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More Heads Around a Screen: Pilot Findings From a Study on the Use of Tablet PCs to Support Collaborative Learning

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ABSTRACT

The use of the Tablet PC in education is a relatively new phenomenon. This paper focuses on the use of Tablet PCs to support collaborative learning with student teams '*working with and around*' the tablets. It proposes an evaluation framework to assess Tablet PCs' effectiveness. In a four week pilot study, students engaged in various collaborative learning activities using Tablet PCs in the classroom. The post-survey results indicate strong positive correlations among eight of the nine framework constructs, with "Perceived Learning Outcomes" positively correlated with every other construct except "Motivation". Results also suggest that the Technology Acceptance Model (TAM) and the concept of "Usefulness" in particular may play a significant role in influencing "Perceived Learning Outcomes" and "Time Management" strategies when using Tablet PCs for collaborative learning.

Keywords

Collaborative Learning, Active Learning, Tablet PCs, Technology Acceptance Model

INTRODUCTION

The use of Tablet PCs (TPC) in education is a relatively recent phenomenon. However, research thus far seems to indicate a promising future for the use of the TPC in education (Willis and Miertschin, 2004). The focus and purpose of this paper is to gain a better understanding of how TPCs may be used to support and/or enhance Team Based or Collaborative learning. Current literature on the use of TPCs suggests that the benefits of using TPCs in an educational setting are multifaceted. Results of searches of both educational and management scholarly databases reveal that further research is needed. In particular, more discussion is needed on the use of "digital ink" and its impact on team-based and collaborative learning. To further explore the potential of collaborative learning, the design of this study limits the number of TPCs to one per team. A post-test only experimental design (Cook, Campbell and Peracchio, 1990) is used to explore students' impressions and reactions to the TPC itself. The objective of the study is to create an environment for collaborative learning and interactions (literally, more heads around a highly mobile and movable screen).

This paper is organized as follows. First, selected issues from previous research and literature are reviewed to provide a background surrounding the use of TPCs in education. Next, a theoretical framework for how TPCs impact upon collaborative learning is presented. The framework is based upon nine different constructs: "Motivation", "Enjoyment",

"Ease of Use", "Usefulness", "Perceived and Actual Learning Outcomes" (here only "Perceived Learning Outcomes" will be discussed), "Self and Collective Efficacy", "Time Management" (or time saving) and "Intention to Use." Next, there is a discussion of hypotheses related to the previously mentioned constructs, procedures and the results of a four week-long pilot study using TPCs for collaborative and team based learning. Lastly, there is a discussion of the limitations of this research and suggestions for future research.

BACKGROUND

TPCs have been found to be quite effective in lecturing and presentations; note-taking; collaborative learning (to a limited degree); interaction facilitation between and amongst students and teachers; and in grading. Table 1 presents a brief list of studies related to these various areas. In this section, we present examples focusing on the Tablet PC studies that discuss collaborative learning.

Much of the literature to date focuses on using the TPC as an enhancement to lectures and presentations (Mock, 2004). Examples of note-taking experiences with TPCs are found in (Kam, Wang, Alastair, Tse, Chiu, Glaser, Tarshish and Canny, 2005) where TPCs were used successfully for cooperative and augmented note taking. TPCs have also been used to support real-time conversation and slide annotation amongst groups of students during a lecture. Results from such activities suggest that the use of the TPC in such a collaborative environment will have a positive effect on the collective efficacy of a group engaging in collaborative learning activities.

With respect to teacher-student and Student-Student Interaction, many examples of studies where TPCs enhance teacher-student interaction as well as student-student interaction may be found in recent literature (Anderson, Anderson, Hoyer, Simon, Videon, and Wolfman, 2003; Arnett, Schmidt and Shim, 2005; Berque, Bonebright and Whitesell, 2004; Pérez-Quiñones and Turner, 2004; Simon, Anderson, Hoyer and Su, 2004; Wilkerson, Griswold, and Simon, 2005). The results of many of these studies suggest that the increased level of interaction enabled by the TPC enhances student enjoyment, perceived usefulness as well as perceived learning outcomes. Other examples of TPC use in grading and peer assessment in (Popyack and Herrmann, 2003; Simha, Hanlon, Gaiman, Kiraly, and Arai, 2005) found that the use of the TPC provides an ideal way to provide feedback on electronic submissions of term papers and other assignments.

