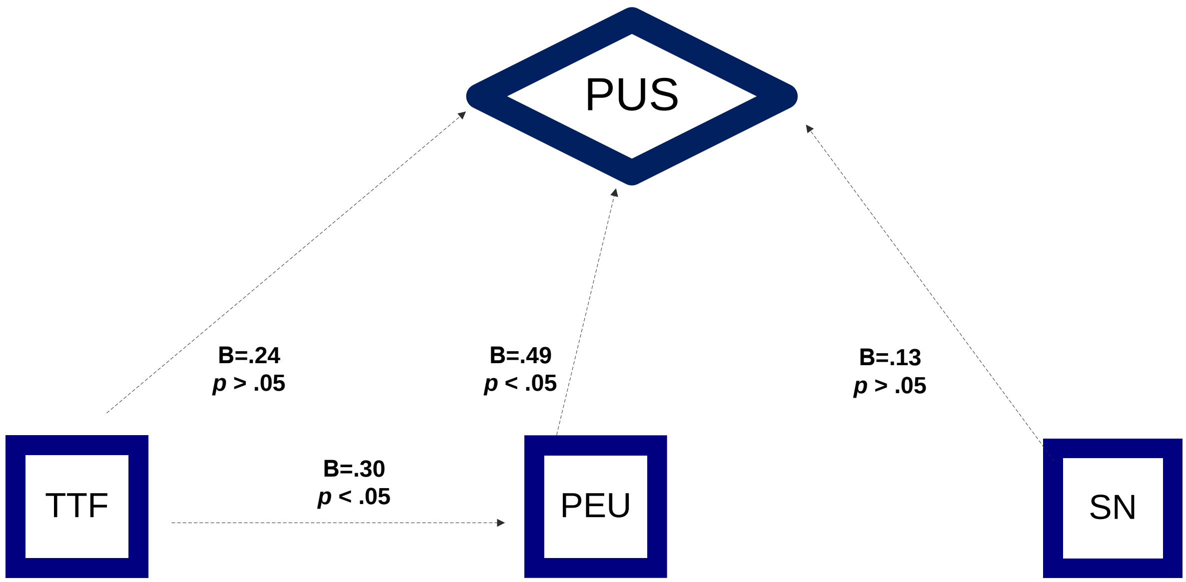

Figure 13: Paths to Perceived Usefulness Using Time 1 Data

Testing the model with Time 2 data, TTF direct path ($\beta = .002$, $p > .05$) to PUS was not statistically significant. Also, indirect effect of TTF on PUS through PEU (.13) was accounted for, increasing the total effect of TTF on PUS ($\beta = .13$). Even though student's perception of the Task-Technology fit increased from Time 1(Mean=912) to Time 2 (Mean=954), TTF had no direct impact on PUS. Consistent with Time 1 data, TTF continued to affect PUS, indirectly through PEU. Figure 14 shows both the direct and indirect paths to perceived usefulness using Time 2 data.

Task-Technology Fit → Perceived Usefulness, $\beta = .00$, $p = .97$

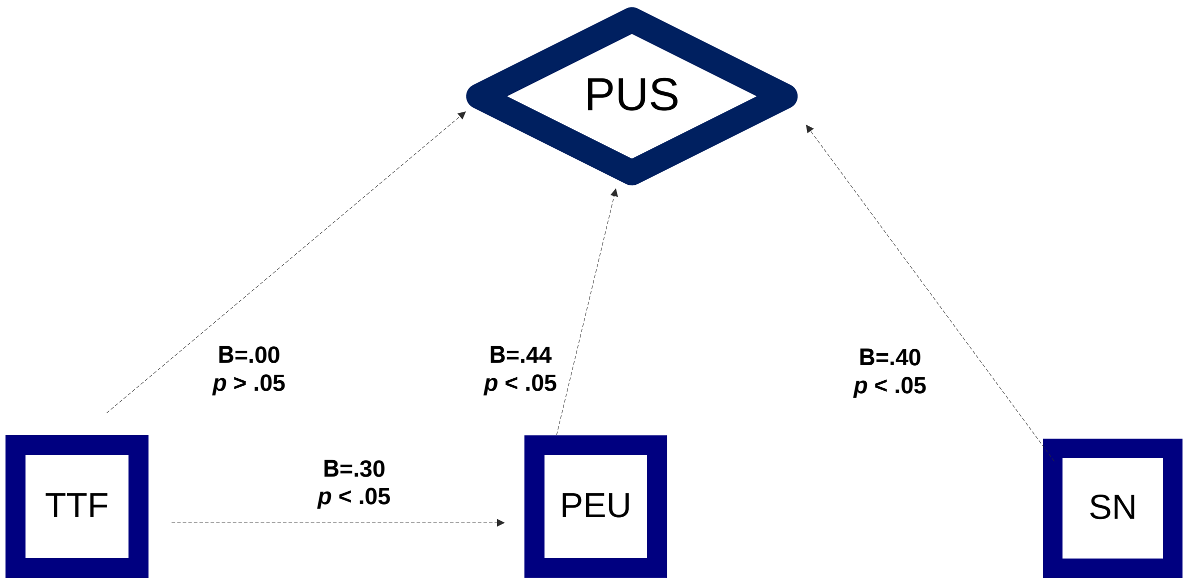

Figure 14: Baths to Perceived Usefulness Using Time 2 Data

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Research Question 5

Question 5: How do the antecedents of perceived ease of use (Enjoyment, External Control, and Computer Self-Efficacy) affect student's perceived ease of use of VMware?

Multiple regression analysis was conducted to predict Perceived Usefulness (PEU) from Perceived External Control (EC), Task-Technology Fit (TTF), Computer Self-Efficacy (CSE), and Enjoyment (ENJ). Four predictors were entered simultaneously into the analysis: TTF, EC, ENJ, and CSE. Standard multiple regression analysis revealed that the model statistically significantly predicted Perceived Ease of Use of VMware as a network virtualization tool (see Figure 15), $F_{4} = 76.57$, $p<.05$. The overall variance explained by the four predictors was 82%. Each predictor except for CSE was positively related to the outcome variable. Enjoyment ($\beta =$ .45, $p < .05$), had the strongest load on perceived ease of use (PEU). The reported path coefficients using Time 1 data were:

