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DOES TECHNOLOGY AFFECT STUDENT PERFORMANCE

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ABSTRACT

This study presents findings that demonstrate that frustration with information technology use is a component of the learning environment and as a construct has an impact that is almost as large as the students' GPA on online students' performance midway through the course. We surveyed 368 accounting students. Their responses indicate that they like technology; they believe it to be beneficial, and they expect to be able to use it effectively. However, there appears to be a stronger relationship between frustration and performance in the online students. In all cases, students who earned "A's" reported fewer frustrating events while online students who scored lowest on the exam reported the most frustration with the software. An additional finding shows that lower scoring students believe the software is more useful than the students who scored higher on the exam.

Key words: Online homework, technical efficacy, frustration, structural equation modeling

Data availability: Data are available upon request

INTRODUCTION

Much of the focus in information systems research has been either techno-centric, studying the effect of technology on organizations or individuals; or human-centered, studying the interaction between human and Information Technology (IT) (Orlikowski, 2007). Given the ubiquitous nature of IT in various aspects of professional and personal life, it now seems logical to view IT as an integral part of our environment. Today's universities house an entire generation of young adults who have used technology throughout their lives. They do not complain when asked to use a new technology for class.

Our study found that college students like technology; they believe it to be beneficial, and they expect to be able to use it effectively. However, there is also a feeling of frustration. Technicism, the belief that technology can rescue society from its woes, (Schuurman, 1997), appeals to the Superman qualities students emulate. Like Ironman, students are not born with super powers, but with the help of technology, they believe they can achieve more. Although the use of technology and the inherent frustration is so intertwined with the educational setting, it can affect the human psyche, motivation and ultimately the success of students.

This study presents findings that demonstrate that frustration with IT use is inherent in the learning environment and particularly affects low-performing students. Frustration with required technology use is intuitive and commonplace, yet it is rarely examined in the educational systems literature. Our results indicate we should re-examine IT literature regarding adoption to include frustration with specific IT use and its impact on student performance.

Many characteristics of the world have changed in the past 200 years such as national boundaries, average temperatures and populations, yet we still teach the way we have taught for hundreds of years. One concession to change has been the use of technology to help students learn. Throughout history, the invention of new technology has benefitted civilization. For example, modern medicine has improved health while railroads have improved transportation. We assume that since the technology is available, it should be used. It has become part of our environment, and we use it automatically. This paper examines student performance when students use web-based homework software in accounting classes to determine whether technology affects their final grades. Using structured equation modeling, SEM, we find that frustration plays an important role when using technology, especially for online students. In this study, frustration is negatively related to student performance. Students reporting the most frustration also reported the lowest grades.

The remainder of the paper is organized as follows. In the next section, we review the existing literature on technology, e-learning and web-based homework to develop a theoretical foundation for the impact of relevant constructs in these environments on student performance. We utilize the literature to develop research hypotheses to answer our research question. Next, we present our research design, used to test our hypotheses and present the items used to collect data. We then present our data analysis utilized to test our hypotheses and discuss our findings. We conclude the paper in the final section and offer limitations and directions for future research.

LITERATURE REVIEW AND HYPOTHESIS DEVELOPMENT

Technology in Education

Web-based homework (WBH) software is part of a broader concept called e-learning which refers to the use of electronic technology to deliver content or help students practice and learn educational material. Hamid (2001) suggests that the "e" in e-learning has been the focus of what the technology can do, but that we should look at how students learn and adapt the technology to their needs. He suggests that "in our eagerness to embrace technology, we sometimes forget the fundamentals" (p. 313), suggesting we may adopt the technology without being sure it will help students learn. He believes we should examine the e-learning concept to avoid potential pitfalls such as learning computer-based skills that may become obsolete at the expense of time-tested skills such as critical thinking. Yet, assessment mechanisms, such as homework assignments and exams, are increasingly completed online using web-based homework software (Dillard-Eggers et al., 2008). Now, millions of university students complete homework assignments online, using web-based software provided by textbook publishers. The use of the technology is based on the belief that practice is necessary for achievement and homework is assigned for practice, and the faster the students receive the feedback, the more they will learn (Pascarella, 2004). The growth in this method of delivery and assessment suggests that research into its efficacy is both timely and important.

WBH software is a web-based learning environment where students solve homework problems and receive instantaneous feedback on their progress and performance. The pervasive use of IT in the business sector and the technochanges (Bruque et al., 2008) that result from IT-induced change have had an impact in the classroom. In many places, the organization adopts IT and transforms the workplace, but at today's universities, the professor adopts the IT and transforms the learning environment.

As budgets shrink, class sizes increase causing professors to make changes to class because of the grading load. Rather than eliminate homework completely, some faculty members use WBH software solutions, and the technology allows students to practice and receive instant feedback. An added benefit is that the grades are instantly recorded for the educator's use.

But WBH does have some drawbacks. If a student enters the wrong answer, some publishers' WBH sites give no indication as to why it is wrong. It could be something as simple as a rounding error, decimal or transposed number, but the student does not know that. (Newer versions of the software sometimes include a link to the corresponding part of the textbook or give hints.)

Another drawback involves students gaming the system, meaning the student tries to complete the task of finishing the assignment without actually doing any work (Baker et al., 2004). Some WBH versions can be set to provide hints after the first, second, or n^{th} attempt, so students quickly learn to enter anything the first few times in order to get to the hints. Sometimes the hints will provide a formula, so the student does not have to open the book.

One more drawback is that simply grading based on right-or-wrong places emphasis on the correct answer and not on the process. Creating a balance sheet using WBH software is simply a matter of selecting an item from a list. The form is already created for the student, and the list of accounts from which the student selects answers is not comprehensive.

The use of WBH can also take more time than paper homework. One study found that students using WBH spent an average of thirty minutes to an hour more each week on homework than paper-based homework students (Bonham et al., 2001). They say the reason is that students get credit for doing paper homework whether it is right or not, but online homework only gives credit for correct answers.

Finally, a study by Caruso (2004) also found problems with educational technology in that many students believed it was extra work to learn the software and the course material. Some of them had trouble running the applications or web pages on their computers, some had trouble printing and several lacked technical support.