Communication and the flexible conveyance of ideas are central to an effective educational process (Parker, 1999). In terms of collaborative learning, the TPC's extra layer of flexibility to generate "on the fly" drawings and commentary facilitates group brainstorming, discussion and interaction, which is so essential to *collaborative learning* (Alavi, 1994).
Based on findings from searches on various scholarly databases (see a summary of studies in Table 1), there seems to be limited research that centers on collaborative learning with the TPC as a key component of the learning or communication processes. In this study, we focus on increasing the evidence on collaborative applications for TPCs.

TPC Literature Summary Table						
Authors	Lecturing-Presentation	Note-Taking	Collaborative-Learning	Teacher-Student-Interaction	Student-Student-Interaction	Grading
Anderson, et al, 2004	X					
Anderson, et al, 2003	X			X		
Anderson, et al 2005	X			X	X	
Beavers, et al 2004			X		X	
Berque et al 2004	X	X	X	X	X	
Peiper et al 2005	X	X	X	X	X	
Golub, 2004	X					
Hulls, Carol C.W.	X			X		
Kam, M., et al, 2005	X	X	X	X	X	
Kim et al 2004		X				
Kam et al 2002	X	X	X	X	X	
Pérez-Quiñones et al, 2004		X	X		X	X
Simha et al, 2005						X
Ward and Tatsukawa, 2003		X				
Wilkerson et al, 2005				X	X	
Willis and Miertschin, 2004	X	X	X	X	X	

Table 1. TPC Literature Summary

RESEARCH FRAMEWORK FOR COLLABORATIVE LEARNING WITH TABLET PCS

Leveraging research in the area of technology acceptance, technology-supported and collaborative learning, we propose a theoretical framework that models the impacts of TPCs on: "Motivation", "Enjoyment", "Ease of Use", "Usefulness", "Perceived and Actual Learning Outcomes", "Self and Collective Efficacy", "Time Management" and lastly "Intention to Use" (see Figure 1). This framework is an extension of TAM (Davis, 1989).

