Enabling Laptop Exams Using Secure Software: Applying the Technology Acceptance Model

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ABSTRACT

The perceived ease of use and usefulness of secure software that enables laptop exams is examined. The technology acceptance model (TAM) is used to link faculty and administrative support with perceptions of ease of use and usefulness. Data for the empirical examination were collected by a survey of business students in a required laptop program. The quantitative technique uses a structural equation model. Results indicate that measures of faculty support impact both ease of use and perceived usefulness. In turn, attitudes toward using the system and degree of system use are influenced. Interestingly, technical support for the secure software had no meaningful impacts in the model. We draw upon the findings to describe specific actions by faculty that can improve student experience with laptop exams and identify other actions that appear to have no effect.
Keywords: Laptop Examinations, Examination Security Software, Technology Acceptance Model

1. INTRODUCTION

Declining technology prices, increasingly tight university operating budgets, and increasing awareness by educators about the value of computer technology for enhancing learning have motivated a number of colleges and universities to institute student laptop programs. When compared to traditional computer labs or desktop computers in dormitory rooms, the mobility of laptops provides a number of teaching and learning-oriented advantages. Using laptops as part of the learning evaluation and assessment process has the potential to be one such advantage.

Two issues arise immediately, however. One issue is whether instructors can provide a secure examination environment in which students are constrained from accessing either notes on their laptop hard drives, the Internet, or other students via email and instant messaging. Another issue is the extent to which students will accept laptop-based assessment techniques as reasonable substitutes or enhancements to traditional forms of assessment.

Recently, as faculty at a college with a mandatory laptop program who are interested in using laptops for assessment purposes, we attempted to address these two issues. Relatively easily we found software that enables a secure examination environment. More important then was the second issue: investigating student reactions to laptop assessment techniques.

In this work we report on our efforts to both explore the extent to which students accept laptop technology as an assessment tool and learn more about the factors that affect students' levels of acceptance. Understandably, students will more likely accept a new testing environment if the tool is perceived to be useful and if changes required on their part are seen as reasonable. To gauge the extent to which the software technology is perceived to be both easy to use and useful, we looked to the Technology Acceptance Model (TAM) (Davis, 1989; Davis, Bagozzi, & Warshaw, 1989) as a framework of our literature and empirical investigations.

According to the model, acceptance of technology depends upon user perceptions of the technology's usefulness and ease of use. These perceptions in turn affect user willingness to apply the technology at high levels and on an ongoing basis into the future. While acceptance of general technology has received widespread attention from previous research (Adams, Nelson, & Todd, 1992; Davis, 1989; Davis, Bagozzi, & Warshaw, 1989; Venkatesh & Davis, 1996; Igbaria, Zinatelli, Cragg, & Cavaye, 1997; Gefen & Straub, 2000; Legris, Ingham, & Collerette, 2003; Shih, 2003), little has been done to investigate evaluation and assessment software technology. Thus, we extend work on the TAM to software on laptops that is used for assessing student learning in a secure environment. In doing so, we hope to

provide insights into laptop user attitudes towards the ease of use and usefulness of software for exam delivery. Such evidence can help improve future implementations of software technologies in laptop programs elsewhere and provide additional support for the generalizability of the TAM.
The remainder of this paper is organized into six sections. Section 2 explains how the TAM can be used as a theoretical framework for understanding the relationship between technology characteristics and user acceptance. Section 3 describes the data collection process and the sample characteristics, while Section 4 identifies and describes the TAM model input measures and their psychometric properties. Analysis of the model results is provided in Section 5. Finally, we discuss the results of our analyses in Section 6 and offer some concluding remarks in Section 7.

2. THE THEORETICAL MODEL

The technology acceptance model is adapted from the theory of reasoned action (TRA). A well-known model, the TRA is concerned with predicting and explaining human intentions and behavior (Ajzen, 1980; Chau & Hu, 2001; Davis et al., 1989). Thus, the TAM applies the TRA to predicting and explaining user acceptance of a computer technology.