Before the use of WBH became commonplace, Eskew and Faley (1988) examined determinants of accounting students' performance and found past academic performance to be the best indicator of future performance, in that grades predict other grades. A study by Palocsay and Stevens (2008) also found GPA to be the best predictor of student performance. Research that has examined personal characteristics as predictors of student success such as Cron et al., (2005), found a negative relationship between negative emotions and student performance. They report a negative relationship between student performance and low learning goals and no significant relationship between student performance and high learning goals. In other words, students with high learning goals will experience negative emotions, but the emotions will be neutralized, whereas a student with low learning goals will experience a negative emotion, and it will affect their performance. From this, we would expect negative emotions with the WBH software to have a negative impact on student performance, particularly on students with low learning goals. However, the negative emotions used in Cron's study involved more than just frustration; they also included anger, fear, disappointment, shame and discomfort. This study examined frustration and student performance.

Frustration

Doob and Sears (1939) define frustration as interference with goal-directed behavior. Frustration is an emotional state that arises when a person is attempting to reach a goal and is thwarted (Berkowitz, 1989). From the IT literature, Bessiere et al. (2006) wrote that "nearly every computer user has, at one time or another, experienced frustration" (p. 942). Frustration is present when a person has a limited amount of time to complete a task and something occurs to thwart its progress. For example, a professor may have ten minutes to type and print a document. Everything is going fine, and she clicks the print button with two minutes to spare. However, the printer fails to print. She does not understand how the printer works, but she knows it is supposed to print. In addition, when students use online homework grading systems, they read a problem and enter an answer. If the answer is correct, they move on, but if the answer is incorrect, they must repeat the process. Are they frustrated? Frustration is likely to be present in every computer application.

Another study that has included frustration as an emotion is by Hove and Corcoran (2008). They reported the effect of educational technologies and their impact on learning by demonstrating that use of a virtual learning environment, such as Blackboard, resulted in higher levels of frustration than occurred in normal lecture classes. Based on their findings, we believe online students will experience more frustrating events.

H1: Online students experience higher levels of frustration associated with using technology for learning than face-to-face students

Usefulness

Other characteristics of educational technology are important to our study. Gunawardena and Duphorne (2000) reported that a technology's usefulness is more important to students than its ease of use. In information systems research, usefulness is defined as the user's subjective probability that the technology will increase job performance (Davis et al., 1989). The relationship between usefulness and student performance is also tested in our study.

We began this study with the belief that most students seem to like technology. We further believe that students who select an online course may do so because of their affinity for technology. Since technological usefulness is determined by the user's belief in the technology's ability to help a user attain a goal, it seems logical to believe that students taking the course online will believe the technology is more useful than face-to-face students. TAM, the Technology Acceptance Model (Davis et al., 1989), is a model of why people use technology. His study found that at the beginning of a fourteen-week period, behavioral intention to use and ease of use were both influential in determining use, but at the end of the period, intention to use was affected directly by usefulness. From this, WBH would be expected to be adopted and used by students because of its usefulness after the instructor demonstrates how to use it. Based on TAM, over time the students should use it because of its ability to help them complete their job of learning accounting and finishing their homework.

H2: Online students report higher scores for the usefulness of the web-based homework software

Self-Efficacy

Bandura (1977) defined an outcome expectancy as one's estimate that a particular behavior or act will lead to a particular result or outcome. He defined efficacy expectation as the conviction one has about one's ability to successfully execute the act required to produce the desired outcome. "The strength of people's convictions in their own effectiveness is likely to affect whether they will even try to cope with given situations… The stronger the perceived self-efficacy, the more active the efforts" (p. 193). Cennamo (1991) wrote that self-efficacy is the degree to which a student feels capable of learning from a given method.

Artino (2010) found that self-efficacy, achievement emotions and satisfaction can predict a student's choice to take an online course or a face-to-face course. He believed that online students had higher levels of self-efficacy. Our third hypothesis is based on his study which predicted choice based on self-efficacy. Our study will test to see if online students do indeed have higher levels of self-efficacy than face-to-face students.

H3: The level of self-efficacy is higher for online students than for face-to-face students.

Technical Efficacy

If self-efficacy is a belief that you can produce a desired effect by your actions, then technical efficacy is the belief that you can use technology to reach a goal or complete a task. Technical efficacy has to do with the level of confidence one has about one's own ability to use technology.

Compeau and Higgins (1995) found that computer self-efficacy can influence one's use of technology and Durndell and Haag (2002) found that higher computer self-efficacy was related to an increased use of the internet.

If self-efficacy is the degree to which a student feels capable of learning from a given method (Cennamo, 1991) and computer self-efficacy can influence one's use of technology (Compeau and Higgins, 1995) and higher computer self-efficacy is related to higher use of the internet (Durndella nd Haag, 2002), then a high level of technical-efficacy should induce a student to take a course online. We believe that if technical-efficacy is high the student will have faith in his or her ability to complete the course online. We believe that online students will report higher technical efficacy scores than face-to-face students.

H4: Online students report higher technical efficacy scores than face-to-face students

Textbook publisher John Wiley and Sons disclosed in their Annual Report (2009) that their higher education division sales totaled $230 million with 9% of their sales attributed to WileyPLUS, their version of web-based homework solutions. McGraw-Hill launched Connect in 2009, their exchange that supports a WBH product. Their Annual Report states "As technology continues to be the key trend in higher education for course management and content delivery [we] will aggressively pursue a variety of e-initiatives, including electronic books, homework support for students and online faculty training (2009, 39).” Publishers provide it, but faculty members assign it. We hope that faculty members are assigning it because they believe it will be useful to students. Therefore, our last hypothesis follows:

H5: The use of technology for learning enhances student performance

A theoretical model of our research is presented in Figure 1. The model is based on the following research:

	Previous Study Examined	**Source**
1.	Self-efficacy is positively related to Technical-efficacy and Usefulness, Homework, and Test grades	Agarwal and Karahanna, 2000; Bandura, 1977
2.	Technical-efficacy is related to Usefulness and Frustration	Bandura, 1977
3.	Usefulness has an effect on Homework and Test grades	Davis, 1989
4.	GPA is a significant predictor of Homework and Tes scores	Eskew and Faley, 1988

FIGURE 1
Theoretical Model

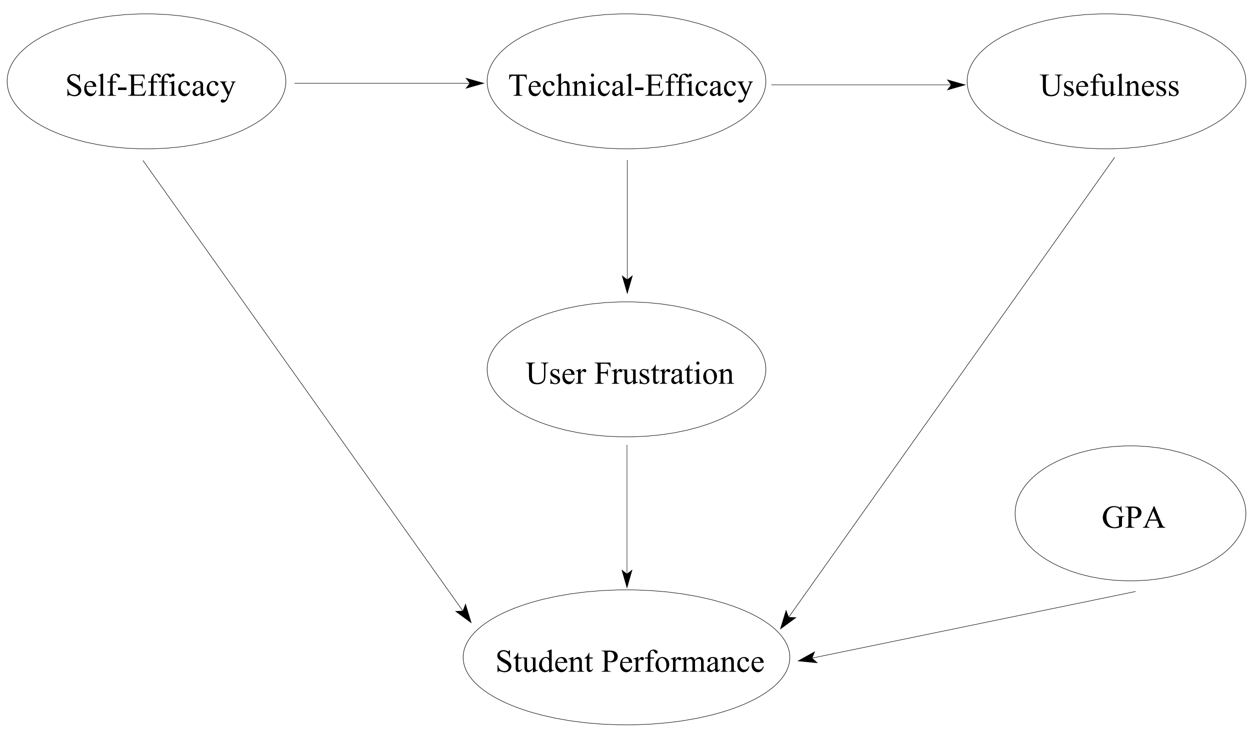


TABLE 1

Descriptive Statistics

	All Students	Face-to-Face Students	On-line Students
Age			
18-21	68.0%	73.0%	59.0%
22-27	18.0%	19.1%	19.0%
28-39	9.5%	5.0%	19.0%
40 and over	4.5%	2.8%	7.0%
Gender			
Male	43%	44%	42%
Female	57%	56%	58%
Where do you live?			
On campus	26.1%	31.2%	17.3%
Walk to campus	17.1%	18.4%	14.8%
Off campus	56.8%	50.4%	67.9%
Prior experience with homework software?			
Yes, in accounting class	11.4%	13.6%	9.0%
Yes, in class other than accounting	41.3%	24.3%	46.8%
Yes, accounting and another class	38.3%	56.4%	31.5%
No	9.0%	5.7%	12.6%

RESEARCH DESIGN

Students at a large (17,000 students) public, southern institution, in eight principles of accounting classes completed the same survey three times during a semester. The students all had the same instructor who administered the survey over two consecutive semesters. This study used existing scheduled classes. There were roughly 100 accounting majors using Wiley Plus, sixty non-majors used Connect by McGraw Hill for financial accounting, and the remaining 200 students taking managerial accounting used Cengage Now. The students were required to work all homework problems using the WBH software. Table 1 presents the age, gender, location and prior experience of the students in total and divided into online and face-to-face groups.

INSTRUMENTATION

In Table 2, T1 refers to the first time the survey was conducted which was two weeks after the start of the term; T2 refers to the time the second survey was conducted which was after the second test in week nine; and, T3 was at the end of the term after the final exam in week 15. We wanted to establish how students felt about the use of web-based homework and whether those feelings changed over time. We used a Likert scale where 1 indicates “strongly agree” and 5 indicates “strongly disagree.” In total, 368 students completed all three surveys. There were 111 online students and 257 students taking the course face-to-face.

Frustration Construct

Bessiere et al. (2002) and Ceaparu et al. (2004) defined user frustration as being thwarted in one's progress by a technical issue. Students use WBH software to complete accounting homework assignments which present technical challenges to master while learning accounting principles. Ceaparu et al. (2004) provides the basis for the frustration construct in the questionnaire as:

- 1 - I feel anxious when I run into a problem on the computer or have a problem with the web-based homework software.
- 2 - I feel helpless when I encounter a problem on the computer or have a problem with the web-based homework software.
- 4 - Frustrating experiences with the web-based homework software severely impacted my ability to get the assignment completed.