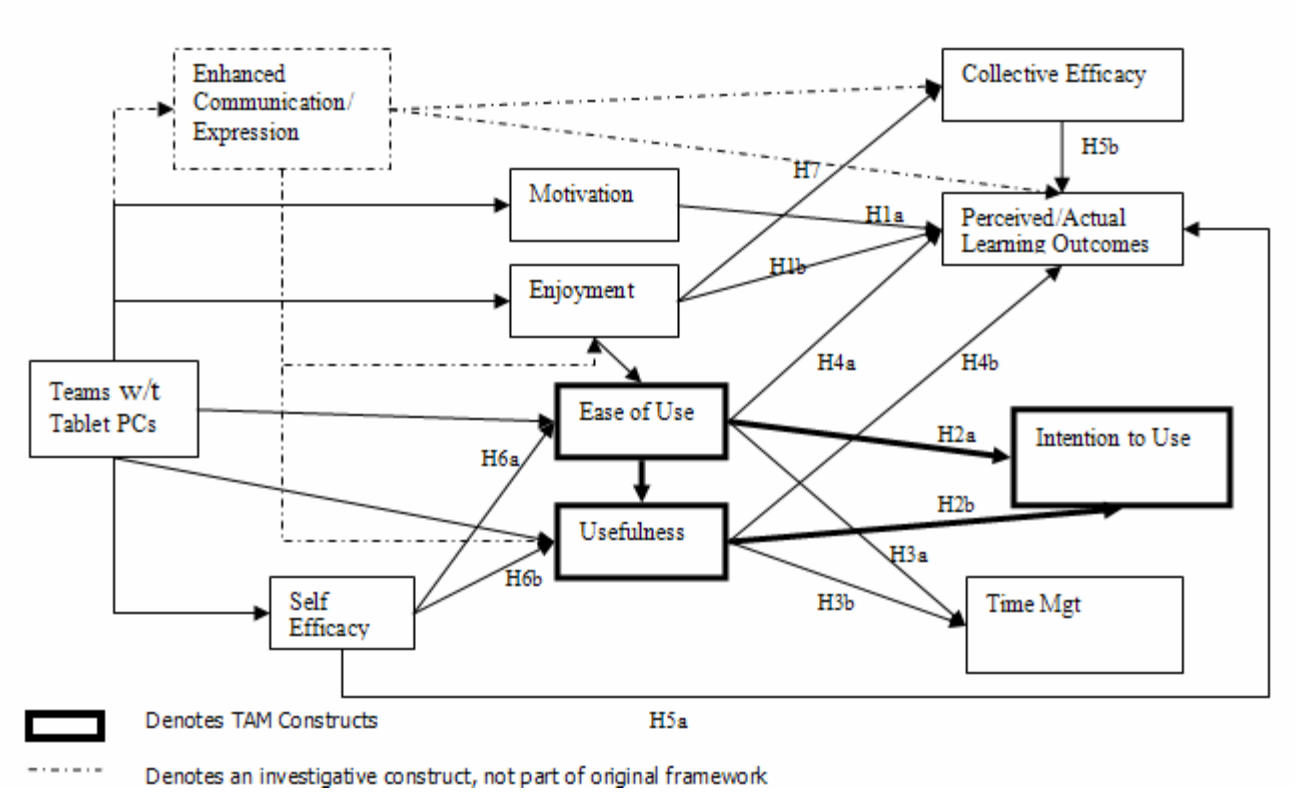

Figure 1: Collaborative Learning with Tablet PC Research Framework

In any type of learning situation the idea of "Motivation" is likely to play a crucial role (Martens, Gulikers and Bastiaens, 2004; Pintrich, 2003). It is also likely to play a role in technology acceptance as well as social interaction (Ryan and Deci, 2000; Venkatesh and Smith, 1999). It is also expected that "Enjoyment" will influence "Ease of Use", "Intention to Use" (Agarwal and Karahanna, 2000; Venkatesh, 2000), "Perceived Learning Outcomes" and the "Collective Efficacy" of the group (Alavi, 1994; Brooks and Brooks, 1993). In addition, the three main constructs of TAM (Davis, 1989) may also explain user acceptance with regard to using the TPC to learn collaboratively. Similar studies of user acceptance as related to groupware and collaborative learning are described in (Day, Hao and Van Slyke, 2004; Van Slyke, Hao and Day, 2002). Our model posits that the two constructs of perceived "Ease of Use" and "Usefulness" will positively correlate with "Perceived Learning Outcomes" and "Time Management." (Yi and Hwang, 2003).

"Self Efficacy" may be defined as "belief in one's capabilities to organize and execute the course of action required to produce a given attainment" (Bandura, 1997). It is expected to positively correlate with "Ease of Use" as well as "Perceived Learning Outcomes." Previous studies have shown a strong positive correlation between "Self Efficacy", "Perceived Learning Outcomes" and "Ease of Use" (Hiltz and Goldman, 2005; Venkatesh, 2000; Yi and Hwang, 2003; Zimmerman, 1989). Bandura also defines "Collective Efficacy" as "a group's shared belief in its conjoint capabilities to organize and execute the course of action required to produce given levels of attainment" (Bandura, 1997). (Bandura, 2000) cites numerous examples of research done on the importance of collective efficacy. In this study it is anticipated that "Collective Efficacy" will have a strong positive correlation with "Perceived Learning Outcomes".

Based on literature reviews, it appears that the TPC may also allow communication and expression to be enhanced between the instructor and the students, and amongst students. Future research will examine the relationship of the enhanced, flexible means of expression and communication that the TPC provides as a tool for computer mediated instruction, learning and its relationship to the previously described constructs.