Perceived Ease of Use ← Task-Technology Fit, $\beta = .30$, $p = .01$

Perceived Ease of Use ← Enjoyment, $\beta = .45$, $p = .01$

Perceived Ease of Use ← External Control, $\beta = .31$, $p = .01$

Perceived Ease of Use ← Computer Self-Efficacy, $\beta = -.09$, $p = .09$

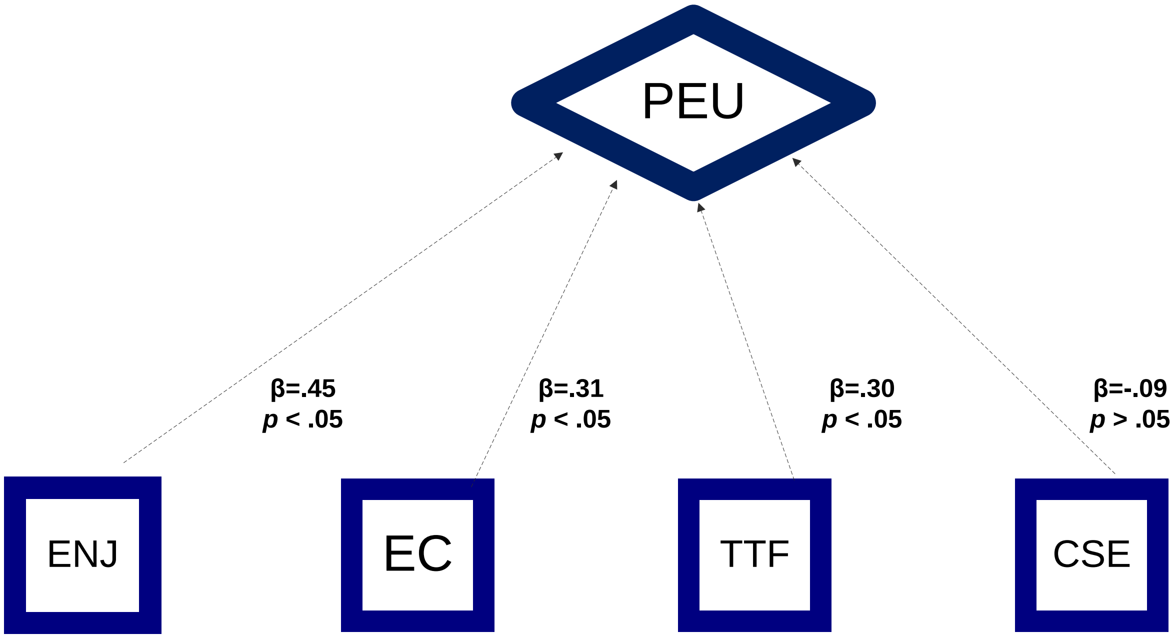

Figure 15: Path Coefficients of the Determinants of Perceived Ease of Use on Time 1

Testing the model with Time 2 data, multiple regression analysis was conducted to predict Perceived Usefulness (PEU) from Perceived External Control (EC), Task-Technology Fit (TTF), Computer Self-Efficacy (CSE), and Enjoyment (ENJ). Four predictors were entered simultaneously into the analysis: TTF, EC, ENJ, and CSE. Standard multiple regression analysis revealed that the model statistically significantly predicted Perceived Ease of Use of VMware as a network virtualization tool (see Figure 16), $F_{4\,=}$ 43.57, p<.05. The overall variance explained by the four predictors was 76%. Each predictor was positively related to the outcome variable. External control (β = .49, p < .005), had the strongest load on PUS. The reported path coefficients using Time 2 data were:

Perceived Ease of Use ← Task-Technology Fit, $\beta = .30$, p =.01

Perceived Ease of Use ← Enjoyment, $\beta = .32$, p =.01

Perceived Ease of Use ← External Control, $\beta = .34$, p =.01

Perceived Ease of Use ← Computer Self-Efficacy, $\beta = .03$, p =.91

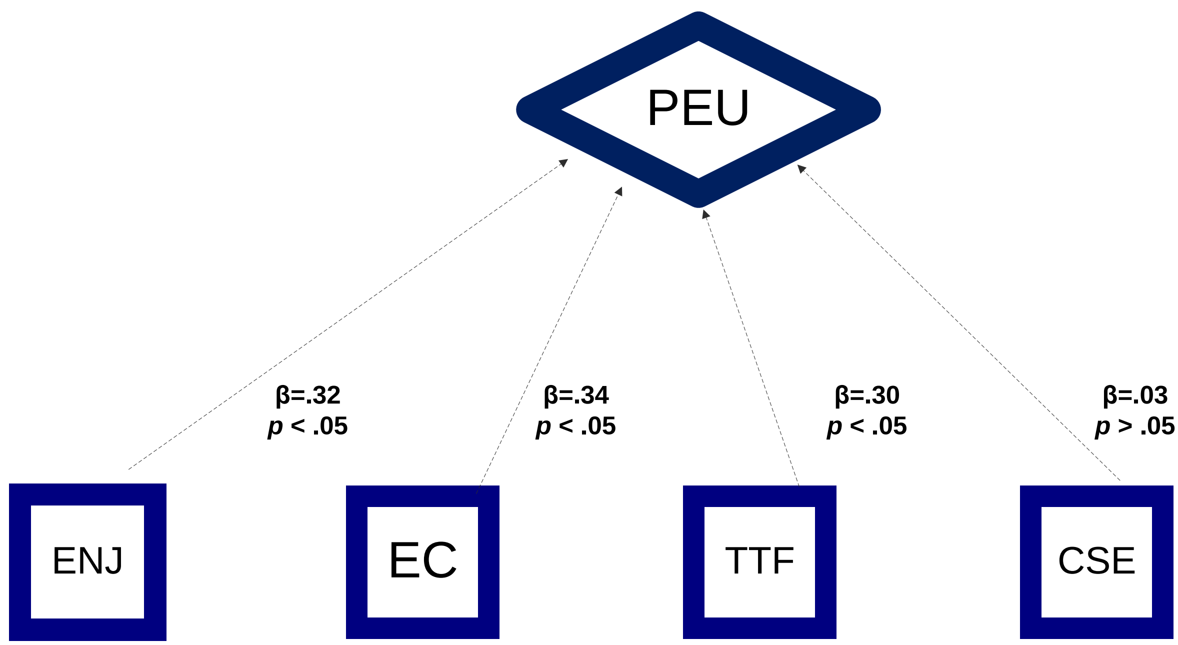

Figure 16: Path Coefficients of the Determinants of Perceived Ease of Use on Time 2

Research Question 6

Question 6: Does voluntariness moderate the affect of subjective norms on intention?

Voluntariness did not moderate the effect of subjective norms on intention toward using VMware. Subjective norms had a positive direct effect on intention regardless of whether VMware use was perceived to be mandatory or voluntary. This finding might indicate that teacher's attitude toward the technology, and their ability to provide support and opportunities to use has stronger impact on student's intention compared to merely mandating students to use the technology under examination. The direct relationship between subjective norms and intention was sufficient on its own to trigger compliance. The reported path coefficient for both Time 1, and Time 2 respectively were:

Voluntary Moderator → Intention, $\beta = .11$, p=.32

Voluntary Moderator → Intention, $\beta = .00$ p=.87

Research Question 7

Question 7: What are other variables (prior experience, age, major.) can contribute to the model?

Demographic differences in age, academic major, employment status, academic enrollment, VMware experience, and Computer Networking experience were examined to determine their effect on actual utilization of VMware as a network virtualization technology tool for the purpose of studying and learning computer networking skills. Additionally, in this section the instructor's influence on intension and actual utilization was specifically examined.

Using ANOVA procedure with SPSS 16.0 for Windows, tests of between-subjects effects was examined to determine if the difference in the means of actual utilization of VMware between Computer Engineering Technology (CET) students, Electronics Engineering Technology (EET) students, Computer Information Systems (CIS) students, Professional Development (PD) students, and other majors (Other) students was statistically significantly different. Using Time 1 data, the resulting statistical tests failed to reject the null hypothesis ($F_{4,55} = .75$, $p > .05$), concluding that the difference in actual utilization between the academic major groups (CET, EET, CIS, PD, and Other) was not statistically significant. The same statistical tests using Time 2 data ($F_{4,55} = 1.89$, $p > .05$), confirmed the same results. Furthermore the same test was performed to examine the impact of academic major on intension and was found to be statistically insignificant both on Time 1 ($F_{4,55} = 1.02$, $p > .05$), and on Time 2.

Tests of between-subjects effects was examined to determine if the difference in the means of actual utilization of VMware between age groups (18-20; 20-25; 25-30; 30-35; 35-40;

and over 40) was statistically different. Using Time 1 data, the resulting statistical tests failed to reject the null hypothesis ($F_{5,55}$ = .68, p> .05), concluding that the difference in actual utilization between the age groups was not statistically significant. The statistical tests using Time 2 data ($F_{5,55}$ = .59, p> .05), confirmed the same results. Furthermore the same test was performed to examine the impact of academic major on Intention and was found to be statistically insignificant both on Time 1($F_{5,55}$ = 1.95, p> .05), and on Time 2.

