AN INQUIRY INTO PERFORMANCE IN MATHEMATICS OF STUDENTS USING COMPUTER AS A TOOL

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ABSTRACT

The research investigated the mathematics performance of students using the computer to enhance their mathematics skills. With Technology Acceptance Model (TAM) approach, the study focused on the effect of variables such as perceived usefulness, perceived ease of use, computer self-efficacy, subjective norms, attitude and actual use of the computer to account the success in an introductory algebra course. The important findings of the longitudinal study suggested that the perceived usefulness is the most significant predictor of perceived ease of use where as perceived ease of use did not support the attitude to use the computer. The duration of actual use of the computer contributed significantly towards students' achievement in their mathematics performance.

INTRODUCTION

The importance of using technology in classroom for teaching mathematics has "increased dramatically" over the course of the last several years (Lappan, 2000). Amarasinghe and Lambdin (2000) described three different varieties of technology usage: I-using technology as a data analysis tool, II-using technology as a problem solving/mathematical modeling tool, and III- using technology to integrate mathematics with context. Technology has no doubt become an integral part of higher education enabling students to access information rapidly and visually (Smith, 2002).

Researchers (Balacheff & Kaput, 1996; Kilpatrick & Davis, 1993) discussed the impact of technological forces on learning and teaching mathematics. The power of computer leads to fundamental changes in mathematical instruction. It is appropriate to note how the computer algebra systems (CAS) are becoming a part of the growing technology based in the curriculum for mathematics. Several studies on the use of CAS within college mathematics curriculums, more specifically calculus courses, differential equations courses, and introductory college algebra courses have been investigated (Leigh-Lancaster, 2000). The first calculus study found students' attitude and confidence were positively affected by CAS (Schrock, 1989), a second study also indicated student achievement was positively affected by CAS (Cooley, 1995), while the last study found no significant improvement in academic performance following the implementation of CAS in the Calculus curriculum (Keepers, 1995). But, when CAS was used as an instructional tool, students outperformed the control group both conceptually and computationally (Tiwari, 1999) in the college algebra class.

A longitudinal research study of African American and Caucasian students from 18 Four- year institution suggested that the Caucasian students scored higher than their African American counterparts on seven standardized tests measuring critical thinking scale, knowledge of mathematics, science reasoning, reading and writing skills (Flowers & Pascarella, 2003). Flowers and Pascarella, also revealed that Caucasian students achieved greater gains on standardized measures such as mathematics and vocabulary than African American students. Although recent studies have indicated that the gap in achievement test scores among ethnic groups has narrowed appreciably over the years (Cross, 1995; Gross, 1993; Jones 1985), many of these studies revealed that Asian/white students continue to substantially outperform students from underrepresented ethnic minority groups, particularly African Americans on tests of mathematics achievements.

Computer Assisted Instruction (CAI) in Mathematics is definitely a supplement to regular classroom in basic mathematics and algebra to benefit the students in mathematics. If CAI is used appropriately, the gap between white/Asians and African Americans students should begin to close (Brown, 2000).

The research focused on the attitude and acceptance level of students using computers to enhance their mathematics scores. A positive attitude arises due to previously successful experiences or from a perception that success is possible. The researcher wanted to know whether the perception of acceptance of technology could change students' performance of mathematics or enhance their mathematical problem solving skills. Using the Technology Acceptance Model, this study inquired students' success in mathematics using computer as a tool.

THE TECHNOLOGY ACCEPTANCE MODEL

The Technology Acceptance model (TAM) is a management information system-specific model used as an important theoretical tool to analyze how people perceive technology and its usage. According to Davis, Bagozzi, & Warshaw (1989), the perception or attitude towards the use of the computer directly influence intentions to use the computer and ultimately actual computer use and the computer usage behavior. An individual's initial attitude regarding a computer's usefulness influence the attitude towards the system use and that significantly improved the computer self-efficacy for both males and females (Torkzadeh, Pflughoeft & Hall, 1999). A significant and growing body of subsequent research has confirmed the usefulness of TAM as a tool for investigating user information technology acceptance (Taylor and Todd, 1995; Szajna, 1996; Chau, 1996; Geffen and Straub, 1997).