The framework for this research may be summarized by the following hypotheses:

When using the TPC for collaborative learning:

H1a & b: *Higher degrees of "Motivation" and "Enjoyment" will increase "Perceived Learning Outcomes."*

H2a & b: *Higher degrees of perception of "Usefulness" and "Ease of Use" will increase the degree of "Intention to Use" TPCs for future tasks.*

H3a & b: *Higher degrees of the perception of "Ease of Use" and "Usefulness" will increase the "Intention to Use" the TPC for "Time Management."*

H4a & b: *Higher degrees of perception of "Usefulness" and "Ease of Use" will increase "Perceived Learning Outcomes."*

H5a & b: *Higher degrees of "Self Efficacy" and "Collective Efficacy" will increase "Perceived Learning Outcomes."*

H6a & b: *Higher degrees of "Self Efficacy" will increase perceived "Ease of Use" and "Usefulness".*

H7: *Higher degrees of "Enjoyment" will increase "Collective Efficacy."*

TASK

During the fall 2005 semester in a graduate level course on Knowledge Management which met once a week, students were assembled into 10 teams. By design, the number of TPCs were limited (one per team) since the objective of the study is to create an environment for collaborative learning and interactions (literally, more heads around a highly mobile and movable screen). Initially, five of the teams were given TPC to use in class while the remaining five groups did not. All teams were assigned the same tasks with some teams completing the task with the TPC and the other teams completing the same tasks without the TPC. The following week the teams that didn't use the TPC in the prior week were then asked to accomplish their various task(s) in class using the TPC. Thus, usage of the TPC alternated between teams each week, for a period of four weeks. As a part of the normal course load, all of the students were given various articles, case studies and websites related to the subject of Knowledge Management (KM) to read or examine in and outside of class. Four different TPC centered tasks were assigned; a different one each week. Some of the tasks included leveraging the note-taking digital ink capabilities of the TPC, including drawing concept maps and charting, and recording interview notes, while working in teams.

METHODOLOGY

To test the research hypotheses, at the end of the semester a 46 item survey was administered to elicit student reactions and impressions of the TPC. A total of 33 out of 40 students responded to the survey, which was created using previously validated scales (as briefly discussed later) that related to the earlier described constructs. All questions were designed based on a 7 point Likert-like scale where "7" reflected a most positive answer and "1" a most negative answer. The survey also included several open ended questions so that students might express their own comments. Table 2 summarizes the sources used to ground the survey questions for each of the constructs.

Study	Motivation	Ease of use	Usefulness	Intention to use	Self-Efficacy	Enjoyment	Perceived Learning Outcomes	Collective Efficacy	Time Management
(Malhotra and Galletta, 2002)	X								
(Davis, 1989)		X	X						
(Venkatesh, 2000)				X	X	X			
(Hiltz et al, 2000)							X		
(Riggs et al, 1994)								X	
(Wu, 2005)									X

Table 2: Source of Adapted Survey Questions

ANALYSIS AND RESULTS

We analyzed and coded the responses of the 33 participants. Responses were grouped by constructs ("Motivation", "Enjoyment", "Ease of Use", "Usefulness", "Perceived and Actual Learning Outcomes", "Self and Collective Efficacy", "Time Management" strategies and "Intention to Use"). Table 3 shows mean values by construct. Except for "Usefulness" all the constructs yield values that were above the middle value of four (4) on the questionnaire scale.