Tests of between-subjects effects was examined to determine if the difference in the means of actual utilization of VMware between employments groups (Full-time, Part-time, and Unemployed) was statistically different. Using Time 1 data, the resulting statistical tests couldn't reject the null hypothesis ($F_{3,55}$ = 1.07, p> .05), concluding that the difference in actual utilization between the employment groups was not statistically significant. The statistical tests using Time 2 data ($F_{3,55}$ = .87, p> .05), confirmed the same results. Furthermore the same test was performed to examine the impact of employment status on intention and was found to be statistically insignificant both on times.

Tests of between-subjects effects were examined to determine if the difference in the means of actual utilization of VMware between enrollment groups (Full-time, degree seeking; Part-time, degree seeking; Full-time, non-degree-seeking; Part-time, non-degree-seeking) was statistically different. Using Time 1 data, the resulting statistical tests failed to reject the null hypothesis ($F_{3,55}$ = 1.81, p> .05) concluding that the difference in actual utilization between the academic enrollment groups was not statistically significant. The statistical tests using Time 2 data ($F_{3,55}$ = .87, p> .05), confirmed the same results. Likewise, the same test was performed to examine the impact of academic enrollment status on intention and was found to be statistically insignificant on both times.

Tests of between-subjects effects was examined to determine if the difference in the means of actual utilization of VMware between the VMware experience groups (Not familiar with VMware at all; Familiar with VMware but never use it; Used VMware before to some extent; and Used VMware before to a great extent) was statistically different. Using Time 1 data ($F_{3,55}$ = 1.07, p> .05) the resulting statistical tests couldn't reject the null hypothesis and concluded that the difference in actual utilization between the VMware experience groups was not statistically significant. The statistical tests using Time 2 data ($F_{3,55}$ = 1.45, p> .05) confirmed the same results. Likewise, the same test was performed to examine the impact of academic enrollment status on intention and was found to be statistically insignificant on both times.

Tests of between-subjects effects was examined to determine if the difference in the means of actual utilization of VMware between the Computer Networking experience groups (No computer networking experience at all; Some computer networking experience; Long computer networking experience) was statistically different. Using Time 1 data, the resulting statistical tests ($F_{2,55}$ = 3.57, p< .05) rejected the null hypothesis concluding that the difference in actual utilization between the computer-networking experience groups was statistically significant. The statistical tests using Time 2 data ($F_{2,55}$ = 2.38, p>.05) did not confirm the same results. Likewise, the same test was performed to examine the impact of academic enrollment status on Intention and was found to be statistically insignificant on both times.

Additionally the effect of the instructor on students' believes and behaviors was investigated. Using Time 1 data, the instructor's effect on actual utilization was not significant ($F_{1,55} = 3.81$, $p > .05$); only 5% of the variance in actual utilization was explained by the instructor. Instructor's effect on intention was not significant ($F_{1,55} = 4.05$, $p > .05$); only 6% of the variance in intention was explained by the instructor. Likewise, the instructor's effect on subjective norms was not significant ($F_{1,55} = 3.61$, $p > .05$); only 5% of the variance in subjective norms was explained by the instructor. The analyses suggest that the instructor's effect was not statistically significant using time 1 data.

On Time 2; however, instructor's effect was significant on actual utilization ($F_{1,55} = 10.64$, $p < .05$); 15% of the variance in actual utilization was explained by the instructor. Instructor's effect was also significant on intention ($F_{1,55} = 4.05$, $p < .05$); 7% of the variance in intention was explained by the instructor. Likewise, instructor's effect was significant on subjective norms ($F_{1,55} = 12.59$, $p < .05$); 18% of the variance in subjective norms was explained by the instructor The analyses suggest that the effect of the instructor on subjective norms, intension, and on actual utilization was statistically significant using time 2 data.

Summary

The results of the path analysis are summarized in Table 21 for Time 1 data and in Table 22 for Time 2 data, depicting each path between two variables in the model along with their statistical significance.

Table 21: Path Significance for the Expanded TAM Using Time 1 Data

Paths		β	*t*	*p*
Enjoyment to Perceived Ease of Use	ENJ → PEU	.45	6.37	.01
External Control to Perceived Ease of Use	EC → PEU	.31	4.22	.01
Computer Self-Efficacy to Perceived Ease of Use	CSE → PEU	.00	-1.74	.09
Task-Technology Fit to Perceived Ease of Use	TTF → PEU	.30	4.0	.01
Perceived Ease of Use to Perceived Usefulness	PEU → PUS	.49	3.85	.01
Subjective Norms to Perceived Usefulness	SN → PUS	.13	1.46	.15
Task-Technology Fit to Perceived Usefulness	TTF → PUS	.24	1.85	.07
Perceived Usefulness to Intention	PUS → AT	.32	2.31	.02
Perceived Ease of Use to Intention	PEU → AT	.30	2.20	.03
Subjective Norms to Intention	SN → AT	.07	.64	.53
Voluntary Moderator to Intention	VM → AT	.11	1.01	.32
Intention to Actual Utilization	AT → AU	.03	.21	.83
Perceived Ease of Use to Actual Utilization	PEU → AU	.54	4.37	.01

PEU: perceived ease of use; ENJ: perceived enjoyment; EC: external control; TTF: task-technology fit; CSE: computer self-efficacy; PUS: perceived usefulness; SN: subjective norms; AT: intention toward utilization; VM: voluntary moderator; AU: actual utilization.

Table 22: Path Significance for the Expanded TAM Using Time 2 Data

Paths		β	*t*	*p*
Enjoyment to Perceived Ease of Use	ENJ → PEU	.32	3.16	.01
External Control to Perceived Ease of Use	EC → PEU	.34	2.82	.01
Computer Self-Efficacy to Perceived Ease of Use	CSE → PEU	.03	.66	.91
Task-Technology Fit to Perceived Ease of Use	TTF → PEU	.30	3.59	.01
Perceived Ease of Use to Perceived Usefulness	PEU → PUS	.44	3.18	.01
Subjective Norms to Perceived Usefulness	SN → PUS	.40	3.56	.01
Task-Technology Fit to Perceived Usefulness	TTF → PUS	.00	.03	.97
Perceived Usefulness to Intention	PUS → AT	.09	.90	.45
Perceived Ease of Use to Intention	PEU → AT	.72	6.88	.01
Subjective Norms to Intention	SN → AT	.13	1.32	.26
Voluntary Moderator to Intention	VM → AT	.00	-.17	.87
Intension to Actual Utilization	AT → AU	.57	2.86	.01
Perceived Ease of Use to Actual Utilization	PEU → AU	.00	.114	.91

PEU: perceived ease of use; ENJ: perceived enjoyment; EC: external control; TTF: task-technology fit; CSE: computer self-efficacy; PUS: perceived usefulness; SN: subjective norms; AT: intention toward utilization; VM: voluntary moderator; AU: actual utilization.

CHAPTER 5: CONCLUSIONS AND RECOMENDATIONS

Purpose of the Study

The purpose of this causal study was to test the Technology Acceptance Model (TAM) with two different data sets obtained over two measurement points as reported by Engineering and Technology students with respect to their perceptions, beliefs, intentions ,and behaviors toward VMware as a network virtualization technology. Specifically, the researcher studied how intention predicted or caused actual behavior, and how intention was a function of two main components: perceived ease of use and perceived usefulness. Furthermore the study analyzed how perceived external control, perceived enjoyment, and computer self-efficacy caused the formation of student perception of ease of use; and how task-technology fit constructs caused the formation of perceived usefulness of VMware. The original TAM Model was expanded with antecedents to ease of use: Enjoyment (ENJ), External Control (EC), and Computer Self-Efficacy (CSE). The Task-Technology Fit (TTF) construct was also added to examine its effect on the Perceived Usefulness (PUS) of the technology. To incorporate social influences, the researcher expanded the model with Subjective Norms (SN), and Voluntariness (VOL).