The TAM traces the impact that external variables have on the beliefs, attitudes, and intention to use a technology (Davis et al., 1989; Legris et al., 2003). Davis (1989) and Davis, Bagozzi, & Warshaw (1989) conclude that two primary determinants of technology acceptance are perceived ease of use and perceived usefulness. Usefulness refers to an individual's perception of how a particular technology will improve performance, while ease of use refers to an individual's perception of the amount of effort needed to use the system (Davis, 1989; Davis et al., 1989; Venkatesh & Davis, 1996). The model has been widely used to predict the acceptance of different information technologies. Results indicate there is indeed, a positive relationship among employee perceptions of usefulness and ease of use, employee behavioral intentions to use the technology, and their subsequently using and accepting the technology (Adams et al., 1992; Davis, 1989; Davis et al., 1989; Venkatesh & Davis, 1996).

Given the success of this model, we used it to help determine what we should (and should not) do in our laptop program to successfully implement the exam software. The model could also indicate whether the software selected was itself affecting student attitudes and intentions towards using it. Figure 1 presents the TAM framework adapted for our purpose. Specifically, we developed two measures for the model's external variables construct: Faculty Support and Technical Support. These allow us to separate into two broad categories those actions we were performing within the laptop program to implement the exam software and trace their impacts on the other model constructs of student beliefs, attitudes, and behavioral intentions to use the software technology. Our measures for these constructs are derived from those proposed by Davis (1989).

3. THE EMPIRICAL STUDY

The sample was collected using a paper and pencil survey of students enrolled in what is commonly referred to as the 'Junior-level Business Core' or the 'Common Body of Knowledge.' In two sections of this course, students were required to complete an examination using their laptops and software that provided a secure testing environment. The software not only displayed a word processing document and a spreadsheet, both of which were developed by the faculty team, but also prevented students from exiting these documents to perform any other actions, e.g., accessing hard drives, the Internet, or email.

3.1. Sample Data

A total of 107 students were enrolled in the two sections of the business core, which was taught by a team consisting of five faculty members. There were 63 students enrolled in the morning section and 44 in the afternoon section. The examination was administered during a common time to 98 students using the secure software. Of the 9 that did not take

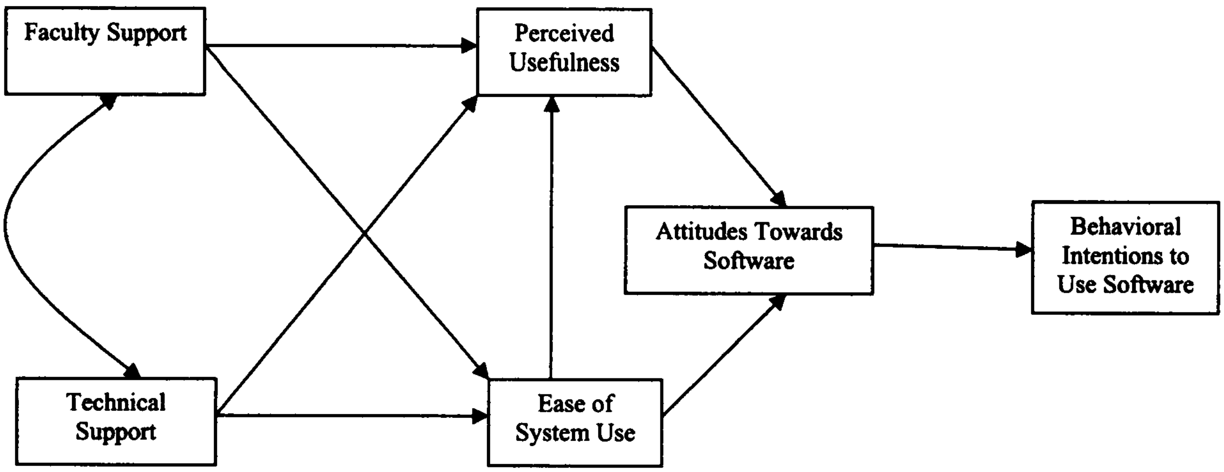

Figure 1. The Technology Acceptance Model

Characteristic	Sample	College Population	*Test Statistic*
			t-Statistic
Average GPA	3.06	2.98	*1.25*[a]
Average Age (years)	22.2	21.6	*1.68*[a]
			z-Statistic
Gender:			*0.26*[b]
Female	40.00%	39.00%	
Male	60.00%	61.00%	
			Chi-Square Statistic
Major:			*13.89*[c]
Marketing	28.33%	22.20%	
Information Systems	11.67%	12.60%	
Finance	11.67%	11.60%	
Management & Human Resources	16.67%	14.00%	
Production Operations Management	3.33%	5.60%	
Professional Golf Management	3.33%	0.70%	
Accounting	20.00%	16.20%	
Economics-Finance	5.00%	6.10%	
Other/Undeclared	N/A	9.00%	
Number of Observations	*60*	*837*	