Adapted from the theory of Reasoned Action (TRA), the TAM by Davis (1989) identified two distinct constructs, perceived usefulness and perceived ease of use which directly affect the attitude towards target system use and indirectly affect actual system use. TAM has been well tested and proven to be quite reliable and robust in predicting user acceptance in business related studies. To gain a better understanding of information technology, adoption and its use in organization the TAM has been widely used (Chismar & Wiley-Patton, 2003). Fishbein & Ajzen (1975) provided the theoretical basis in developing the Theory of Reasoned Action (TRA) that emphasized the importance of the determinant's consciously intended behaviors. According to this, a person's performance of a specified behavior is determined by his or her behavioral intention to perform the behavior. The TAM was formulated to trace the impact of external factors on internal beliefs, attitude and intentions. The behavioral intentions suggested by TRA are a measure of one's intention to perform a specified behavior and attitude represents an individual's feelings about performing the behavior (Ajzen & Fishbein, 1980).

The TAM used the ideas delineated in TRA and expanded it by incorporating two key sets of constructs: a) Perceived usefulness (PU) and Perceived Ease of Use (PEU), (b) User's Attitude (AT), and Actual Use (AU) of the computer. TRA and TAM, both of which have strong behavioral elements, assumes that when someone forms an intention to act, that they will be free to act without limitation. In the real world there will be many constraints, such as limited ability, time constraints, environmental and organizational limits, or unconscious habits which will limit the freedom to act (Bagozzi, Davis & Warshaw, 1992). TAM accounts the psychological factors that affect computer acceptance.

Attitude towards usage and intentions to use may be ill-formed or lacking in conviction or else may occur only after preliminary strivings to learn to use the technology evolve. Thus actual usage may not be a direct or immediate consequence of such attitudes and intentions (Bagozzi, Davis & Warshaw, 1992). Each of the factors of TAM is defined as follows:

Perceived usefulness: The degree to which the individual believes that use of target system could enhance the job performance (Davis, 1993).

Perceived ease of use: The degree to which the individual believes that using the target system would be free of mental and physical efforts (Davis, 1993).

Attitude toward use of target system: The degree to which an individual evaluates and associates the target system with his or her job (Davis, 1993).

Actual system use: a behavioral response, measured by the individual's action in reality (Davis, 1989).

TAM also suggested that when users are presented with a new software package, a number of factors influence their decision about how and when they will use it, notably perceived usefulness and perceived ease of use. A causal relationship between attitude towards mathematics (ATM) and achievement in mathematics (AIM) has long been assumed to exist. That is, a more positive ATM contributes to a higher level of AIM (Suydam &Weaver, 1975). According to this study there was a reciprocal relationship between attitudinal measures and achievement in mathematics. That implied making to learn mathematical content in different set up, either computer software or any other method will improve the performance in mathematics.

The usage of technology in mathematics instructions shows a positive relationship between technology and student achievement in mathematics. However, influence of perception regarding technology among post-secondary learning communities has not been evaluated. The researchers inquired whether the perception of acceptance of technology could change students' performance of mathematics or enhance their mathematical problem solving skills. The study focused on the Technology Acceptance Model (TAM) to explain the student's attitude to actual use of computer software for mathematics that had impact on their final exam score. The researcher analyzed what is the inter-relationship among perceived usefulness and perceived ease of use of the computer. Does the students' attitude toward using the computer predict the actual use of the computer and to what extent does computer self-efficacy affect perceived usefulness, perceived ease of use, students' attitude and their actual computer use? How that affects the student's final exam score? By using the TAM model, the correlational inquiry developed a conscientious analysis how the students feel about the technology usage and how did it affect their achievement in mathematics.

The success of information system can be measured by two indicators: frequency and intensity (Davis, 1993). According to Davis, frequency of use and amount of time spent using a system are typical of usage metrics. Davis suggested that the frequency is measured by using scale such as "Don't use at all" to "Use several times a day". Based on Kelman's framework (1958), Davis, Bagozzi, & Warshaw (1989) had noted that social influences may affect behavioral intentions indirectly via attitude (AT), due to internalization and identification processes, or influence behavioral intentions directly by compliance.