Sample and Data Collection

Students enrolled in one introductory level course (CET 2486C Local Area Networks) in the Engineering and Technology division at Valencia Community College (VCC) were purposefully targeted. Four sections were offered during the fall term of 2009. Out of 79 students enrolled in all sections, 71 students chose to participate in the first data collection which was conducted on the fourth week of the term. The second data collection took place during the 15^{th} week of the term. Out of the 69 enrolled then (ten students had dropped out), 61chose to participate, yielding a response rate of 88%. There were total of 56 valid participants who completed the survey on both times. Two of the four sections were taught by the researcher (Instructor 1), and the other two were taught by another instructor (Instructor 2) who was also interested in using the technology under examination. For each instructor, student use of VMware as a network virtualization technology was made voluntary in one section and mandatory in the other. Respondents were separated into mandatory and voluntary usage contexts to test the mediating effect of voluntariness on subjective norms. All four sections were offered in a face-to-face environment. The same WebCT course shell was used to facilitate the delivery of course material.

Survey Instruments

Eleven instruments were used in this study (see Table 23) to measure a total of ten variables. This study was conducted on the scale level: each of the ten variables in the model was examined by computing the sum of the scores of the corresponding items. Task-Technology Fit (TTF) was measured as the interaction term between Tool Functionality (TF), and Task Characteristics (TC). Voluntary Moderator (VM) was calculated as the product of Voluntariness (VOL) and Subjective Norms (SN).

Table 23: Survey Instruments

Instrument	Number of Items
Tool Functions	5
Task Characteristics	10
Perceived Usefulness	4
Subjective Norms	5
Voluntariness	3
Perceived Enjoyment	3
Computer Self-Efficacy	10
Perception of External Control	6
Perceived Ease of Use	5
Intention to Use	2
Actual Utilization	5
Demographics	6
Total	64

Design of the Study

Path analysis was used to study the correlations between the model variables. Both confirmatory and explanatory path analysis were performed to ensure that all direct and indirect paths contributing to explaining the variance in student actual utilization of VMware as the final outcome variable were accounted for. Two instructors participated in this research study (the researcher was one of them). To ensure fidelity of implementation and to increase inter-instructor reliability, the same WebCT course shell was used in all four sections where all assignments, case studies, and lecture notes were hosted. This was done to ensure consistency in instruction and in availability of resources. The Two participating instructors met biweekly face-to-face to ensure consistency in instructional activities and to discuss implementation problems as reported by students and how support could be provided to students during their implementation of the technology on their home system. Each section met once a week for three and half hours (four credit-hours) course. Each instructor supported all four sections during their office hours. Instructor 1's office hours were utilized by his and instructor 2's students and the same was true for instructor 2's office hours. Additional each instructor implemented the technology in both voluntary and mandatory contexts.

Participation in this study was done by completing the online questionnaire. Teaching and learning VMware along with the four homework assignment were part of the normal course activities. Each of the four assignments covered certain hands-on objectives with respect to network configurations and troubleshooting. To learn the objectives, master the skills and ultimately complete the assignments a student could equally use either the physical equipment on-campus or VMware off-campus. The assignments were purposefully designed as such to practically demonstrate to the students how VMware is used in production environments

In this research project, the causality issue in the belief-intention-behavior relationship as reported by participating students was investigated. Casual pathways among students' perception of Task-Technology Fit, perceived enjoyment, perceived external control, computer self-efficacy, perceived ease of use, perceived usefulness, subjective norms, voluntariness, intentions, and actual utilization with regard of VMware were investigated and measured. For example, the researcher studied how intention predicted or caused actual behavior, and how intention was a function of two main components: perceived ease of use and perceived usefulness. Furthermore the study analyzed how perceived external control, perceived enjoyment, and computer self-efficacy caused the formation of student perception of ease of use; and how task-technology fit constructs caused the formation of perceived usefulness of VMware. The model was tested twice using two different data sets from two different measurement points.

Research Questions

Based on the target population, the research participants, and the surrounding circumstances, the following seven research questions were answered:

1. How does the proposed expanded technology acceptance model explain the variance in student's actual use of VMware?
2. What is the inter-relationship among perceived usefulness, perceived ease of use, and student intention toward using VMware?

3. What is the role of subjective norms in the proposed model in explaining student intention and behavior toward VMware?
4. What are the effects of the constructs of the Task-Technology Fit variable (task characteristics and tool functionality on student's perception of VMware usefulness?
5. How do the antecedents of perceived ease of use (Enjoyment, External Control, and Computer Self-Efficacy) affect student perceived ease of use of VMware?
6. Does voluntariness moderate the effect of subjective norms on student intention and behavior?
7. What are other variables (age, specialization, experience,) that can contribute to the proposed model in increasing its power of explaining the variance in student's actual utilization of VMware?

Conclusions

This section summarizes the findings of this research study and presents them by research question.

Research Question 1

Research Question 1: How does the proposed expanded Technology Acceptance Model (TAM) explain the variance in student's actual use of VMware as a network virtualization technology?

The proposed expanded Technology Acceptance Model (TAM) was able to explain 31% of the variance in Actual Utilization (AU) as the final outcome variable, using Time 1 data. Further analysis revealed that Perceived Ease of Use (PEU) as an exogenous variable, strongly determined AU using Time 1 data. Using Time 2 data, the model explained 34% of the variance in AU as the final outcome variable with intention toward utilization (AT) being the strongest determinant of AU. The overall explanatory power of the model is consistent with the results from previous studies where TAM explained on average 35% of the variance in the outcome variable (Taylor & Todd, 1995; Venkatesh, 2000).

In the initial stage of introducing VMware, students perception of how easy the technology was to use was the strongest determinate of their actual utilization of the technology. As time progressed perceived ease of use no longer directly determined actual utilization. Instead, perceived ease of use indirectly determined 16% of actual utilization through intention. Other exogenous variables such as student perceived usefulness of the technology and social influences (subjective norms) indirectly determined Actual utilization through intention. The results are consistent with previous studies. Ajzen (1991) explained how those users who intended to use a new technology or a system were more likely to actually use it. However the same study also reported that it takes a longer time for intention to form and to become concrete compared to other perceptions such as perception of ease of use. The findings from our research is consistent with Venkatesh (2000) in reporting that initially, perceived ease of use was a very strong determinant of intention and that intention in return caused actual utilization. For our participants, before intention was fully formed, perceived ease of use alone determent actual utilization however, allowing time for intention to form, it became the strongest determinant of actual utilization.

Research Question 2

Research Question 2: What is the inter-relationship among perceived usefulness (PUS), perceived ease of use (PEU), and student intention (AT) toward using VMware as a network virtualization Technology?

Using Time 1 data, perceived ease of use was a statistically significant predictor of perceived usefulness. Student intention toward VMware as a network virtualization technology was significantly affected by perceived ease of use and perceived usefulness. Together, perceived ease of use along with perceived usefulness accounted for 62% of the variance in student intention toward the target technology, and individually, each was a significant predictor of student's intention. The findings from this research are consistent with previous studies (Venkatesh & Davis, 1996, 2000) in concluding that perceived ease of use is a strong determinant of intention and in that both perceived ease of use and perceived usefulness together play the most significant role in how intention forms.

The results, using Time 2 data confirmed the same findings. The regression weight of perceived ease of use on perceived usefulness was almost the same as in Time 1. Also, perceived ease of use along with perceived usefulness accounted for 81% of the variance in student intention toward the target technology. However, the path from perceived usefulness to intention was not significant using Time 2 data. Even though this contradicts the findings from previous studies (Klopping & McKinney, 2004; Taylor & Todd, 1995), this could be explained by the fact, that even though students perception of the usefulness of VMware continued to increase from Time 1 to Time 2 as the result of their direct interaction with the technology through course work, and homework assignments, other factors; however, such as the availability of resources, support, and social influences were stronger predictors of student intention.