[a] t-statistic = two-tailed [b] z-statistic = two-tailed [c] df = 8

Table 1. Data Characteristics

the exam, 5 students were excused due to illness and 4 had conflicts with the common exam time and were given the exam in a traditional, hand-written format at another time.

The 98 students who used the secure software for the exam were given the opportunity to complete a questionnaire five days following the exam experience and prior to receiving their exam scores. A verbal reminder to return the questionnaire was provided during class time prior to the exam scores being released. No additional reminders were provided due to concerns over latency effect and attribution of exam performance. That is to say, no other reminders were given to improve the response rate because of the concern that too much time might elapse since using the software. In such a case, the students' responses might not reflect their immediate perceptions after using the software, giving rise to a latency effect. Also, if students received their examination scores before completing the questionnaire, their examination score, particularly if lower than desired, could influence their perceptions of the software if they attribute their performance to the software. We wished to mitigate either occurring so that we could obtain responses that best reflect students' true perceptions of the examination software. Of the 98 possible respondents, 62 students responded, with 60 students fully completing the questionnaire for a 61% response rate.

3.2. Characteristics of the Respondents

Data characteristics for the sample are shown in Table 1. The average GPA of 3.06 appears high, but it is the case that all students enrolled in the course must complete several qualifying courses with a minimum GPA. These requirements prohibit some students, who tend to have lower GPAs, from enrolling in the course. The average age of the respondents was 22.2 years. Both genders were roughly equally represented, at 40% females and 60% males. The percentage of the sample students in each major ranged from a high of 28.33% in Marketing to 3.33% in both Production Operations Management and Professional Golf Management.

3.3. Nonresponse Bias

As is the case of any research depending on data collected by survey, nonresponse is a concern. To examine the possible presence of nonresponse bias, the sample characteristics were compared to the corresponding values at the College level. The students enrolled in the College represent the population of students which could have been selected into the sample for this study. Table 1 displays the values for these demographics and the corresponding statistic testing the significance of the difference between the sample and the population values. All these tests were two-tailed and found no meaningful differences between the sample and the population at a 5% significance level. Based on the comparison of these demographic variables between the sample and the population, we concluded that nonresponse bias does not present a problem for the sample.

4. THE MEASURES AND THEIR PSYCHOMETRIC PROPERTIES

We modified prior work by Davis (1989) and developed questionnaire items for the measures of the TAM's various constructs. For all measures, students were asked the extent to which they agreed or disagreed with each of the items, and were presented with the ordered answer choices of Strongly Disagree, Disagree, Neutral, Agree, or Strongly Agree. To evaluate the appropriateness of the survey instrument generally, we pre-tested an initial questionnaire with 11 students who had completed the course a year earlier and were familiar with the examination software. Based on their feedback concerning the intent of the questions, we eliminated four items.

All of the questionnaire items are shown in Table 2 along with the measures formed by collections of these items. Also shown in Table 2 are the psychometric properties of these measures. The psychometric properties of convergent validity, discriminant validity, and construct validity were evaluated for the measures using the results of a confirmatory factor analysis based on structural equations modeling (i.e., Covariance Analysis in Linear Structural Equations in PC SAS version 9). The indicants were the questionnaire items and all the measures were reflective in their own indicants.
Each pair of measures was allowed to pair-wise correlate. The estimation method used was maximum likelihood. The summary statistics regarding the fit between the model and the data were: a goodness of fit index of 0.65; adjusted goodness of fit index of 0.56; root mean square residual of 0.10; a chi-square statistic of 493.54 (284 degrees of freedom); a normed chi-square statistic of 1.74; Bentler's comparative fit index of 0.89; and Bentler and Bonett's non-normed and normed indexes of 0.88 and 0.78.