Construct	Means	Stdev
Motivation	4.85	1.11
Enjoyment	4.82	1.55
Ease of Use	4.38	1.43
Usefulness	3.26	1.60
Intention to Use	4.69	1.69
Self Efficacy	4.44	1.14
Collective Efficacy	4.29	0.88
Time Management	4.38	1.79
Perceived Learning Outcomes	4.08	1.21

Table 3: Means & Standard Deviations by Construct

According to TAM (Venkatesh and Davis, 2000), the construct of "Usefulness" is a key determinant of "Intention to Use." Thus it was determined that this construct should be examined more closely to determine if differences within the population concerning perception of "Usefulness" might correlate with the other constructs. Upon close examination of mean responses per respondent to 3 of the 4 survey questions related to the construct of "Usefulness", a decision was made to split the population into two groups. Respondents who had mean responses of less than 3 were designated as a member the "Low Usefulness" group and those at 3 or higher were designated as a member of the "High Usefulness" group. Such a division divided the population nearly in half with the "High Usefulness" group having 15 members and the "Low Usefulness" group having 18. After grouping all data based on either the high or low membership, T-tests, calculation of means and variance were performed to see what impact if any that membership in either group had on the other constructs (See Table 4 for results).

	High Usefulness Group		Low Usefulness Group		T-test
Construct	Mean	Var.	Mean	Var.	p
Motivation	4.49	0.93	5.15	1.31	0.04
Enjoyment	5.71	0.70	4.07	2.22	0.00
Ease of Use	5.02	1.23	3.85	1.78	0.00
Usefulness	4.77	0.79	2.00	0.47	0.00
Intention to Use	5.82	0.52	3.74	2.87	0.00
Self Efficacy	4.69	0.72	4.10	1.74	0.12
Collective Efficacy	4.46	0.57	4.16	0.95	0.17
Time Management	5.63	0.72	3.30	2.96	0.00
Perceived Learning Outcomes	4.96	0.56	3.36	1.05	0.00

Table 4: T-test Differences on Split Groups

T-tests performed on the two groups yielded a "p" of $< .05$ on all constructs except "self efficacy" and "collective efficacy". This clearly indicates a significant difference between the two groups as it relates to every construct except for the efficacy measures. Therefore this may suggest that the construct of "Usefulness" is a strong determinant of effective use of the TPC

for collaborative learning. The implication is that the tool (the TPC) must be a good fit for the learning task if it is to be deemed useful by participants in the task.

Correlation Analysis Discussion

Tables 3a and 3b show the results of a bivariate correlation analysis (Pearson's R) to determine correlations amongst the various constructs, based on the mean of the responses of each respondent grouped by construct. Also considered here is "Communication Enhancement" (i.e. did the TPC enable participant to express ideas more effectively?) While it was not defined as a construct within the original framework we pilot tested the construct of "Communication Enhancement" (CE) with one survey question. In summary, the constructs show statistically significant moderate to strong correlations (Figure 2).

	Motivation	**Enjoyment**	**Ease of Use**	**Usefulness**
	Motivation	*Enjoyment*	*Ease of Use*	*Usefulness*
Motivation	1.00			
Enjoyment	0.04	1.00		
Ease of Use	-0.05	****0.68	1.00	
Usefulness	**-0.31	****0.66	****0.57	1.00
Intention to Use	0.05	****0.86	****0.58	****0.69
Self Efficacy	0.17	0.01	-0.04	*0.27
Collective Efficacy	0.17	****0.46	****0.44	*0.28
Time Management	-0.11	****0.66	****0.43	****0.67
Perceived Learning Outcomes	0.11	****0.68	****0.46	****0.80
Communication Enhancement	0.03	****0.68	****0.59	****0.56

Table 3a: Bivariate Correlation

	Intention to Use *ITU*	**Self Efficacy** *Self Efficacy*	**Collective Efficacy** *CE*	**Time Management** *TM*	**Perceived Learning Outcomes** *PLO*	**Communication Enhancement** *CEnh*
ITU	1.00					
Self Efficacy	0.03	1.00				
CE	***0.37	-0.03	1.00			
TM	****0.71	0.14	**0.30	1.00		
PLO	****0.67	**0.32	****0.51	****0.67	1.00	
CEnh	****0.55	0.13	****0.49	****0.44	****0.68	1

Note:
*values marked with "****" means significant at α= 0.01, df = 31. "***" means significant at α= 0.025, df = 31. "**" means significant at α= 0.05, df = 31. "*" means significant at α= 0.10, df = 31.*