Much of the research seeking to understand the dynamics of human decision making in the context of accepting or resisting the technology has come from the field of management information systems (MIS). According to Chismar and Wiley-Patton (2003), in previous studies the Technology Acceptance Model has been widely used by information technology researchers to gain a better understanding of information technology adoption and its use in organizations. It had been applied and tested in academic and corporate settings involving students, business managers, clerical and administrative types as subjects.

When end users perceived the target system as one that is easy to use and nearly free of mental effort, then they may have a favorable attitude towards using the system as implied by a research study by Pan, Sivo, & Brophy (2003). When the end users have a positive attitude to use, then the frequency and duration of system use would prove successful (Pan, Sivo, & Brophy, 2003). The success of a computer training program has been studied widely from the angle of system user characteristics, because success of using this is determined by the attitudes and perception that the participants possess when either opportunities or demands to use technology arise (Sivo, Pan & Brophy, 2004).

Computer Self-efficacy

Davis cited Bandura's cognitive theory that defined self-efficacy as "judgments of how well one can execute courses of action required to deal with prospective situations" (1989:321). Self-efficacy beliefs are theorized to function as proximal determinants of behaviors. According to the theory of Bandura (1977), self efficacy judgments are distinguished from outcome judgments. Bandura's "outcome judgment" is similar to perceived usefulness (Davis, 1989). Originally from Bandura's (1977) self- efficacy theory, computer self-efficacy became a pivotal issue in technology acceptance. McCauley and Courneya stated self-efficacy as "self-efficacy is not concerned with the skills an individual has but, rather, with the judgments of what an individual can do with the skills he or she possesses" (1993:66). The self-efficacy is achieved but not ascribed. In real life situations, human beings tend to regulate choices and efforts by first evaluating information regarding their skills and abilities (Torkzadeh & Van Dyke, 2001). They also believed that self-efficacy is achieved "at various levels of specificity and at different degrees of correspondences" (2001:276). According to Decker, (1998), the human interaction is a cognitive process and self-efficacy is achieved through the cognitive interaction. The self-efficacy significantly transfers positive skills to real life experiences.

According to Agarwal and Karahanna (2000), self-efficacy exhibits a stronger influence on perceived ease of use than perceived usefulness. The researcher used computer self-efficacy (CSE) in the present study to denote self-efficacy for enhancement of mathematics achievement through using computer technology for the course.

SUBJECTIVE NORMS

According to Anandarajan, Igbaria, and Anakwe (2000), the definition of Subjective Norm (SN) is two-fold: vertical pressure and horizontal pressure. Vertical pressure is referred to the social pressure from people who are subordinate to the individual (i.e., a vertical dyads relationship); horizontal pressure refers to the social pressure from people closely related to the individual (e.g., close friends). There is more likelihood for those who report high subjective norms to accept and adopt the new system (Anandarajan, Igbaria & Anakwe, 2000; Liker & Sindi, 1997). Subjective norms include users' perception of the external forces and their motivation to comply with the forces (Robinson, 2001). From the perspective of university faculty in the context of faculty development, Wolski and Jackson (1999) also agreed to this proposition.

The vital role of Subjective Norms (SN) was acknowledged by Lim (1999) that subjective norms with perceived behavioral control are the strongest predictors of users' intention to technology acceptance. Based upon his research the perceived behavioral control is a similar construct as to perceive ease of use, that focuses on one's own perception of the behavior. The behavior performed could be easy or difficult.

Although the TAM has been validated and retested since 1989, studies of the TAM on a non-voluntary basis are rarely conducted (Sivo, Pan & Brophy, 2004). Venkatesh (2000) advised that future research should examine mandatory usage contexts to test the boundary conditions of the proposed technology Acceptance. According to Pan, Sivo & Brophy, (2003), the relation between attitude and students' achievement should be addressed.

METHODOLOGY

In this longitudinal and correlational study the data collection instrument is the questionnaire with five varied sections with another section for demographic study were administered three times in the semester to see if there was any change in their perception and attitude that contributes to their achievement to improve their grades. The students' actual use of the computer determined their end of course result was the outcome variables. The participants were African American college students enrolled in an Introductory Algebra course using the computer technology. The following six instruments were used in the data collection survey questionnaire.

