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The Impact of Paradigm Development and Course Level on Performance in Technology-Mediated Learning Environments

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Abstract

We investigate the effect of paradigm development and course level on the outcomes of web based technology-mediated learning environments in order to ascertain if these external factors can help explain student outcomes. Using an institutional database of student outcomes, we were able to examine data from over 13,000 students in 167 undergraduate courses from the years 1997 – 2003. Using this data we examined the question which types of courses are best suited for delivery using web-based technologies. The findings indicate that technology-mediated learning can be used more effectively for some courses than others. Our results suggest that student grades are significantly higher and withdrawal rates lower for courses with high paradigm development (e.g., Biology, Computer Science) than for courses with low paradigm development (e.g., Sociology, English). Even stronger relationships emerge when including the hypothesized moderating effect of course level (introductory or advanced). When taking course level into account, student satisfaction is better in advanced high paradigm classes than in advanced low paradigm classes. The opposite holds when comparing satisfaction in introductory low paradigm classes with introductory high paradigm classes. Withdrawal rates are lower in advanced high paradigm classes than introductory high paradigm classes, while the opposite holds for low paradigm classes, with introductory low paradigm classes having lower withdrawal rates than advanced low paradigm classes.

Keywords: Technology-mediated learning environments, paradigm development

Introduction

Universities and business organizations are increasingly turning to technology-mediated learning as an educational tool (Dumort, 2000). Worldwide spending on online education exceeded $9 billion in 2003 and was in the $12-$14 billion range in 2004, with a 30% annual e-learning spending increase through 2008 (Sarker & Nicholson, 2005). Estimates indicate that 2,000,000 students take online postsecondary courses (Galt Gobal Review, 2001) and predictions are that the number of university and colleges offering web-based courses will continue to increase. The *Condition of Education Report 2002* by the National

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Center for Education Statistics reported that undergraduate and graduate students participated in distance education at the rate of 8% and 12%, respectively (Wirt & Livingston, 2002). By far the most common method of participation was via the Internet–60% for undergraduates and 68% for graduates.

As we increasingly rely on this new tool, it is becoming painfully obvious that there is much that we still need to learn about its effective use. Recent studies investigated various ways to use this tool to improve student performance by assessing participation in student study groups, the number of web pages accessed by students (Wang & Newlin, 2002), the level of effort on homework (Dutton, Dutton, & Perry, 2001), and by examining learning styles and patterns of usage (Lu, Yu, & Liu, 2003). Researchers have assessed student performance by grades (Christophel, 1990), satisfaction (Biner, 1993; Gunawardena, 1995), and withdrawal rate (Phipps & Merisotis, 1999). A review of the learning effectiveness of Asynchronous Learning Networks (ALN) by Swan (2003) indicated that interaction with course content (Swan et al., 2000), interaction with instructors (Arbaugh, 2001; Picciano, 1998), interactions with classmates (Richardson & Swan, 2003), and vicarious interactions (Sutton, 2001), all improved learning. But, these studies implicitly assume Information Technology (IT) may be effectively applied in all learning environments.

Course Suitability in Technology-Mediated Learning (TML) Environments

Although past research has compared face-to-face teaching with technology-mediated learning environments, we concentrate instead on comparing the use of IT in learning environments without any face-to-face communications. Technology-mediated learning environments (TML environments) are environments "in which the learner's interactions with learning materials (readings, assignments, exercises, etc.), peers, and /or instructors are mediated through advanced information technology" (Alavi & Leidner, 2001, p.2) such as the web. For as long as there have been "distant" modes of learning, research has been conducted to examine if it is as good as "traditional" methods of delivery. While some studies find differences in effectiveness when comparing IT-mediated and traditional face-to-face learning environments, many studies indicate that there are no significant differences (Russell, 1999; Sarker & Nicholson, 2005). We believe that it is time to investigate more systematically what makes technology-mediated learning environments different (more effective in some circumstances, while less effective in others), rather than simply trying to emulate the face-to-face experience in an online environment. That is, "by focusing on whether we can do the old things just as well in different ways, we are blind to the possibilities of doing new and different things" (McDonald, 2002 p.11). The University (virtual or otherwise) is still an organization which needs to avoid the pitfall of expecting technology to increase effectiveness just by being used; rather we need to turn our attention to how it is used.

TML effectiveness studies (vis a vis face-to-face) have been conducted predominantly via field experimentation, surveys, or quasi-experiments (non-random comparison of face-to-face with online courses). A c*ourse* is defined here as an organized series of lessons about a specific subject. While these studies offer preliminary findings about what courses might best be suited for delivery over the web, a more comprehensive sample is necessary to understand TML applications from the broader institutional perspective. Having data regarding course outcomes from a large number of courses across varied *disciplines* (or field of study) seems more appropriate. In this study we use an archival research approach that is primarily concerned with the ex post facto examination of historical documents. It allows a systematic investigation of courses to determine if course characteristics might explain TML outcomes.