Table 3b: Bivariate Correlation continued

DISCUSSION

For the preliminary analysis of the data collected in this pilot, the authors focused on identifying bivariate correlations among constructs. The analysis shows that the construct of "Motivation" seemed to play no role in "Perceived Learning Outcomes." It showed no significant correlation with any other construct other than "Usefulness"; and that correlation was a negative one. This may suggest that perhaps while students were eager (motivated) to use the TPC for collaborative learning, some may have failed to see the "Usefulness" of it as it related to the task, or simply that our measurement of "Motivation" needs more refinement. A confirmatory factor analysis will be undertaken in future analyses to identify whether the questions supporting the "Motivation" construct load as a factor and the reliability of this construct.

Additionally, the construct of "Self Efficacy" significantly and positively correlated with "Perceived Learning Outcomes." However, it seemed to play no part in perception of "Ease of Use" (in fact a slightly negative relationship seems to occur with "Ease of Use"). Interestingly, these results are in stark contrast to the findings of (Yi and Hwang, 2003) regarding the relationship between these two constructs. The negative relationship of "Self Efficacy" with "Ease of Use" could perhaps be explained by the fact that multiple individuals were gathered as a group around a single TPC. Perhaps the limited number of TPCs may have prevented individuals from freely exercising self efficacy and from experiencing/perceiving "Ease of Use." However, because this preliminary analysis looks only at bivariate correlations, we have not taken into account a possible