The Usability instrument: The instrument measures two constructs: Students' perceived usefulness (PU) and perceived ease of use (PEU) of computer. In the survey perceived usefulness measured four items such as using computer would improve my math performance...and Perceived ease of use measured nine items such as I will find computer easy to use for my math... Each of the two scales adapted from Davis' (1989) research measured thirteen items together.

The Computer Self-Efficacy (CSE) Instrument: The instrument validated by Lee (2002) measured students' beliefs about their computer skills. The questionnaire is composed of two sections: course content self-efficacy and general software feature use self-efficacy. This instrument measured eight items with a general statement "I feel confident.....Doing well in my math course or Understanding course material in math.

Subjective Norms (SN) Instrument: According to Wolski and Jackson (1999), there are two types of external pressures from vertical (relationship between faculty and students) and horizontal dyads (relationship between students and students) relationships influenced the technology acceptance in higher education settings. In this study, the subjective norms construct was measured by a four item subjective norms instrument. Participants were asked to answer the questions to the best of their perceived ability about the use of computer technology. The four items in subjective norms instrument started with: "My Parents think....My Instructor thinks....were measured on the six point Likert scale starting from "Strongly Disagree", Disagree"…..

The Attitude (AT) instrument: This was adapted from Ajzen and Fishbein's (1980) attitude scales. Students were requested to respond to the six scales by selecting one option for each item that best matched their attitude toward computer use.

The System Use Instrument: This instrument measured frequency and duration of students' survey report (FP and DP) and their actual use in the lab (FA and DA). Davis argued "frequency of use and amount of time spent using a target system are typical usage metrics employed in MIS research" (1993: 480). The two self-report scales were measured by following questions: "Less than once a week", "Once a week"….

The survey questionnaire carried the above five varied sections with another section for demographic study were administered three times in the semester to see if there was any change in their perception and attitude that contributes to their achievement to improve their grades. The students' actual use of the computer determined their end of course result was the outcome variables. The researcher tested and expanded the TAM by adding subjective norms and computer self efficacy to better explain students' attitude towards the acceptance of technology and to analyze if it has any bearings towards student's achievement in mathematics. The student demographics questions containing eleven items were to find out their gender, race, previous experience, choice and learning habits. The study was conducted on an item scale level and was tested computing the sum of the scores of corresponding items. The design of the study was based on path-analytic modeling. Path analysis procedure was used to analyze the direct and indirect effect of variables hypothesized as causal. SPSS was used to find the coefficients of the pathways through multiple regressions in statistical analysis.

RESULTS

In the longitudinal study the participants were African American students of which 273 students participated in TAM1, 233 students participated in TAM2 and 226 students participated in

TAM3. Using SPSS for windows the reliability of those five scales was studied and is presented in the following table.

Table 1: Internal Consistency of Reliability Testing

Cronbach Alpha (Standardized) for Instruments and Sample size	TAM1	TAM2	TAM3
Alpha	.7797	.8337	.8584
N	273	233	226

The results of the study are reported in the following sections that showed the data characteristics

In TAM1, the perceived usefulness was supported by computer self-efficacy (.366) and by subjective norms (.238). The Perceived-ease-of use was highly supported by perceived usefulness (.605), by computer self-efficacy (.214) and subjective norms (.122). It showed that perceived usefulness is helping the attitude (.320) while perceived ease of use was (.099). The frequency and duration of computer use what they stated in the survey report and their actual use of computer in the lab was not supported by the attitude data. According to the statement in the survey, the students reported that they would stay longer time and because of that the duration of reported use contributed to students' final scores. The associated t-values were not significant when the variables are supported little or none by the data. In accordance with the results, the relationships among those variables on the TAM1 are through path coefficients were illustrated as follows.