Perceived Usefulness Construct

Davis et al. (1989) defined perceived usefulness as the user's belief that the technology will improve or increase his or her job performance. Usefulness is an important construct in information systems research. Brown et al. (2002) explored the use of mandated technology in the banking industry. In testing the perceived usefulness construct, they asked people to respond to the statements, "[the software] enables me to accomplish tasks more quickly," "[the software] has improved the quality of the work I do," and "[the software] gives me greater control over my job." These statements were adapted for use in the questionnaire as:

- 1 - Using web-based homework software enables me to finish the homework assignment faster than if I used paper.
- 2 - Web-based homework software has improved the quality of the work I do compared to paper homework.
- 3 - Web-based homework software gives me greater control over my work compared to paper homework.

Self-Efficacy Construct

Bandura (1974) described self-efficacy as a belief in oneself giving the feeling that one is capable of behaving in a way that will allow for the achievement of goals. Greene and Miller (1996) found evidence to support a connection between self-efficacy, an attitude of mastery learning, and successful achievement of student goals. Their survey included the statement, "I can do well on this exam." This was the basis for the self-efficacy construct in the questionnaire as:

- 1 - I can complete homework assignments successfully.
- 2 - When I work accounting problems using the web-based homework software, I can get the right answers.

Technical Efficacy Construct

Sitzmann et al. (2008) report that technology self-efficacy, known as technical-efficacy, refers to trainees' confidence in both their computer skills and their ability to overcome technical difficulties. Agarwal and Karahanna (2000) found that personal innovativeness, their term for technical efficacy which is based on a willingness to try out new technology, was an antecedent to cognitive absorption and perceived usefulness but was not related to self-efficacy. One technical

TABLE 2

Item Responses

Survey Questions and student responses at Time T1, T2, and T3 showing the percentage of students answering Strongly Agree, Agree, Neutral, Disagree, and Strongly Disagree followed by the mean response of all students compared to the means of the online students and the means of in-person students. Any significant differences are noted in the last column.

		Percent Responses By All Students					Mean			
	T1, T2, or T3	1 Strongly Agree	2 Agree	3 Neutral	4 Disagree	5 Strongly Disagree	All Students	Online Students	In-Person Students	P-values
Frustration										
I feel anxious when I run into a problem with the web-based homework software.	T1	10.6	38.0	20.7	25.3	5.4	**2.77**	3.05	2.65	**.002**
	T2	7.1	40.2	24.7	26.4	1.6	**2.75**	2.85	2.71	.225
	T3	7.6	42.4	21.2	25.0	3.8	**2.75**	2.81	2.72	.460
I feel helpless when I encounter a problem on the computer or have a problem with the web-based homework software.	T1	5.2	21.7	23.4	39.1	10.6	**3.28**	3.43	3.22	.080
	T2	5.4	27.2	26.1	37.0	4.3	**3.08**	3.14	3.05	.464
	T3	5.7	28.5	22.6	35.3	7.9	**3.11**	3.15	3.09	.628
Frustrating experiences with the web-based homework software severly impacted my ability to get the assignment completed.	T1	3.2	13.1	27.5	42.8	13.5	**3.50**	3.67	3.42	**.030**
	T2	2.7	18.5	26.6	42.4	9.8	**3.38**	3.38	3.38	.979
	T3	6.3	18.0	35.1	32.4	8.1	**3.23**	3.23	3.23	.995
Usefulness										
Using web-based homework software enables me to finish the homework assignment faster than if I used paper.	T1	20.3	41.4	27.9	9.5	0.9	**2.27**	2.10	2.34	**.025**
	T2	15.8	45.9	30.2	8.1	-	**2.28**	2.33	2.26	.438
	T3	18.5	47.3	23.4	10.8	-	**2.23**	2.27	2.21	.524
Web-based homework software has improved the quality of the work I do compared to paper homework.	T1	13.1	46.4	26.1	13.1	1.4	**2.40**	2.23	2.47	**.017**
	T2	12.6	46.8	28.8	11.7	-	**2.33**	2.30	2.34	.651
	T3	18.0	41.9	27.5	12.2	0.5	**2.35**	2.23	2.40	.099

(continued)

TABLE 2 (continued)

		Percent Responses By All Students					Mean			
	T1, T2, or T3	1 Strongly Agree	2 Agree	3 Neutral	4 Disagree	5 Strongly Disagree	All Students	Online Students	In-Person Students	P-values
Web-based homework software gives me greater control over my work compared to paper homework.	T1	19.4	45.0	22.5	11.7	1.4	**2.30**	2.00	2.43	**.000**
	T2	14.9	45.5	31.1	8.6	-	**2.29**	2.17	2.34	.093
	T3	16.2	48.6	26.1	8.1	0.9	**2.28**	2.12	2.35	**.019**
<u>Self-Efficacy</u>										
I can complete homework assignments successfully.	T1	47.7	47.3	4.5	0.5	-	**1.60**	1.47	1.65	**.010**
	T2	35.1	59.0	4.1	1.8	-	**1.69**	1.70	1.69	.853
	T3	40.5	52.7	5.0	1.8	-	**1.67**	1.64	1.68	.614
When I work accounting problems using the web-based homework software, I can get the right answers.	T1	34.2	48.2	14.9	2.7	-	**1.83**	1.71	1.89	**.037**
	T2	27.0	55.4	13.1	4.5	-	**1.88**	1.88	1.88	.996
	T3	30.6	55.9	10.4	2.3	0.9	**1.84**	1.83	1.84	.851
<u>Technical-Efficacy</u>										
I tried to discover new functions in the web-based homework software (calculator, hints, etc.)	T1	14.0	45.0	25.2	14.0	1.8	**2.46**	2.38	2.50	.249
	T2	13.1	54.1	20.3	11.7	0.9	**2.34**	2.27	2.37	.328
	T3	17.1	45.5	23.4	13.5	0.5	**2.33**	2.20	2.39	.070
If I heard about a new information technology, I would look for ways to experiment with it	T1	18.5	56.8	19.8	5.0	-	**2.18**	2.01	2.25	**.008**
	T2	18.9	59.9	16.2	4.1	-	**2.09**	2.00	2.13	.149
	T3	21.2	51.8	22.1	5.0	0.9	**2.16**	2.17	2.16	.870
Using a computer is an efficient way for me to learn new things.	T1	34.7	56.8	7.2	1.4	-	**1.77**	1.64	1.83	**.016**
	T2	27.9	59.5	12.2	0.5	-	**1.82**	1.71	1.86	**.032**
	T3	32.9	55.9	11.3	-	-	**1.79**	1.74	1.81	.316

efficacy item in the questionnaire was adapted from their work. This item was phrased, “If I heard about a new information technology, I would look for ways to experiment with it.”