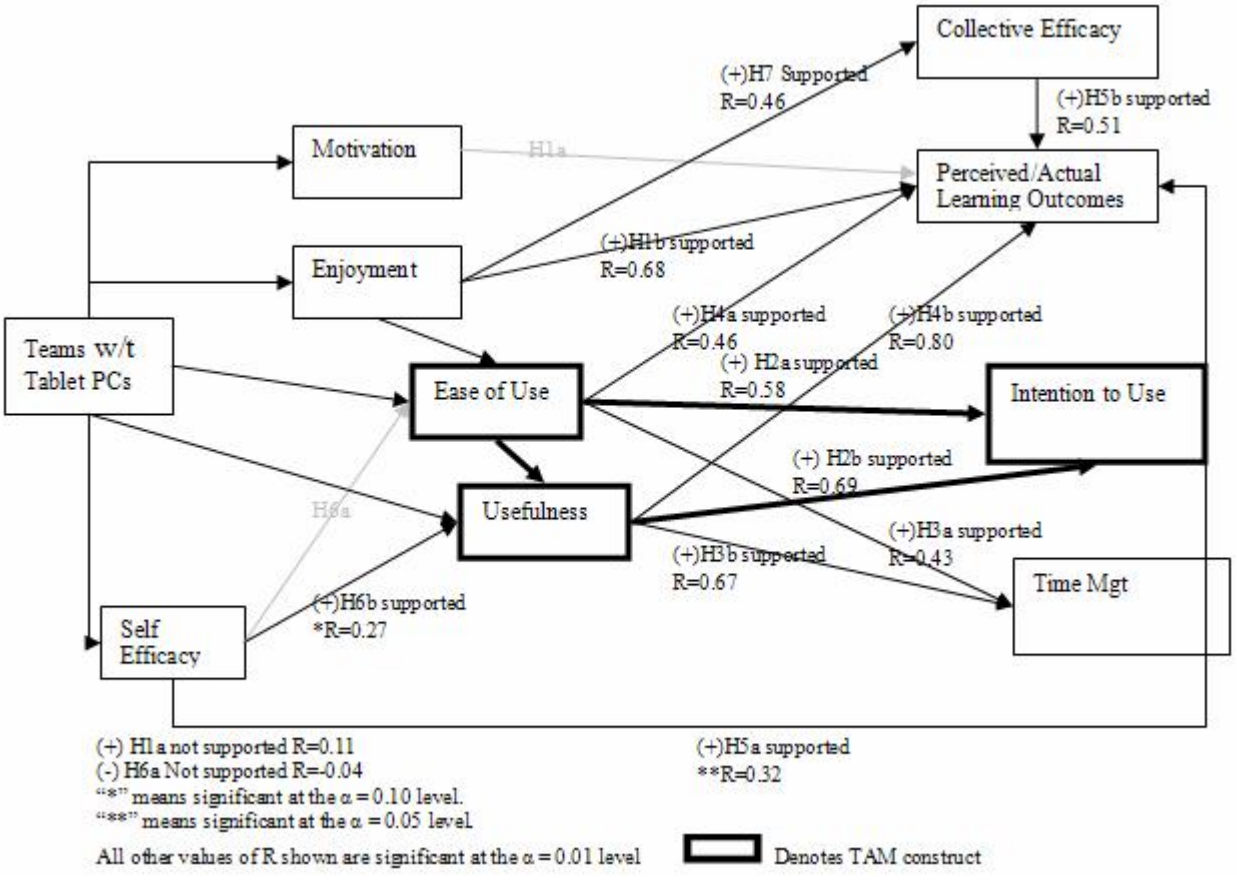

Figure 2: Significant Bivariate Correlations Results

role played by mediating and intervening variables. "Collective Efficacy" on the other hand did indeed have a significant correlation with "Ease of Use" and with "Perceived Learning Outcomes" which may suggest that when using the TPC for collaborative team-based learning, group synergy as it relates to efficacy outweighed that of any specific individual with respect to "Ease of Use." The implication may be that the group as a whole found the TPC to be an easy to use tool in coordinating/assisting in group effort. On a related note, since interaction and sharing of knowledge amongst a group of

learners is the real catalyst for collaborative learning to occur, the fact that collective efficacy had a significant positive correlation with "Perceived Learning Outcomes" highlights this approach to learning, where the group and their interactions outweigh in importance that of the single individual.

The set of significant positive correlations amongst the constructs of "Enjoyment", "Ease of Use", "" and "Intention to Use" show results and directions similar to prior research on the Technology Acceptance Model (TAM). The TAM states among other things that the constructs of "Ease of Use" and "Usefulness" will lead to "Intention to Use" (Venkatesh, 2000). The determinants of perceived "Ease of Use" are also in agreement with prior findings that suggest that "Enjoyment" correlates positively with perceived "Ease of Use" (Venkatesh, 2000). However, in (Venkatesh, 2000) the construct of "Self Efficacy" is shown to be one of the determinants of perceived "Ease of Use". In this pilot study, "Self Efficacy" showed no correlation with "Ease of Use." Also "Perceived Learning Outcomes" has significant positive correlations with the three basic constructs of the TAM framework ("Ease of Use", "Usefulness" and "Intention to Use") as well as with one of the determinants of perceived "Ease of Use," "Enjoyment." The significant positive correlation suggests that in a TPC-supported collaborative learning setting, the "Intention to Use" construct has a considerable relationship with "Perceived Learning Outcomes." The relationship among "Intention to Use" and "Perceived Learning Outcomes" needs further causality exploration through multivariate statistical analyses.

Although the construct "Intention to Use" has a significant positive correlation with "Perceived Learning Outcomes," the construct "Usefulness" had the strongest correlation of all the constructs with "Perceived Learning Outcomes" ($R = .80$). The strength of this relationship is that much more striking since it was decided to divide the population into two groups based on the "Usefulness" construct. As previously mentioned the two groups showed a significant difference on every construct except "Self Efficacy" and "Collective Efficacy." This suggests that it is important in a setting using the TPC for collaborative learning to make the "tool (TPC) fit the task" (i.e. "Usefulness") if it is to lead to significant "Perceived Learning Outcomes." In fact, the mean response on the "Perceived Learning Outcomes" construct for the "High Usefulness" group was 4.96 while that of the "Low Usefulness" group was 3.359. A T-test confirmed that the two groups differed quite significantly on this construct ($p = 0.00$). Why was there such a stark difference between these two groups? One may only speculate. To elaborate on the previous comment of "making the tool fit the task", the difference in the groups based on the "Usefulness" construct may be in concert with the ideas of functionality and usability (Goodwin, 1987). Goodwin states: "Whether or not a user considers a computer necessary for these jobs (less structured task) depends on how well the computer meets the user's needs". In light of the two groups differing on every construct except "Self and Collective Efficacy", one may speculate that the "low usage" group perhaps found that they could better accomplish their tasks without the use of the functions provided by TPC and the "high usage" group found the functions provided by the TPC to be an enhancement to accomplishing their task.