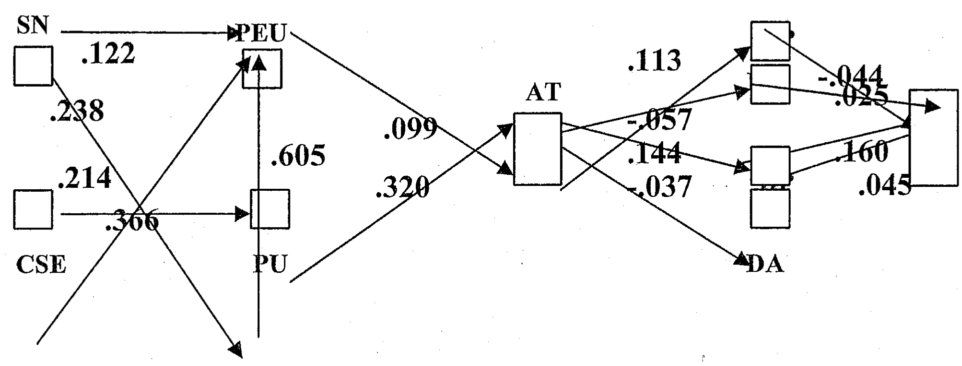

Figure 1: TAM 1

PU: Perceived usefulness; PEU: Perceived ease of use; FP: Frequency of using the computer (stated in the survey); FA: Frequency of Actual use of the computer; DP: Duration of reported use (stated in the survey); DA: Duration of Actual use of the computer; FN: Final exam score.

In TAM2, the computer self-efficacy (.370) and the subjective norms (.387) contributed almost the same amount to the perceived usefulness. Perceived usefulness supported perceived-ease-of use the most (.558). The Computer self-efficacy (.272) and the subjective norms (.100) also gave additional support to perceived ease of use. More over, the perceived usefulness supported the attitude in a considerable amount (.531) in TAM2. The frequency of reported use was supported by attitude (.255) while the duration of use of the computer from the survey report indicated that it was only increased by (.091). The Final grade was supported by the by survey was (.242) and the duration of actual use (.131). The duration and frequency of actual and reported use had increased contribution in TAM2 than TAM1.

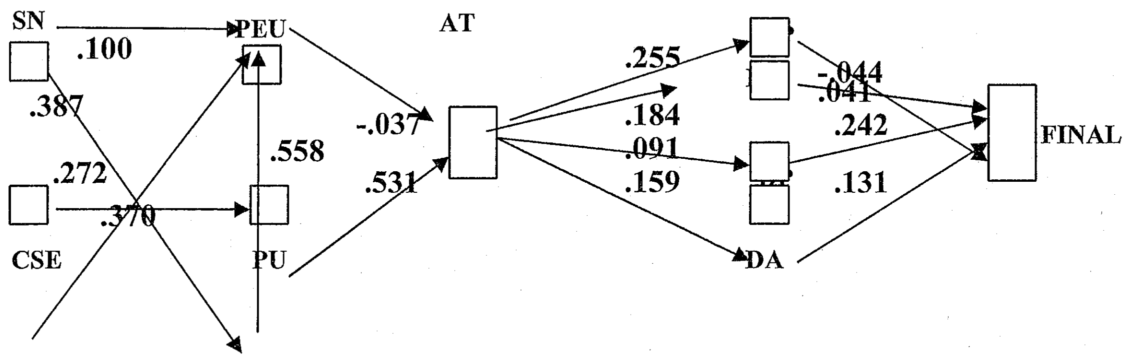

Figure 2: TAM2

PU: Perceived usefulness; PEU: Perceived ease of use; FP: Frequency of using the computer (stated in the survey); FA: Frequency of Actual use of the computer; DP: Duration of reported use (stated in the survey); DA: Duration of Actual use of the computer; Final: Final exam score.

In TAM3, the computer self efficacy contributed more to perceived usefulness (.394) than subjective norms (.328) to the perceived usefulness suggesting that computer self-efficacy best predicts student perception of the usefulness of the math software towards the end of the semester. The perceived usefulness supported perceived-ease of use the most (.510) followed by the contribution from subjective norms (.273) and the computer self-efficacy (.191). As the perceived usefulness supported the attitude in a considerable amount (.424) that suggested that their attitude towards using the math software was influenced by their perception of computer usefulness. But perceived ease of use to the attitude was (.062) only little indicating that the students realized at the end that the computer will not ease their work. How frequently they would use the computer was supported by attitude (.284) and the duration only by (.191). The Final grade was supported by the duration of actual use (.292). It was noticed that the frequency of actual use of the computer was increased.