Research Question 3

Question 3: What is the role of subjective norms in the proposed model in explaining student intention and usage of the technology?

Even though subjective norms did not statistically predict intention or perceived usefulness, it had a positive impact on both using Time 1 data. The researcher was also interested in analyzing the participants' responses by the instructor. Statistical tests indicated that the difference in the mean scores of subjective norms by the instructor was not statistically significant using Time 1 data. The findings from this research contradicts previous studies (C. Pan et al., 2005)This might be explained by the fact that the researcher provided the initial training and support in all four sections during the first phase of implementing the technology and up to the first point of measurement. The researcher motivated all participants equally to use the technology and used various case studies and examples to emphasis the importance of the technology and how it might be utilized for the purpose of learning computer networking skills.

Using Time 2 data, subjective norms as an exogenous variable was found to be a statistically significant predictor of perceived usefulness, and had a positive impact on student intention. This might be explained by the fact that as time progressed, classroom assignments designed purposefully for the student to utilize VMware became more involved and more complex, increasing students' needs for support. Students who were compliant with the social norm were probably more engaged in completing the classroom assignments and in turn were able to realize the usefulness of the technology as a result of their direct interaction with it. Also worthy of mentioning, that the statistical tests, using Time 2 data indicated that the difference in the mean scores of subjective norms by the instructor was statistically significant. Participants from both sections (mandatory, and voluntary) taught by the researcher complied more with the social norms. This compliance might have resulted from motivation. During the second phase of implementation, each instructor, (Instructor 1, and Instructor 2) motivated their students and supported them differently. The level of support and the extent of motivation might have indirectly influenced student perception of what the social norms were in the classroom environment.

Research Question 4

Question 4: What are the effects of the constructs of the Task-Technology Fit variable on student perception of usefulness?

Task-Technology fit was measured as the interaction between student perception of the capabilities and functions of the technology and student perception of the computer networking tasks they were asked to complete as described in classroom and homework assignments. Task-Technology Fit (TTF) was not a significant predictor of student's perception of usefulness, using Time1 data. The results suggest that regardless of how well students perceived VMware to be a suitable or a fit tool in accomplishing specific computer networking tasks as prescribed in various assignments, that perception of fit was not a significant predictor of the usefulness of the technology as reported by the student.

Task-technology fit influence on perceived usefulness weakened over time and was also insignificant using Time 2 data. The findings from this research are consistent with previous studies. Dishaw (1999), when studying software engineers acceptance of programming debugging tools reported that the task-technology fit constructs (tool functionality and task characteristics) didn't cause in difference in users' perceived usefulness of the system. The overall explanatory power of the model; however, increased because of adding the task-technology fit. The findings from this research; however, contradicted what Tulu et al. (2005) reported on how degree of fit between the technology and task was able to successfully predict how physicians' perception of usefulness formed

However TTF was found to be highly correlated with perceived usefulness. This finding might be explained by the fact that as time progressed, and more complex homework assignments were introduced, the perception of fit became unclear to students. Also, unique to this study, task-technology fit highly correlated with subjective norms, suggesting that students with high subjective norms maybe used the technology more compared to those with reported low subjective norms. This explanation is further supported by the high correlation between task-technology fit and actual utilization of VMware using Time 2 data. Also worthy of mentioning, it was found that task complexity was negatively related to the task-technology fit construct. This finding might suggest that at the introductory level of implementing a technology in academic settings, the focus should be on clearly articulating a limited number of less complex and more articulated tasks (Dishaw & Strong, 1999). Task-technology fit was a valuable addition to the model as it was a statistically significant predictor of perceived ease of use for both measurement points. Students who perceived VMware to be fit for the task, perceived the technology to be easy to use.

Research Question 5

Question 5: How do the antecedents of perceived ease of use (Enjoyment, External Control, and Computer Self-Efficacy) affect student perceived ease of use of VMware?

Both enjoyment and external control significantly predicted perceived ease of use using both Time1 and Time 2 data. Analysis also indicated a very strong correlation between enjoyment and external control, with external control as the strongest predictor of perceived usefulness. One possible explanation of this finding is that student who had all the external resources (knowledge, hardware & software resources, and support) to use the technology thought that the technology was both enjoyable and easy to use. The results are consistent with previous studies (Chen, Yang, Tang, Huang, & Yu, 2008) further validating that users' perceived enjoyment of the technology caused a significant difference in their perception of the ease of use of the technology. Also, previous studies (I. Ajzen, 1991; Venkatesh, 2000) confirmed that the greater the perceived behavioral control, the more likely an individual will perform the behavior under consideration.

Computer self-efficacy; however, did not influence ease of use. That might be explained by the fact that the research participants in this study due to their declared major as technology and engineering students, in general, had relatively high self-confidence regarding using a computer to perform a specific task. This finding further emphasizes what was recommended from previous studies (Liu, 2010) with regard to using technology or system specific self-efficacy as a more significant predictor of ease of use compared to general computer self-efficacy.

Also worthy of mentioning, external control as the most influential factor on students perception of ease of use was also found to be very highly correlated with intention and actual utilization using Time 2 data. This finding suggests that students who had the resources and support to use VMware intended to use it more and actually did. Students reported lower external control from Time 1 to Time 2 indicating that the resources and training were not sufficient as time progressed. External control highly correlated with all variables in the model except for with computer self-efficacy.

It is also important to mention here that from the external control instrument, the " I have the resources needed to use VMware off-campus" item received on average a low rating , reflecting the problems students encountered during implementing the technology on their home system. Problems with implementing VMware on students' home systems were two folds. First software problems included operating systems compatibility issues and interoperability with other applications already installed on the user's system. For example, the installation of VMware on Windows XP was slightly different from that on Windows 7. After a successful install, in some instances, the firewall installed on a user's system denied VMware access to system resources. The instructors had to provide customized instructions to deal with the implementation in this highly heterogeneous environment.

The second and more complex obstacle was insufficient hardware resources on some of the students' home systems. To maximize the benefit of VMware, a Personal Computer (PC) needs to be equipped with a certain amount of Random Access Memory (RAM) Also the processor has to support virtualization technology. While some students were able to complete the necessary hardware upgrades, others couldn't. A blog was created to provide technical support in questions-answers format for students in all four sections

Research Question 6

Question 6: Does voluntariness mediate the effect of subjective norms on intention?

Voluntary moderator as an exogenous variable on intention didn't contribute to the variance in intention using both Time 1 and Time 2 data. Respondents were separated into mandatory and voluntary usage contexts in this study to examine whether voluntariness mediated the impact of subjective norms on intention. Analysis revealed that the effect of subjective norms on intention was not mediated by voluntariness. This finding contradicts what was reported by Venkatesh and Davis (2000) in their four longitudinal field studies reported that employees were more likely to recognize and adhere to the subjective norms as projected by their employers more in mandatory settings than so in voluntary settings. This might be explained by the fact that while in a workplace setting compulsory usage with enforced retribution for non-compliance might mediate subjective norms in influencing intentions, in academic settings; however, and especially as it pertains to our participants, student's decision to comply with subjective norms was not influenced by whether the use of VMware as the target technology was compulsory or voluntary. Also, even though in another study in academic settings (Singletary, Akbulut, & Houston, 2002) it was reported that students adhered to subjective norms and used an e-learning system in mandatory contexts only and not in voluntary contexts, the study never explained what the retributions were for non-behavior.