Santhanam et al. (2008) investigated e-learning-based IT training and used a construct called computer (learning) self-efficacy. In their study, learners were trained through a computer-based program so it was presumed that their self-efficacy beliefs regarding learning through computers would influence learning outcomes. They found a significant relationship between computer self-efficacy and learning. They asked users to respond to the statement, "Using a computer is an efficient way for me to learn new things." This question appears to be at the heart of this study so it was included.

- 1 – I tried to discover new functions in the web-based homework software (calculator, hints, etc.)
- 2 – If I heard about a new information technology, I would look for ways to experiment with it.
- 3 – Using a computer is an efficient way for me to learn new things.

Student Performance Construct

Student performance, the dependent variable at time T1 is composed of homework grades and the grade from their first test about week six. At time T2, student performance is measured by the homework grades from T1 to T2 and the second test grade. At time T3, student performance is composed of homework grades since time T2 and the student's final exam grade.

ANALYSIS OF DATA

We collected data and used SPSS to determine the mean response of all students, the mean response of online students and the mean response of in-person students. Our first hypothesis was:

H1: Online students experience higher levels of frustration associated with using technology for learning than in-person students.

As seen in Table 2, online students reported a lower level of frustration at time T1 for items one and three only. In fact, the online students never report more frustration than the face-to-face students. The results, therefore, do not support H1. However, this result could be because people who experience a high level of frustration with computers might not have signed up for an online course.

H2: Online students report higher scores for the usefulness of the web-based homework software.

The results were mixed and only show full support for H2 at T1. The average response for online students for all three items reflected they were more positive in their belief that the technology was useful. However, by T3, there was only a significant difference in the two groups in that the online students believed the software gave them greater control over their work. In previous research (Khanlarian et al., 2010), we noted that students have preconceived ideas about multiple aspects of the software, including its usefulness, and their perceptions change over time. With our current research design, it is difficult to ascribe the change to time alone and rule out aspects such as different software products producing different results. Future research will examine differences across software packages to see if some web-based homework software exhibit different characteristics.

H3: The level of self-efficacy is higher for online students than for in-person students.

As shown in Table 2, H3 is supported at time T1 only. The online students began the semester with a higher level of self-efficacy, but there was no significant difference between the two groups after T1. By the end of the term, the student responses were very similar, leading us to believe that their experiences helped shape their views.

H4: The level of technical-efficacy is higher for online students than for in-person students

As presented in Table 2, the results for testing H4 are mixed for the three technical-efficacy questions asked. Based on the student responses to the technical-efficacy items, our assumption that online students would report higher technical-efficacy was not supported for the first question. There was no significant difference in the responses of the two groups. There was a difference in the responses for the second item at time T1, with online students more inclined to experiment with the software. There was also a difference in the responses for the third item at times T1 and T2. However, by T3, those differences had disappeared. It appears that online students lost some confidence in their ability and face-to-face students gained some over time.

H5: The use of technology for learning enhances student performance

We used structural equation modeling to test H5. After collecting the data, we used SPSS to compute the Correlation Matrix (Table 3). The matrix revealed that Technical-Efficacy was significantly related to Usefulness, and Usefulness was significantly related to Self-Efficacy. It also showed that Self-Efficacy was significantly related to Frustration. We used those paths to create our model. However, before we could run the model, we had to compute Cronbach's alpha to test the reliability of each construct at T1, T2 and T3. According to Chin (1998), Cronbach's alpha should be 0.7 or higher to provide evidence of a reliable construct; however, in exploratory studies such as this one, 0.6 and above is viewed as acceptable. (Using SPSS we ran principal component analysis. We also computed six scores: Average Variance Explained (AVE), Composite Reliability, R-squared, Cronbach's Alpha, Communality, and Redundancy. All were within established parameters and are available upon request.) Construct reliability scores appear in Table 4.

Data had been collected at three different times. We had to decide which set of data to use first. Data from time T1 might be skewed by people who had never used WBH before. Time T3 data might reflect students who were "blaming" the technology for their grade in the course. Therefore, time T2 data was used for analysis first. Subsequently, the procedure was repeated with time T1 data and then time T3 data.

We used SmartPLS software to create a model. Chin (1998) recommends the software as it is more efficient for exploratory use. R-square values of 0.19 are weakly predictive while 0.33 is moderately predictive and 0.67 is substantially predictive (Hubona, 2010).

The model in Figure 2 uses all students at time T2. There are significant paths between all constructs except the path from Usefulness to Student Performance (-0.00). The Frustration to Student Performance path is significant at the $p<.01$ level (-0.15). Student performance is at the weakly predictive level (R-squared = 0.27).

TABLE 3

Correlation Matrix (Time Period 2)
Pearson Coefficient (significance level)

	Frustration 1	Frustration 2	Frustration 4	Usefulness 1	Usefulness 2	Usefulness 3	Self-Efficacy 1	Self-Efficacy 2	Technical-Efficacy 1	Technical-Efficacy 2	Technical-Efficacy 3
Frustration 1	1										
Frustration 2	.571**	1									
Frustration 4	.334**	.523**	1								
Usefulness 1	-.031	-.136**	-.119	1							
Usefulness 2	-.048	-.123*	-.108*	.585**	1						
Usefulness 3	-.015	-.144**	-.153**	.489**	.704**	1					
Self-Efficacy 1	-.197**	-.260**	-.346**	.253**	.305**	.251**	1				
Self-Efficacy 2	-.194**	-.246**	-.277**	.307**	.292**	.254**	.608**	1			
Technical-Efficacy 1	.025	-.029	.020	.194**	.244**	.223**	.084	.074	1		
Technical-Efficacy 2	-.019	-0.32	-.024	.294**	.358**	.302**	.205**	.167**	.501**	1	
Technical-Efficacy 3	-.092	-.193**	-.247**	.497**	.469**	.430**	.331**	.356**	.253**	.483**	1