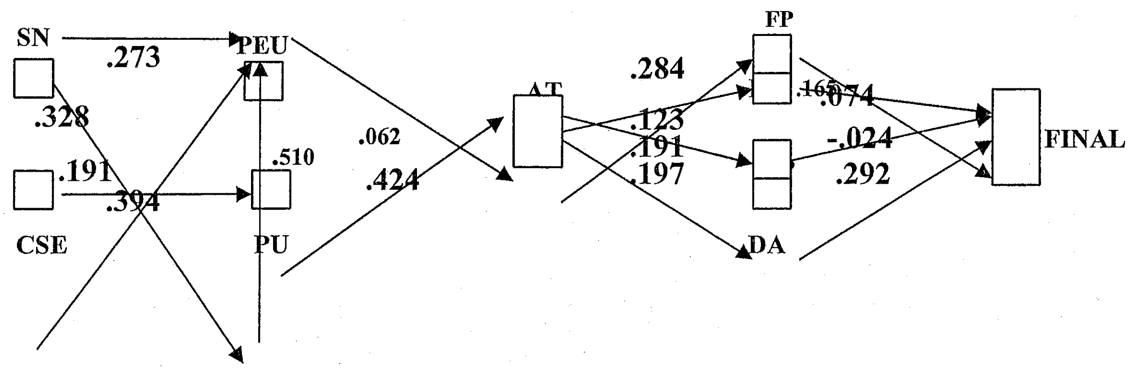

Figure 2: TAM 3

PU: Perceived usefulness; PEU: Perceived ease of use; FP: Frequency of using the computer (stated in the survey); FA: Frequency of Actual use of the computer; DP: Duration of reported use (stated in the survey); DA: Duration of Actual use of the computer; Final: Final exam score.

Inspection of the squared multiple correlations suggested that a substantial portion of each variable explained about 3% (TAM1), 10% (TAM2), and16% (TAM3) of the variation in student's final scores for the algebra course in the following table.

Table 2: Squared Multiple Correlation TAM1-TAM2-TAM3

Variables	PU	PEU	AT	FP	FA	DP	DA	FN
TAM1R-squares	.254	.617	.159	.013	.003	.021	.001	.030
TAM2 R-squares	.419	.648	.253	.065	.034	.008	.025	.095
TAM3 R-squares	.402	.689	.227	.081	.015	.037	.039	.164

PU: Perceived usefulness; PEU: Perceived ease of use; FP: Frequency of using the computer (stated in the survey); FA: Frequency of Actual use of the computer; DP: Duration of reported use (stated in the survey); DA: Duration of Actual use of the computer; FN: Final exam at the end of semester; R-square:

Measure of the proportion of variance of the dependent variable about its mean that is explained by the independent variable(s).

The longitudinal results obtained for the TAM found to be changed over time in the semester as the measures were administered at three different time periods.

Table 3: The change in Beta over time: TAM1-TAM2-TAM3

Beta	VAR	TAM1	TAM2	TAM3
1	CSE	.366**	.370	.394
2	SN	.238	.387	.328
3	SN	.122	.100	.273
4	CSE	.214	.272	.191
5	PU	.605	.558	.510
6	PEU	.099**	- .037**	.062**
7	PU	.320	.531	.424
8	AT	.113**	.255	.284
9	AT	- .057**	.184	.123
10	AT	.144**	.091**	.191
11	AT	- .037**	.159	.197
12	FINAL	- .044**	- .044**	.165
13	FINAL	.025	.041**	.074**
14	FINAL	.160**	.242	- .024**
15	FINAL	.045**	.131**	.292

** denotes when the t-test for the estimate is not significant ($p > .05$).

DISCUSSION AND CONCLUSION

Mathematics is an important subject in school or in a college curriculum and the importance of mathematics in this technological world is undeniable. There has been many factors contributing to the above statement but achievement in teaching and learning has been amazingly altered through the application of modern technology applied to different curriculum. Textbook learning is not enough for struggling students no matter which ethnic group they belong. Anxiety towards mathematics is a common problem for students who are slow in mathematics. Students using computer software in mathematics have shown better attitudes and are more hopeful to achieve better grades. Computer software offers immediate and personal feedback as well as privacy so that students can take their own time to get through the materials and practice as many times as they wish for a better understanding.