Unique to this study, the reason that voluntariness did not mediate subjective norms might have been that the retribution for non-compliance was not strong enough. There were total of four homework assignments with a total weight of 20% of student's overall grade. This percentage might not have been significant enough for those with low subjective norms scale to encourage and trigger utilization. For the participants in this research study, the support, attitudes, and motivations projected by the instructor about the importance and usefulness of the technology, interacting with student's personality and tendencies for complying with subjective norms influenced student's intention equally toward using VMware in both mandatory and voluntary settings.

Research Question 7

Question 7: What are other variables (prior experience, employment, academic enrollment, age, major..) can contribute to the model?

Six demographic variables: age, employment status, academic enrollment status, major, prior VMware experience, and prior computer networking experience) were examined for their influence on student intention and actual utilization of the target technology. Using Time 1 data, within the six variables considered, only prior computer networking experience statistically significantly influenced both intention and actual utilization. Students who reported a moderate to strong computer networking experience had more positive intention toward VMware and actually utilized VMware more compared to those with no prior computer networking experience. Using Time 2 data, none of the six demographic variables: age, employment status, academic enrollment status, major, prior VMware experience, and prior computer networking experience) was statistically significant in influencing student decision to adopt and use VMware as a network virtualization technology tool.

One more additional analysis was performed to test the instructor's effect on the model. Two instructors were involved in this research study: instructor 1(the researcher) and instructor 2. Using Time 1 data, analysis revealed that the instructor did not contribute to the variance in student intention and actual utilization of VMware. This might be explained by the fact that instructor 1 equally motivated, and trained all students from the beginning of the term and up to the first point of measurement (end of the fourth week of the term). From the fifth week and after, each instructor was responsible for supporting, and motivating their own students.

Using Time 2 data; however, the instructor statistically significantly contributed to student's subjective norms, student's intention toward the technology, and student's actual utilization of VMware. This finding is not surprising as instructor 1 (the researcher) was generally more motivated about and committed to facilitating the conditions necessary to help student adopt and use VMware. It is also possible that instructor 1 was more familiar with the technology and provided more adequate support to his students. Students enrolled in the two sections taught by instructor 1 reported high scores in question such as " the instructor's use of VMware in class inspired me to use VMware", and "I have the knowledge necessary to use VMware"

The findings from this research further emphasizes what was reported from previous studies (Grandon, Alshare, & Kwun, 2005) about the role of the instructor in influencing students' decision for adoption. Grandon, et al. reported that instructors who succeeded in making the technology convenient for their students to use it were actually more successful in getting their students to utilize the technology. In this study, the primary reason for considering the VMware technology by the faculty and the institution was to provide an alternative, convenient, off-campus arrangement for students to practice practical computer networking skills. Even though VMware was available for students to use on-campus, it was not convenient for them to use on-campus. Every student in this study wanted the convenience of practicing at home by implementing VMware in his/her home system. Both instructors in this study supported students in implementing the technology at home by answering implementation-related questions and providing guidance. Instructor 1; however, provided more support (for example, Instructor 1 helped his students with memory installation to overcome hardware related problems), enabling more of his students to successfully implement the technology on their home systems and in turn making it convenient for his students to use the technology. This in turn, as a result of their direct interaction with the technology, might have allowed instructor 1's students to use VMware more and to realize its usefulness in learning computer networking.

The pedagogical implications of this finding reveals that while it is important to help students see how easy the technology is through, for example, training; and while it is also important to help them see how useful the technology is by providing experiences (such as homework assignments) enabling the students to use the technology to interact with the curriculum; it is also far more important to make it convenient for students to use the technology. In this study, those who successfully implemented VMware on their home systems were able to conveniently access the technology off-campus and in turn used VMware more.

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Significance of Findings

This causal and correlational study focused on examining the factors influencing student's perceptions, intentions, and behaviors toward VMware as a computer networking virtualization technology tool using the Technology Acceptance Model (TAM). The Technology Acceptance Model (TAM) was expanded with both antecedents of perceived ease of use (enjoyment, computer self-efficacy, and external control), and antecedents of perceived usefulness (task-technology fit construct). Subjective norms and voluntariness were also included to account for the impact of social influences on student's decision for adoption and usage. The findings of this research study are summarized here as follow:

1. The expanded Technology Acceptance Model (TAM) moderately explained the variance in Valencia's Engineering and Technology students' use of VMware.
2. Student's reported enjoyment realized from using VMware predicted their perception of ease of use of the technology.
3. External control, representing the facilitating conditions necessary for adoption (resources and knowledge) was the strongest predictor of students reported ease of use.
4. External control highly correlated with enjoyment, perceived usefulness, intention, subjective norms, and actual utilization.
5. General computer self-efficacy didn't contribute to explaining the variance in perceived ease of use.
6. Perceived ease of use was a statistically significant predictor of perceived usefulness.
7. Perceived ease of use was the strongest predictor of student intention toward VMware.

8. The task-technology fit construct was a moderate predictor (though, statistically insignificant) of perceived usefulness using Time 1 data; however, that effect diminished and was nonexistent using Time 2 data.
9. Task-technology fit was a statistically significant predictor of perceived ease of use.
10. The effect of subjective norms significantly increased over time, and was statistically significant in explaining the variance in perceived usefulness using Time 2 data.
11. Voluntariness didn't mediate the influence of subjective norms on intention.
12. Perceived ease of use was the strongest predictor of actual utilization using time 1 data
13. Intention statistically significantly predicted the variance in actual utilization using Time 2 data.
14. Age, employment, academic status, major, and VMware experience did not have any causal relationship with the model.
15. Prior computer networking experience initially, significantly influenced student's decision for adoption; however, as time progressed, that influence ceased to exist.
16. Instructor statistically, significantly influenced intention and actual utilization of VMware as the target technology of this user's acceptance study.

Limitations

There were some limitations related to measurement that should be noted. These limitations are summarized as follow:

1. Participation in the study was limited to students who were enrolled in CET2486 Local Area Networks. They were a convenience sample to the researcher and the results might not be applicable to other domains, settings, or groups.
2. Only two instructors participated in the research study. The researcher accounted for one of them. The researcher's attitudes, beliefs, experience, and motivation significantly influenced the participants in this technology acceptance study.
3. This study was a self-reported study and as is the case with other studies of the same nature, its validity is dependent on the participants' understanding and honest response to the questions.
4. The study explained a low percentage of the variance in actual utilization, suggesting that the model might be omitting or overlooking other important factors influencing student adoption of VMware.
5. Both the task characteristics scale and the tool functionality scale were never used before in any previous studies, and were specifically generated for the intended population and the target technology in this study.
6. Items in the perceived usefulness instrument, even though, mostly adopted from previous studies, included VMware specific items which may not be adoptable in other technology acceptance studies.

7. The reliability of the study and the ability to generalize the results is hindered by the small number of participants.

Further Research Recommendations

1. Actual usability items need to focus on more realistic goals during early stages of adoption and implementation. Also, the scale for perceived usefulness should focus on measuring the usefulness of the technology with regard to accomplishing basic tasks. In general, a more clear understanding and a better articulation of the task is necessary to accurately measure student's perception.
2. An instrument specific to testing the influence of the instructor on student intention and actual utilization of the target technology needs to be included.
3. In early phases of adoption, more focus should be placed on perceived ease of use and on further understanding the determinants of perceived ease of use for the target technology. In similar future studies, the external control items should further detail the facilitating conditions necessary for adoption. For example, items measuring specifically the extent of training and the quality of support should be included.
4. When learners or users are also responsible for not only adopting the technology, but also for implementing the technology on their own, a separate instrument assessing ease of implementation in addition to the instrument assessing ease of use might be necessary.
5. Even thought the current study did not detect a significant path from general computer self-efficacy to perceived usefulness, it might be useful to include a domain specific VMware self-efficacy.