Convergent validity was analyzed using statistics calculated based on the standardized path coefficients from the estimated confirmatory factor analysis are reported in Table 2. These results include the standardized path coefficients whose magnitudes can be used to evaluate the reliability of each item. The larger this path coefficient is the greater the item reliability. Also shown is a reliability coefficient for each measure calculated using the standardized path coefficients for each of its items. The measure reliability coefficient evaluates the internal consistency of the items. The closer this reliability coefficient is to one, the greater the measure reliability. The percentage of shared variance by the items in each measure is also shown in Table 2. This measure indicates the percentage of variation in the measure explained by the items forming the measure and implicitly the percentage of unexplained variation.

Since the standardized path between each indicant and its measure was at least as large as 0.73, item reliability is satisfied (Rainer and Harrison, 1993). Composite reliability is also satisfied because the reliability coefficients range from 0.75 to 0.97 (Nunnally, 1978). Last, all the average percentages of shared variance are 60% or greater, demonstrating satisfactory levels (Rivard and Huff, 1988). Due to these desirable values, convergent validity is satisfied for each measure (Rainer and Harrison, 1993; Igbaria and Greenhaus, 1992).

Discriminant validity was also examined using the results from the confirmatory factor analysis. The squared correlation between each pair of measures is compared to the average percentage of shared variances. Discriminant validity is satisfied if, for each measure pair, the average percentages of shared variance are greater than the corresponding squared correlation (Fornell and Larcker, 1981). The squared correlations are reported in Table 3. For all but one pair of measures, squared correlations were less than all the corresponding average percentage of shared variances and thus, satisfy discriminant validity. Discriminant validity is violated for the pair of measures Attitudes Towards Software/Behavioral Intentions to Use Software, implying that the indicants across both measures cannot differentiate between the two measures. These two measures then, satisfy convergent validity but not construct validity.

Based on the results for convergent validity and discriminant validity, construct validity is satisfied (Rainer and Harrison, 1993). We were able to conclude that our items and measures have desirable psychometric properties. In other words, we can be confident that the items and measures perform reasonably well in measuring the intended underlying constructs.

5. MODEL ANALYSIS

Because our model was relatively complex compared to the sample size, we used the summation of the questionnaire items as the measures and employed maximum likelihood estimation for the structural model. The overall fit of the model was evaluated using several summary statistics, which are reported in Table 4. The goodness of fit index is 0.93 and when adjusted for degrees of freedom is 0.77. The root mean square residual is 0.06 while the chi-square statistic is 14.82 and significant at a 5% level. The normed chi-square statistic is 2.47. Bentler's comparative fit index is 0.96 while the incremental fit indexes ranged from 0.85 to 0.96. Even though these statistics provide mixed findings regarding the goodness of fit between the model and the data, the values are sufficient for us to conclude the fit is acceptable (Hair, Anderson, Tatham, and Black, 1992). This acceptability judgment is based on more of these summary statistics meeting the generally accepted cutoff values than not. Thus, the variations found in the data are consistent with those implied by the theoretical model and we conclude that the data "fits" the model.

The estimated structural model is shown in Figure 2. Based on the significant paths, faculty support has a meaningful impact on behavioral intentions to use the examination software. The impact is mediated by perceived usefulness and attitudes towards the software. The ease of system use also impacts in a meaningful way the behavioral intentions to use the system, through attitudes towards the system and also through perceptions of usefulness. Various aspects of technical support show no significant effects.

6. DISCUSSION

We applied the TAM to help us determine whether the actions we were performing in our laptop program to implement exam software were influencing, either positively or negatively, student acceptance of the software. In addition we also wanted to determine whether aspects about the software itself affected student acceptance.