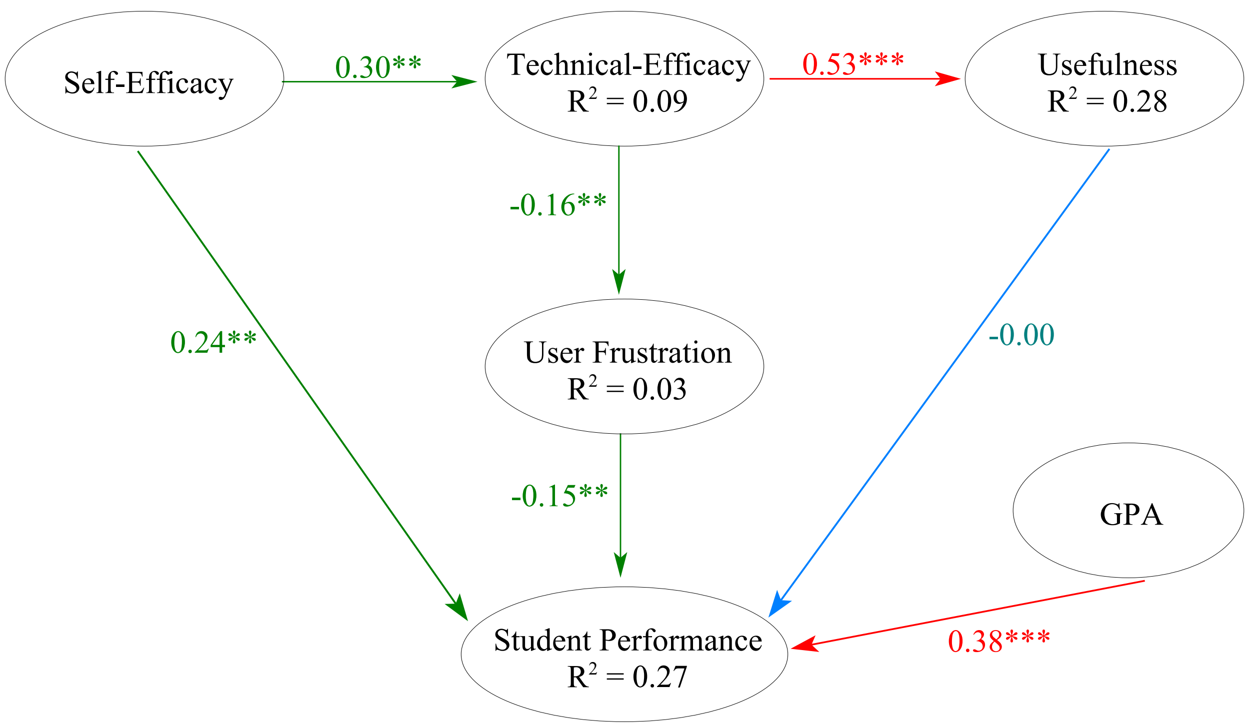
** Correlation is significant at the 0.01 level (2-tailed).
* Correlation is significant at the 0.05 level (2-tailed).

TABLE 4

Test of Construct Reliability (Cronbach's Alpha)

	Time T1	Time T2	Time T3
Frustration	0.787	0.733	0.821
Usefulness	0.807	0.814	0.814
Self-Efficacy	0.705	0.754	0.823
Technical-Efficacy	0.658	0.672	0.738

FIGURE 2
All Students at Time T2



Path Coefficients:
No asterisk = not significant
* Significant at $p < 0.05$
** Significant at $p < 0.01$
*** Significant at $p < .001$

TABLE 5

Path Coefficients, Significance, and R-Squared for All Students at Times T1, T2, and T3

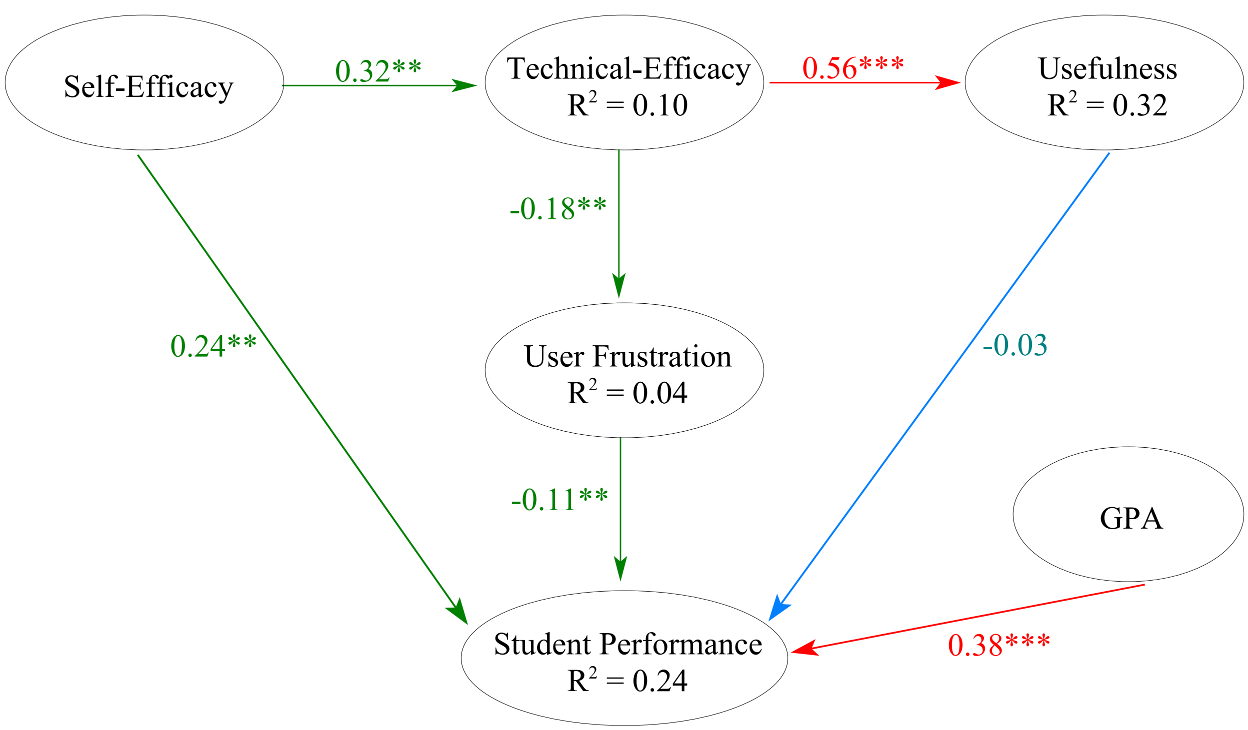
	All Students T1		All Students T2		All Students T3	
	Path Coefficients	Significance	Path Coefficients	Significance	Path Coefficients	Significance
Technical-Efficacy to Usefulness	0.58	p<.001	0.53	p<.001	0.59	p<.001
Self-Efficacy to Technical-Efficacy	0.35	p<.001	0.30	p<.01	0.36	p<.001
Technical-Efficacy to Frustration	-0.20	p<.01	-0.16	p<.01	-0.12	p<.01
Self-Efficacy to Student Performance	0.21	p<.01	0.24	p<.01	0.25	p<.01
Usefulness to Student Performance	-0.04	Not sig.	-0.00	Not sig.	-0.09	Not sig.
Frustration to Student Performance	-0.08	Not sig.	-0.15	p<.01	-0.15	p<.05
GPA to Student Performance	0.31	p<.001	0.38	p<.001	0.32	p<.001
Regression Model Dependent Variable	R-Squared		R-Squared		R-Squared	
Usefulness	0.33		0.28		0.34	
Technical-Efficacy	0.12		0.09		0.13	
Frustration	0.04		0.03		0.02	
Student Performance	0.17		0.27		0.23	