If used properly, the usage of technology in mathematics instruction showed positive results. The influence of perception on using technology towards improving the performances in mathematics was not evaluated previously. Working on mathematics software designed to fit the content of the syllabus and textbook helps students to overcome the anxiety. Software was designed so that they can generate as many examples as the students want on the specific topic or the problem. Teachers are not available to students at any time but the computers are suitable for students to access what they need, and when they need. Effective use of technology provides a student centered learning environment and hands-on learning can solve the problem we are facing in schools and colleges towards mathematics.

The researcher tested and expanded the TAM by adding subjective norms and computer self efficacy to better explain students' attitude towards the acceptance of technology and to analyze if it has any bearing towards student's achievement in mathematics. The student demographics questions containing eleven items were used to determine gender, race, previous experience, choice and learning habits. The study was conducted on an item scale level and was tested computing the sum of the scores of corresponding items. The design of the study was based on path-analytic modeling. The causal relationship between the variables was studied as the questionnaire was administered to the same group of students in the same sections of this Introductory Algebra class. The lab report collected the duration and frequency of using the computer for their mathematics work according to the syllabus.

In the findings of TAM approach to the study, the researcher observed that the explained variance was approximately 3% in TAM1, 10% in TAM2 and 16% in TAM3 to students' final grade. After almost half of the semester passed, the students' started to visit the lab more frequently than in the beginning of the semester, and it showed a positive attitude. The perceived usefulness became the strongest predictor towards the student's perception that computer usage will free their efforts. They do not have to do hard work and math would be easier on the computer. The students started realizing that the computer's role in learning the math concepts and doing their homework is important.

The increase of subjective norm contribution towards the perceived usefulness, explained that students started to see classmates spending more time doing their math homework. This influenced the students in a positive way. Their perceived usefulness influenced their attitude positively (53%) while the drop in perceived ease of use showed that they slowly realized that the computers would not do the work for them.

Frequency and duration of actual use of the computer significantly increased from TAM1 to TAM2. In TAM2, the final grade was supported mostly by the duration of computer usage, which increased from 4% to 9%. In TAM2, the perceived usefulness is still the strongest predictor towards both students' attitude and perceived ease of use. The subjective norms and computer self-efficacy played a positive role in students' perception regarding computer use for their mathematics course.

In TAM3, the variance explained was approximately 16% in students' final grade. Possibly as the students approached the end of the semester, their class tests did not encourage them to have positive attitudes. Students already realized that it was not feasible to make up the lost time. The contribution of subjective norms was dropped from TAM2 to TAM3 suggesting that peer pressure is not helping them with computer use.

The original TAM (Davis, 1989) showed that the perceived ease of use (PEU) played an important role in influencing the usage of technology, but this study observed no significance of PEU. This deviation suggests that PEU may have a limited role in mathematical studies using a computer as a tool. A recent study (Saade, Nebebe, & Tan, 2007) regarding multimedia learning environments found weak relationship between PEU and attitude which also supports this study. But perceived usefulness had a significant impact towards students' attitude, which ultimately contributed to their lab time.

There was an increased contribution in attitude that they are going to use the computer frequently. The frequency of lab visits was dropped while the duration of staying in the lab was increased indicating that students tried to finish their home work by staying on the computer longer. So, the duration of actual use of the computer in the lab had doubled the contribution towards its share of the final grade. Towards the end of the semester students realized they have to spend more time using the computer to catch up with homework, otherwise, it will be difficult for them to obtain a good grade. The findings of the study showed that the perceived usefulness was the most significant predictor of perceived ease of use of students' using the computer software to enhance their mathematics performance. Subjective norms contributed to perceived ease of use and perceived usefulness, whereas, computer self-efficacy supported perceived usefulness and perceived ease of use. The duration of actual use of the computer enhanced students' final score in mathematics.

In the beginning of the semester, however, the students of the algebra class did not have a positive attitude towards using the computer for their math work. The students did not like to spend their time on the computer, as they could not see the effect right away. Even if they have developed a positive attitude by the end of the semester, there was not enough time left in the semester to make up for a better grade. From the demographic survey report it was found that 85% of students preferred face-to-face instruction for mathematics instead of interacting with a computer. The study suggests that the Technology Acceptance Model (TAM) can be effectively used in future research for predicting the computer usage behavior when used as a tool.

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