Results for the estimated technology acceptance model indicate that actions on the part of faculty impact student behavioral intentions to use the exam software. More precisely, faculty support significantly affects student perceptions on the usefulness of the software and their

Measures and Indicants	Standardized Path Coefficient	Reliability	*Percentage of Shared Variance*
Faculty Support		0.75	*0.60*
For each of the following factors, indicate the extent to which you agree or disagree that it helped your use of the software:			
Faculty explaining the advantages of the software.	0.82		
Faculty explaining laptop-based exams and related software is inevitable.	0.73		
Technical Support			
The IXL Staff...		0.95	*0.82*
is helpful when someone has a problem with the software.	0.88		
seems knowledgeable about the software.	0.91		
is able to identify the source of most of the software problems.	0.84		
is supportive when someone has a question or problem with the software.	0.98		
Perceived Usefulness		0.97	*0.80*
Using the software...			
gives me greater control over my exam performance.	0.92		
improves my exam performance.	0.92		
saves me time in the exam.	0.81		
enables me to accomplish the exam tasks more quickly.	0.85		
enhances my effectiveness on the exam.	0.94		
improves the quality of the work I do.	0.90		
increases my productivity.	0.91		
Ease of System Use		0.87	*0.77*
I often become confused when using the software.	0.90		
I make errors frequently when using the software.	0.86		
Attitudes Towards Software		0.96	*0.81*
I enjoy completing an exam using the software.	0.88		
I prefer to complete an exam using the software.	0.95		
I would like to use the software for all my exams.	0.96		
I hate using the software.	0.90		
I wish all my classes would use the software exams.	0.81		
Behavioral Intentions to Use Software		0.97	*0.83*
In the future I intend to...			
say positive things about the software to future students.	0.88		
recommend the software to instructors who ask for advice.	0.92		
encourage the faculty team to continue using the software.	0.95		
use the software whenever I have the option.	0.95		
encourage other instructors to allow me to use the software.	0.91		
request using the software in other courses.	*0.86*		

Note: IXL represents the laptop program help desk.

Table 2. The Items, Measures, and Convergent Validity Results

attitudes towards the software. This suggests that students can be convinced of the benefits and usefulness of exam software that essentially locks down their laptops, restricting the usage of their own laptops. Our results show this can be achieved by faculty simply reminding students of the software's benefits. The main benefits that were emphasized were the abilities to type rather than write 1- to 2-page essay answers, use grammar and spell checkers, use deletion rather than an eraser or cross-out to edit answers, perform calculations only once on a spreadsheet and reduce transfer errors from using a calculator with paper-based exams, and use the laptops for assessments (i.e., extend their required laptop beyond a note-taking tool). Faculty can also impact student acceptance of such exam software by pointing out that progress happens. We chose to tell the students that just as laptops are now pervasive and nothing new to the students, laptop-based exams are becoming more widely used and the students are simply part of the early adopter phase.

Evidence from the TAM suggested that these actions on our part interacted with the perception students had about the usefulness of the software and their general attitudes towards using it. Given what we emphasized to the students how the software improved many of those aspects of a paper-based exam that students typically complained about, these results are not too surprising. Still, it is a useful confirmation and we will continue with these actions in the future.

In contrast to the results for actions by faculty, results for actions on the part of the technical support staff suggest they are not worth repeating. We suspect though, that the two

Measure Pair	*Squared Correlation*
Faculty Support / Technical Support	*0.03*
Faculty Support / Perceived Usefulness	*0.17*
Faculty Support / Ease of System Use	*0.08*
Faculty Support / Attitudes Toward Software	*0.26*
Faculty Support / Behavioral Intentions to Use Software	*0.25*
Technical Support / Perceived Usefulness	*0.06*
Technical Support / Ease of System Use	*0.07*
Technical Support / Attitudes Towards Software	*0.08*
Technical Support / Behavioral Intentions to Use Software	*0.11*
Perceived Usefulness / Ease of System Use	*0.42*
Perceived Usefulness / Attitudes Towards Software	*0.79*
Perceived Usefulness / Behavioral Intentions to Use Software	*0.71*
Ease of System Use / Attitudes Towards Software	*0.46*
Ease of System Use / Behavioral Intentions to Use Software	*0.46*
Attitudes Towards Software / Behavioral Intentions to Use Software	*0.90*