6. Future work should focus on the longitudinal analysis in order to strengthen the directional of causality proposed in the model or to possibly detect new paths of value to explaining the variance in the actual utilization of VMware.
7. Further research is needed to test the ability of voluntariness to mediate the influence of subjective norms on intention when more stringent retributions for nonbehavior are enforced.
8. Collecting qualitative data, using interviews, blogs, or other tools, regarding the issues surrounding the implementation of VMware for students and perceived user resources might be beneficial in explaining the variance in student's actual utilization.
9. Participants in this research study came from an introductory level course, it would be of great value in future studies to include participants from one or multiple of the advanced computer networking courses as those students might have better understanding of the tasks and therefore more accurate perception of the usefulness of the technology.
10. Expanding the Technology Acceptance Model (TAM) with the Fit-Appropriation Model (FAM) (Dennis, Wixom, & Vandenberg, 2001) which accounts not only for the compatibility between the task and the technology but also for the appropriation support through guidance, facilitation, and training might be more suited for academic settings than the inclusion of the Task-Technology Fit (TTF) constructs.

APPENDIX A: VMWARE TOOLS' FUNCTIONS INSTRUMENT

2. VMware Tool Function Items

Instructions:

1.Please respond to the following questions based on your perception about the functionality of the VMware tools regardless of whether you have actually utilized those tools.

2.Please use the following rating scale to respond.

1 = Not At All
2 = Very Small Extent
3 = Small Extent
4= Large Extent
5= Very large Extent

1. To what extent do you believe that the VMware tools (VM Workstation, VM Player, VMnet) support the following computer networking functions?

	Not At All	Very Small Extent	Small Extent	Large Extent	Very Large Extent
Installation of various operating systems	○	○	○	○	○
Interconnecting various operating systems	○	○	○	○	○
Constructing various types of networks at different scales	○	○	○	○	○
Troubleshooting network problems	○	○	○	○	○
Testing the integration or the installation of new networking technologies, services, and applications	○	○	○	○	○

APPENDIX B: TASK CHARACTERISTICS INSTRUMENT

3. Task Characteristics Items

Instructions:

1. Please respond to the following questions based on your perception as to the extent to which you performed the following computer networking tasks.

2. Please use the following rating scale to respond.

1 = Not At All
2 = Very Small Extent
3 = Small Extent
4= Large Extent
5= Very large Extent

2. To what extent did you perform the following computer networking tasks?

	Not At All	Very Small Extent	Small Extent	Large Extent	Very Large Extent
I installed an operating system	○	○	○	○	○
I installed applications and services	○	○	○	○	○
I interconnected networking devices	○	○	○	○	○
I configured TCP/IP properties	○	○	○	○	○
I setup a peer-to-peer connection	○	○	○	○	○
I setup a server-client connection	○	○	○	○	○
I setup and configured a gateway	○	○	○	○	○
I connected a private network to the Internet	○	○	○	○	○
I captured and examined network traffic	○	○	○	○	○
I analyzed network protocols	○	○	○	○	○

APPENDIX C: PERCEIVED USEFULNESS INSTRUMENT

4. Perceived Usefulness

Instructions:

1. Please respond to the following questions based on your perception of how useful VMware is, as network virtualization software, for the purpose of studying and learning computer networking skills.

2. Please use the following rating scale to respond.

1 = Strongly Disagree
2 = Somewhat Disagree
3 = Neither Agree or Disagree
4= Somewhat Agree
5= Strongly Agree

3. How do you rate the usefulness of VMware as a network virtualization tool?

	Strongly Disagree	Somewhat Disagree	Neither Agree or Disagree	Somewhat Agree	Strongly Agree
Using VMware would help me improve my understanding of various networking concepts.	○	○	○	○	○
Using VMware allows me to have the environment I need to practice various computer networking configurations and skills	○	○	○	○	○
Using VMware in my studying would help me experiment with various environments, operating systems and settings otherwise not possible in a traditional, physical environment.	○	○	○	○	○
Overall, I find VMware to be useful in studying computer networking.	○	○	○	○	○

APPENDIX D: SUBJECTIVE NORMS INSTRUMENT

5. Subjective Norms

Instructions:

1. Please respond to the following questions based on your perception of how influenced you usually are by what others think you should do.

2. Please use the following rating scale to respond.

1 = Strongly Disagree
2 = Somewhat Disagree
3 = Neither Agree or Disagree
4= Somewhat Agree
5= Strongly Agree

4. To what extent do you agree or disagree with the following statements:

	Strongly Disagree	Somewhat Disagree	Neither Agree or Disagree	Somewhat Agree	Strongly Agree
The instructor's use of VMware in class inspired me to use VMware	○	○	○	○	○
The instructor thinks that I should use VMware	○	○	○	○	○
My classmates think that I should use VMware	○	○	○	○	○
I am usually inclined to do what my instructor thinks I should do.	○	○	○	○	○
I am usually influenced by what my peers think I should do.	○	○	○	○	○

APPENDIX E: VOLUNTARINESS INSTRUMENT

6. Voluntariness

Instructions:

1. Please respond to the following questions based on your perception of whether your use of VMware was voluntary.

2. Please use the following rating scale to respond.

1 = Strongly Disagree
2 = Somewhat Disagree
3 = Neither Agree or Disagree
4= Somewhat Agree
5= Strongly Agree

5. To what extent do you agree or disagree with the following statements:

	Strongly Disagree	Somewhat Disagree	Neither Agree nor Disagree	Somewhat Agree	Strongly Agree
My use of VMware is voluntary.	○	○	○	○	○
My instructor doesn't require me to use VMware for my course work.	○	○	○	○	○
Although it might be useful, using VMware is certainly not compulsory in my class	○	○	○	○	○

APPENDIX F: PERCEIVED ENJOYMENT INSTRUMENT

7. Perceived Enjoyment

1.Please respond to the following questions based on your perception of how enjoyable VMware is as a network virtualization application.

2.Please use the following rating scale to respond.

1 = Strongly Disagree
2 = Somewhat Disagree
3 = Neither Agree or Disagree
4= Somewhat Agree
5= Strongly Agree

6. To what extent do you agree or disagree with the following statements:

	Strongly Disagree	Somewhat Disagree	Neither Agree or Disagree	Somewhat Agree	Strongly Agree
I find using VMware to be enjoyable.	○	○	○	○	○
The actual process of using VMware is pleasant.	○	○	○	○	○
I have fun using VMware.	○	○	○	○	○

APPENDIX G: COMPUTER SELF-EFFICACY INSTRUMENT

8. Computer Self-Efficacy

1.Please respond to the following questions based on your belief about your own ability to perform a specific task/job using computer software.

2.Please use the following rating scale to respond.

1 = Strongly Disagree
2 = Somewhat Disagree
3 = Neither Agree or Disagree
4= Somewhat Agree
5= Strongly Agree

7. I could complete a task using a software package. . .

	Strongly Disagree	Somewhat Disagree	Neither Agree or Disagree	Somewhat Agree	Strongly Agree
if there was no one around to tell me what to do as I go.	○	○	○	○	○
if I had never used a package like it before.	○	○	○	○	○
if I had only the software manuals for reference.	○	○	○	○	○
if I had seen someone else using it before trying it myself.	○	○	○	○	○
if I could call someone for help if I got stuck.	○	○	○	○	○
if someone else had helped me get started.	○	○	○	○	○
if I had a lot of time to complete the job for which the software was provided.	○	○	○	○	○
if I had just the built-in help facility for assistance.	○	○	○	○	○
if someone showed me how to do it first.	○	○	○	○	○
if I had used similar packages before this one to do the same job.	○	○	○	○	○

APPENDIX H: EXTERNAL CONTROL INSTRUMENT

9. Perceptions of External Control (Facilitating Conditions)

1.Please respond to the following questions based on your belief as to the extent the resources, and conditions necessary for you to use VMware were present.