We ran the model again; this time using the data collected at times T1 and T3. Table 5 presents the path coefficient, R-squared and significance levels at times T1 and T3.

The paths are significant, but the R-squared value is only weakly predictive. The construct User Frustration, dealing with technology, appears to affect Student Performance as measured by grades. The construct Usefulness, also dealing with technology, does not appear to affect Student Performance. Thus, the results show some support for H5.

Running the model with the data from the in-person group explains even less of the model, as seen in Table 6 and Figure 3. The technology constructs do not appear to affect student performance. At the second measuring point, Usefulness as a construct has no significant relationship with the student's performance (-0.03). Also, User Frustration is only slightly a predictor of Student Performance at T2 (-0.11), having increased in size from T1 (-0.07). The Student Performance R-squared has dropped from 0.27 to 0.24, but is still in the weakly predictive range. The relationship between Self-Efficacy and Student Performance remains unchanged (0.24). There does not appear to be a story here.

FIGURE 3
In-Person Students at Time T2



Path Coefficients:
No asterisk = not significant
* Significant at $p < 0.05$
** Significant at $p < 0.01$
*** Significant at $p < .001$

TABLE 6

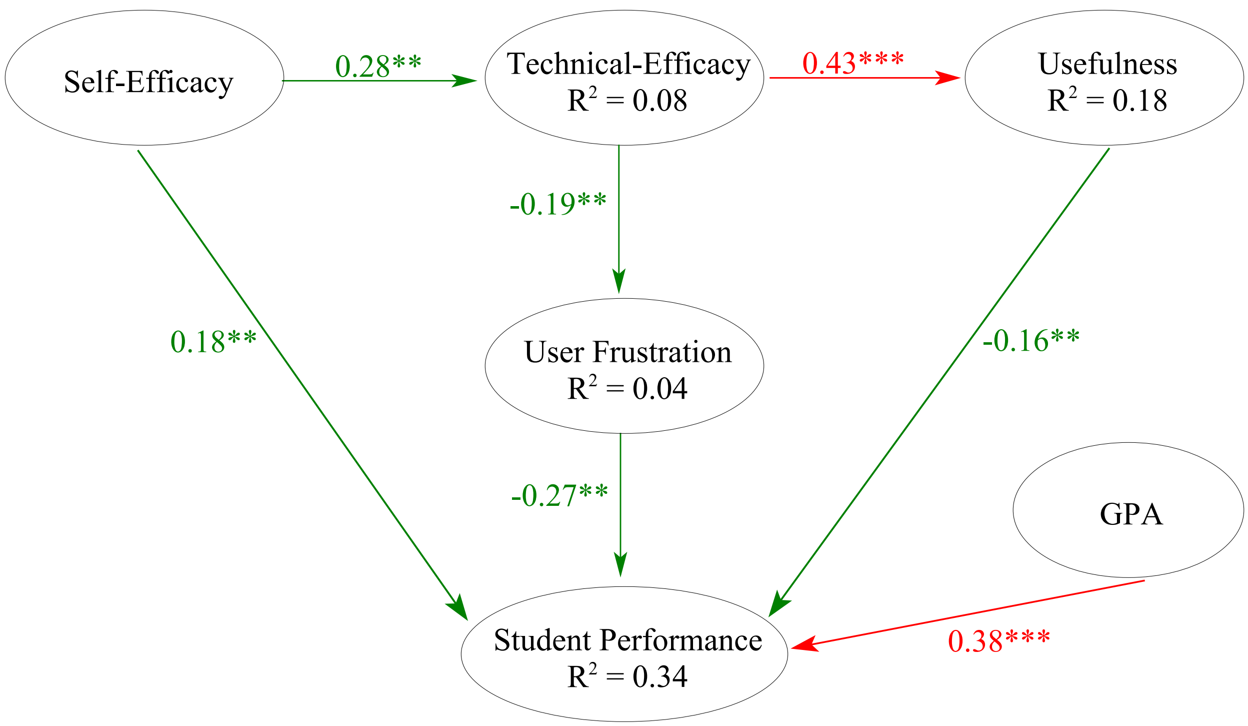
Path Coefficients, Significance, and R-Squared for In-Person Students at Times T1, T2, and T3