** Statistically significant at a 1% level

Table 3. The Squared Correlations of the Measures

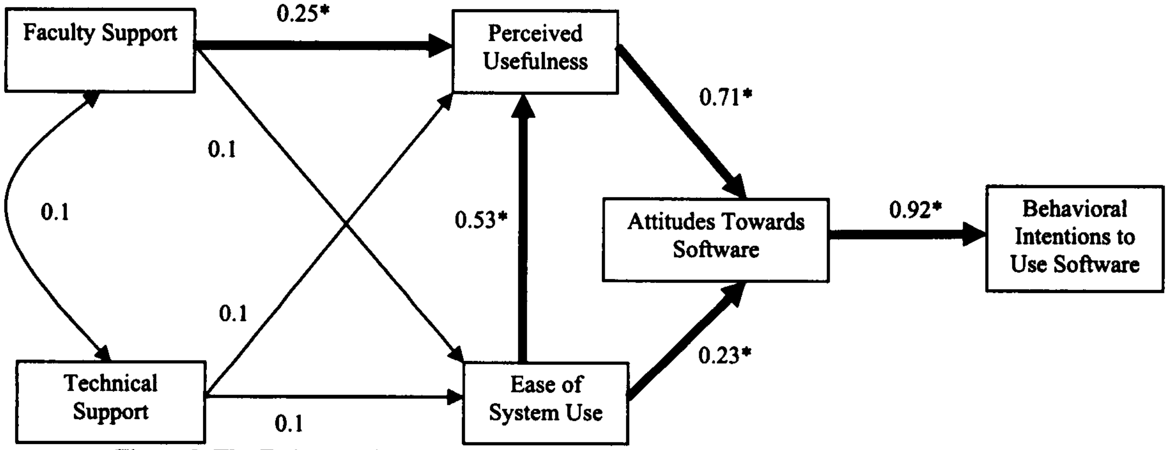

Figure 2. The Estimated Technology Acceptance Mode Using Standardized Path Coefficients

students who relied on the technical staff for an Ethernet cable and to re-boot a locked operating system found the presence and services of the staff to be very worthwhile. So, we interpret the lack of significant results to mean that many more students simply had no need for the services of the technical staff, and our questionnaire items were not able to get the students to separate well enough in their minds the difference between using the technical staff during the exam and the comfort they took in knowing the services were there regardless. While an alternative to dealing with technology problems is to provide a paper-based exam to the few students whose laptops do not work for whatever reason, we wished to mitigate arguments over issues of equality and fairness and kept that option as a last resort. We will continue to have technical staff on hand and provide extra hardware for future exams.

Not surprisingly, results to the TAM also show the ease of system use affects both student perceptions about the usefulness of the software as well as their attitudes towards it. The easier the accommodation required on the part of students to learn a new testing procedure, the more accepting they will be of the procedure. This result also suggests that the software itself was not only reasonably easy for the students to learn and use, but also this is a significant factor in whether students will adopt technology. Given the number and variety of educational packages being promoted to faculty and laptop program administrators, this may be a useful and important reminder to some.

7. CONCLUSION

Large declines in technology prices coupled with developments in education software have been the impetuous for many universities to require that students purchase laptops. However, ongoing innovations in computer technology present ongoing opportunities and challenges then, to these universities. For example, faculty members rightfully see an opportunity to use the laptops for examinations and other forms of assessment. A big challenge though, besides selecting software that will provide a secure testing environment, is obtaining student support since they must believe that learning the new assessment method is worth their while.

The empirical results identify two main factors significantly influencing student attitudes towards and intentions to use examination software. These factors are faculty pointing out the benefits of the software over paper-based examinations as well as the current diffusion of the software, and the ease of using the software itself. An interesting result was the lack of any influence that technical support has on student attitudes and behavioral intentions. While the presence and services of a technical support staff did not appear to have a significant effect on student intentions to use the software, we believe this was due to the fact that very few students required help from the staff. We still recommend they be present at laptop-based examinations.

There are a number of directions for future research based on this study and its results. One is to investigate the lack of meaningful impact in the model from technical support. Logically, one would expect such support to be meaningful. While we have proposed an explanation for this result, additional study is needed to understand technical support's role in the formation of behavioral intentions to use secure examination software. Another line of future investigation is to examine how individual traits (e.g., past computer experience and use, past academic performance, personality traits) would impact the students' perceptions of the examination software, alter results, and affect behavioral intentions. Additionally, as more examination software becomes available it would be interesting to investigate the differences in perceptions of ease of use and usefulness with varying products.

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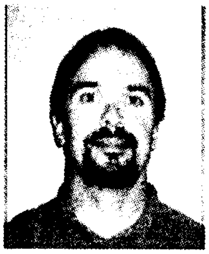

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