2.Please use the following rating scale to respond.

1 = Strongly Disagree
2 = Somewhat Disagree
3 = Neither Agree or Disagree
4= Somewhat Agree
5= Strongly Agree

8. To what extent do you agree or disagree with each of the following statements:

	Strongly Disagree	Somewhat Disagree	Neither Agree or Disagree	Somewhat Agree	Strongly Agree
I have control over when to use VMware.	◯	◯	◯	◯	◯
I have control over how to use VMware.	◯	◯	◯	◯	◯
I have the resources necessary to use VMware on-campus.	◯	◯	◯	◯	◯
I have the resources necessary to use VMware off-campus (at home).	◯	◯	◯	◯	◯
I have the knowledge necessary to use VMware.	◯	◯	◯	◯	◯
Given the resources, opportunities and knowledge it takes to use VMware, it would be easy for me to use it	◯	◯	◯	◯	◯

APPENDEX I: PERCEIVED EASE OF USE INSTRUMENT

10. Perceived Ease of Use

1. Please respond to the following questions based on your perception of how easy or difficult VMware is to use, as network virtualization software, for the purpose of studying and learning computer networking skills.

2. Please use the following rating scale to respond.

1 = Strongly Disagree
2 = Somewhat Disagree
3 = Neither Agree or Disagree
4= Somewhat Agree
5= Strongly Agree

9. To what extent do you agree or disagree with the following statements:

	Strongly Disagree	Somewhat Disagree	Neither Agree or Disagree	Somewhat Agree	Strongly Agree
My interaction with VMware is clear	○	○	○	○	○
My interaction with VMware is understandable.	○	○	○	○	○
Interacting with VMware does not require a lot of my mental effort.	○	○	○	○	○
I find VMware to be easy to use.	○	○	○	○	○
I find it easy to get VMware to do what I want it to do	○	○	○	○	○

APPENDIX J: INTENTION INSTRUMENT

11. Behavioral Intention to Use (Attitude)

1. Please respond to the following questions regarding whether you intend to use VMware in performing and practicing computer networking related skills.

2. Please use the following rating scale to respond.

1 = Strongly Disagree
2 = Somewhat Disagree
3 = Neither Agree or Disagree
4= Somewhat Agree
5= Strongly Agree

10. To what extent do you agree or disagree with the following statements:

	Strongly Disagree	Somewhat Disagree	Neither Agree or Disagree	Somewhat Agree	Strongly Agree
Assuming I had access to VMware, I intend to use it to practice computer networking skills.	○	○	○	○	○
Given that I had access to VMware, I predict that I would use it.	○	○	○	○	○

APPENDIX K: ACTUAL UTILIZATION INSTRUMENT

12. Actual Utilization

Instructions:

The following four questions will invite you to reflect on your actual utilization of VMware as both an operating system virtualization tool as well as a network virtualization tool.

11. How much did you use VMware?

	Less than once a week	Once a week	Twice a week	Three times a week	More than three times a week
In general, how often did you use VMware both on-campus and off-campus?	○	○	○	○	○

12. Purposeful Utilization

	One	Two	Three	Four	Five or More
How many virtual environments/networks have you constructed with VMware?	○	○	○	○	○

13. How much time did you spend working with VMware?

	Less than one hour	Between one and two hours	Between two and three hours	Between three and four hours	More than four hours
On Average, how much time did you spend working with VMware every time you used it?	○	○	○	○	○

14. To what extent did you perform the following?

	Not At All	Very Small Extent	Small Extent	Large Extent	Very Large Extent
I used VMware to perform other tasks not required by my course work	○	○	○	○	○
I voluntarily used VMware to help me with my course work in my other classes	○	○	○	○	○

APPENDIX L: DEMOGRAPHICS INSTRUMENT

13. Demographics

Based on your individual information, please select the most proper answer to each question.

15. Age

- 18-20
- 20-25
- 25-30
- 30-35
- 35-40
- Over 40

16. Employment status

- Full-time employed
- Part-time employed
- Unemployed

17. Academic enrollment status

- Full-time, degree-seeking student
- Part-time, degree-seeking student
- Full-time, non-degree-seeking student
- Part-time, non-degree-seeking student

18. Your declared major

- Computer Engineering Technology (CET)
- Electronics Engineering Technology (EET)
- Computer Information Systems (CIS)
- Professional Development
- Other

19. Please indicate your prior experience with VMware before this course

- I wasn't familiar with VMware at all until it I was introduced to it in this class
- I was familiar with VMware but never actually used it
- I have used VMware before to some extent
- I have used VMware before to a great extent

20. How do you rate your computer networking experience?

- ○ I have no computer networking experience at all
- ○ I have some computer networking experience
- ○ I have a long computer networking experience

APPENDIX M: INFORMED CONSENT LETTER

1. Consent Form

Dear Student
My name is Wael Yousif and I am a professor of computer engineering technology, here, at Valencia Community College. You are being asked to participate in a study conducted to understand the relationship between attitude toward using VMware as Network Virtualization software, and the actual use of VMware for the purpose of studying and learning computer networking.

Two surveys will be administered in this Fall term of 2009. The first survey will be available toward the fourth week of the term while the second will be available toward the end of the term. Each questionnaire will take approximately 30 minutes to complete.

Your participation in this study is voluntary and you may reject to participate without any detrimental effect on your grade or your relationship with your instructor. Moreover, if you chose to participate, you don't have to answer any question that you don't feel comfortable answering. Additionally, you may withdraw from this study at any time. There are no anticipated risks associated with participating in this research study. However, 10 extra points will be added to your grade if your full participation in both questionnaires is verified. Your participation will be verified through your Atlas email. If you don't wish to participate in the survey, you can still earn the same extra credit by completing an alternative assignment which will require approximately the same time and effort required to complete the survey.

Results from this study will help us understand how you perceive VMware as network-virtualization software. Specifically, whether you find it to be easy to use, and whether you find it useful in meeting your learning needs while studying computer networking. Thank you very much for your time and for helping with this important study.
If you have any questions or comments about this research study, please contact Wael Yousif (wyousif@valenciacc.edu) or his advisors, Dr. David Boote (dboote@mail.ucf.edu), University of Central Florida (UCF), College of Education, Orlando, FL.

If you have questions or concerns about your rights as a research participant, you may contact Valencia's Institutional Review Board (IRB) office at irb@valenciacc.edu

Sincerely yours,
Wael Yousif
Professor, Computer Engineering Technology (Networking)

APPENDIX N: UCFIRB PERMISSION LETTER

University of Central Florida Institutional Review Board
Office of Research & Commercialization
12201 Research Parkway, Suite 501
Orlando, Florida 32826-3246
Telephone: 407-823-2901 or 407-882-2276
www.research.ucf.edu/compliance/irb.html

Approval of Exempt Human Research

From: **UCF Institutional Review Board #1**
FWA00000351, IRB00001138

To: **Wael Yousif**

Date: **September 15, 2009**

Dear Researcher:

On 9/14/2009, the IRB approved the following activity as human participant research that is exempt from regulation:

Type of Review:	Initial Review
Project Title:	Examining Computer Engineering Students' Acceptance of Network Virtualization Technology Using the Technology Acceptance Model
Investigator:	Wael Yousif
IRB Number:	SBE-09-06418

This determination applies only to the activities described in the IRB submission and does not apply should any changes be made. If changes are made and there are questions about whether these changes affect the exempt status of the human research, please contact the IRB.

In the conduct of this research, you are responsible to follow the requirements of the Investigator Manual.

On behalf of Joseph Bielitzki, DVM., UCF IRB Chair, this letter is signed by:

Signature applied by Janice Turchin on 09/15/2009 01:35:54 PM EDT

IRB Coordinator

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