	In-Person Students T1		In-Person Students T2		In-Person Students T3	
	Path Coefficients	Significance	Path Coefficients	Significance	Path Coefficients	Significance
Technical-Efficacy to Usefulness	0.58	p<.001	0.56	p<.001	0.61	p<.001
Self-Efficacy to Technical-Efficacy	0.37	p<.001	0.32	p<.001	0.40	p<.001
Technical-Efficacy to Frustration	-0.18	p<.01	-0.16	p<.01	-0.16	p<.01
Self-Efficacy to Student Performance	0.18	p<.01	0.24	p<.01	0.18	p<.01
Usefulness to Student Performance	-0.04	Not sig.	-0.03	Not sig.	-0.05	Not sig.
Frustration to Student Performance	-0.07	Not sig.	-0.11	p<.05	-0.15	p<.01
GPA to Student Performance	0.34	p<.001	0.36	p<.001	0.31	p<.001

Regression Model Dependent Variable	R-Squared	R-Squared	R-Squared
Usefulness	0.34	0.32	0.38
Technical-Efficacy	0.13	0.10	0.16
Frustration	0.03	0.04	0.02
Student Performance	0.18	0.24	0.17

However, when the model is run using online student data, the R-squared value of Student Performance becomes moderately predictive. As seen in Figure 4 and Table 7, the relationship between Perceived Usefulness and Student Performance (-0.16) also becomes significant and the relationship between Technical-efficacy and Usefulness is still very strong (0.43). The R-squared value has improved to become moderately predictive (0.34). An additional crosstabs analysis revealed that online students with lower test scores believed the software was slightly more useful than face-to-face students or "A" students. Of the online students who scored an "A" or "B" on the exam, 8.1% believed the software did NOT help them finish faster, while all of the "D" or "F" students believed it helped them finish faster. "A" and "B" students who think it is not useful combined with "D" and "F" students who think it is useful, partially explain why the relationship is negative.

FIGURE 4
Online Students at Time T2



Path Coefficients:
No asterisk = not significant
* Significant at $p < 0.05$
** Significant at $p < 0.01$
*** Significant at $p < .001$

TABLE 7

Path Coefficients, Significance, and R-Squared for Online Students at Times T1, T2, and T3

	In-Person Students T1		In-Person Students T2		In-Person Students T3	
	Path Coefficients	Significance	Path Coefficients	Significance	Path Coefficients	Significance
Technical-Efficacy to Usefulness	0.52	p<.001	0.43	p<.001	0.49	p<.001
Self-Efficacy to Technical-Efficacy	0.27	p<.001	0.28	p<.01	0.27	p<.001
Technical-Efficacy to Frustration	-0.19	p<.01	-0.19	p<.01	-0.02	Not sig.
Self-Efficacy to Student Performance	0.25	p<.001	0.18	p<.01	0.39	p<.001
Usefulness to Student Performance	-0.13	p<.05	-0.16	p<.01	-0.17	p<.01
Frustration to Student Performance	-0.09	Not sig.	-0.27	p<.01	-0.13	p<.01
GPA to Student Performance	0.25	p<.001	0.38	p<.001	0.37	p<.001

Regression Model Dependent Variable	R-Squared	R-Squared	R-Squared
Usefulness	0.27	0.18	0.24
Technical-Efficacy	0.07	0.08	0.08
Frustration	0.04	0.04	0.01
Student Performance	0.17	0.34	0.38

The relationship between Technical Efficacy and Perceived Usefulness is always significant at the $p<.001$ level, even when we separate the students into online and face-to-face groups. These constructs are very strongly related. It is also interesting to note that Technical-Efficacy and Frustration are negatively related. The students who believe in their ability to complete the assignments did NOT report feeling anxious or helpless and did NOT report frustrating events.

CONCLUSION

In examining the responses of the in-person group, the technology constructs do not appear to have much of an effect on Student Performance. However, the responses of the lower scoring members of the online group lead us to believe that technology and frustration are significant issues that affect their performance. Interestingly, the lower scoring students also believe the software is more useful than the students who scored higher on the exam.

There are several limitations in this study. The study uses theory to derive concepts that are used as constructs in the exploration of factors that influence student performance in the WBH learning environment. Theory provides useful guidance in the identification of these factors. However, this study does not incorporate a complete view of the theoretical foundations from which the concepts and constructs are derived. In doing so, the current study is limited by an incomplete view of the theoretical foundations on which it is based. A more nuanced examination of the underlying theoretical concepts would enhance the richness of the theory-guided examination of the factors in the WBH learning environment that impact student performance. The models are based on responses from the students at one university. It is possible that other students would not answer the same way. The same person was the teacher to all students involved in this study. They may respond differently for different teachers. Also, there is normally a 25% D, W, or F rate for these classes. That could mean that the students who remained for the entire study are more persistent or more motivated. This may have skewed the data.

This paper helps educators and students understand that frustration with technical aspects of on-line learning environments is prevalent, and it has significant impact on students' performance. Moreover, the paper suggests that the impact of frustration changes over the course of the academic terms. This provides educators the opportunity to anticipate for students' frustration and design for it in their pedagogy. In addition, it provides students the opportunity to understand their frustration and mitigate its impact on their performance. For designers, the paper provides valuable insight and guidance to improve design of web-based homework software and online learning environments. Importantly, the authors hope that researchers would validate and extend our research on the impact of technology related factors, including frustration on students' learning outcomes to provide evidence-based guidance to educators, students, and technologists and drive significant improvements in prevalent and pervasive online learning environments.

Ours was an exploratory study. Our next step will be to refine the questionnaire to focus on frustration and its impact on student performance. We will also need to investigate the impact of frustration on students with higher grades compared to the effect on students with lower grades. Finally, an in-depth examination of these constructs in addition to a persistence construct and/or other emotional constructs might be interesting directions for continued study of technology and its impact on student performance.

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