The fact that "Self Efficacy" correlated with no other construct other than "Perceived Learning Outcomes" suggests that although interaction may occur within a group while learning collaboratively, actual learning is still pretty much a self-directed and self-determined endeavor. The construct of "Collective Efficacy" shows a significant positive correlation with the construct of "Time Management". This suggests that the TPC allowed groups to share ideas in a more time-efficient manner. The set of significant positive correlations related to the "Time Management" construct, very similar to the previously discussed "Perceived Learning Outcomes" set of significant positive correlations , also seem to suggest a possible parallel with previous research on TAM. That is, in the context of collaborative learning with the TPC, "Time Management" seems to correlate positively with increased "Intention to Use," "Ease of Use" and "Usefulness."

LIMITATIONS AND FUTURE RESEARCH

Caution needs to be taken when interpreting the results of this research, which was a pilot study of TPC use in a single class. For one thing, the TPC used in this study was not the primary facilitator of group learning. In this research the TPC was more or less a tool which groups used to store/write their collective ideas. Only one TPC was allocated per group and that only on an alternating basis over a 4 week period. Some students were only exposed to TPC use for a limited time. Thus students did not have a substantial amount of time and practice to familiarize them with the tool. Moreover, all groups were exposed to the TPC. Future research will observe collaborative learning with control groups not using the TPC but rather desktops PCs with no digital ink capability, a laptop, or no computer at all. Future research will also investigate the effects of the enhanced communication/expression ("Communication Enhancement") that the TPC allows for in carrying out computer mediated learning and instruction and more specifically its impact on collaborative/team based learning. This exploratory concept, though not specifically and independently addressed in the proposed framework, displayed a significant positive correlation with every other construct except "Self Efficacy." Its significant positive correlation with the construct of "Collective

Efficacy" may suggest that the TPC allowed for enhanced communication within the group thus increasing/influencing group effectiveness. Moreover, the set of significant positive correlations suggests that it could be an intervening variable with all but one of the constructs defined in the proposed framework.

An interesting extension of TAM (although not examined in this study) is TAM2 (Venkatesh and Davis, 2000) in which the authors present a framework which takes into account the social influences on the construct of perceived usefulness. Future research will investigate the effect of social influences on using the TPC for team based learning and its relationship to technology acceptance. Last but not least, the number of students (33) was limited (although above the central limit theorem). Thus, future research will need to investigate the framework with a larger sample and in more than one course.

CONTRIBUTIONS AND CONCLUSIONS

When it comes to collaborative team-based learning using the TPC, The Technology Acceptance Model in addition to explaining "Intention to Use," may also explain or exert a positive influence on "Perceived Learning Outcomes" and "Time Management." Also perceived "Usefulness" plays a very strong role in the successful use of the TPC in supporting collaborative team-based learning. As it concerns collaborative learning with TPCs and TAM, "Collective Efficacy" seems to be a stronger determinant of "Ease of Use" than individual "Self Efficacy."

Bivariate correlations of the survey results of this study support the validity of the proposed model for collaborative learning for the TPC. However further research and analytical refinement is needed to understand how the constructs collectively and synergistically influence each other, through multivariate analyses on a larger data set. The contribution of this current research is that it provides a framework with which to examine the use of the TPC for collaborative team-based learning. Furthermore, it contributes to a further understanding of the applicability of the TAM to computer mediated learning and instruction.

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