Teaching Effectiveness in TML Environments

"For what type of courses, if any, is this new teaching medium effective?" is a question seldom asked. As suggested by Piccoli, Ahmad and Ives (2001, p. 408), "Considerable uncertainty remains regarding the subject matter and content type best suited to delivery in the virtual environment". In their exploratory analysis of the "myth' that any course can be taught online, Sarker and Nicholson (2005) found that both instructors and students indicated that certain kinds of courses were more (or less) suitable for online delivery. For example, some students stated: "I personally find it difficult to learn math, programming, and high-logic based courses this way. What I find easiest is writing or critical thinking style classes," or "Certainly courses involving easier concepts and less instruction, such as English or humanities courses, are easier on an online environment that programming or database courses" (Sarker & Nicholson, 2005, p. 66).

Benbunan-Fich and Hiltz (2002) examined the effect of teaching medium (ALN) on course type, in which they categorized courses as those that were more technical and having a heavy emphasis on mathematical analysis and those that were less technical and having a qualitative posture. They found that the less technical courses resulted in higher student grades and better perceptions of learning. Similarly, Vaverek and Saunders (1993-1994) found that students considered courses like Organization Theory to be more appropriate for computer conferencing than were more technical courses such as Statistics/Epidemiology and Accounting/Finance—findings opposite from what the researchers hypothesized. We think that extent of paradigm development and level of course offers an explanation for these differences between the hypotheses and the actual findings about the effectiveness of IT use for teaching.

The paper next discusses paradigm development, its use in prior research and the possible effect that course level might play in explaining those earlier results. We next introduce our research model along with our hypotheses, followed by a discussion of the methodology used to analyze our large dataset and the results. The paper concludes with a discussion of those results and limitations of our present research effort.

Paradigm Development and Course Level

A theoretical paradigm represents a "constellation of beliefs, values, techniques, shared by members of a given community" (Kuhn, 1970, p. 175). In disciplines with more highly developed paradigms, there is general agreement on common definitions and accepted methodology, and often key concepts are represented through formulas. The physical sciences (i.e., Physics and Chemistry) are believed to have more highly developed paradigms than the social sciences (i.e., Psychology and Sociology) (Beyer, 1978; Kuhn, 1970; Lodahl & Gordon, 1972; Salancik, Staw, & Pondy, 1980). In contrast, the MIS discipline is full of debate about what even constitutes its core. Benbasat and Zmud (2003) attempted to define the core. However, numerous articles, as evidenced by the 2003 special issue of *Communications of AIS* with responses to this article, and the comments of Agarwal and Lucas (2005) suggest that the definition of the core is not agreed upon by members of the discipline. Furthermore, considerable debate, as found in the article by Robey (2003; Also see Hassan, 2006) argue against having a single paradigm in the MIS discipline.

We argue that paradigm development impacts the effectiveness of learning environments. Learning environments fall along a continuum of technology mediation. One end of the continuum is anchored by an environment in which all delivery is face-to-face and there is no technological support whatsoever. The other end of the continuum is an environment in which the delivery is entirely based on the use of advanced information technologies. These two types of learning environments are distinguished by their degree of social presence and media richness. Learning environments that are entirely technology-mediated, especially for relatively short-term college classes, could be expected to be less rich (Daft & Lengel, 1986) than face-to-face learning environments. In particular, in learning environments that are entirely technology-mediated faculty must learn to adapt to the challenges and advantages offered by the technology. They often find that the feedback is slower, the ability to transmit across multiple channels is reduced, and the ability to personalize the communication is less when compared to face-to-face learning environments at the other end of the continuum, at least over the short-term when courses are delivered. Thus, media richness differences are expected to impact the delivery of course materials in different learning environments.

Paradigm development has consequences for the communication of course material. The greater the paradigm development, the more structured is the discipline and the easier it is to communicate its critical terms and concepts. In disciplines with higher paradigm development, there is more agreement about course content. Because students in these disciplines face less ambiguity than in disciplines with low paradigm development, we argue that the greater the paradigm development, the easier it is to communicate course content in TML environments. Thus, TML environments may be a good match for the information processing requirements found in disciplines with high paradigm development (Cheng, 1984). In TML environments, therefore, student performance, as measured by their grades, may be higher in disciplines with high paradigm development than in courses in disciplines with low paradigm development. In high paradigm development courses in TML environments, students should also be more satisfied with their course and more certain about their mastery of course content. Consequently, a smaller percentage of students drop out of the course when compared to students in courses in disciplines with low paradigm development.

While there is theoretical support for paradigm development impacting TML environment effectiveness, the research results are contradictory. In their study of a masters-level professional health care program in the mid 1980s that pioneered heavy reliance on computer conferencing, Vaverek and Saunders (1993-1994) found that in courses in disciplines with higher paradigm development (i.e., Statistics Epidemiology and Accounting/Finance), students evaluated the courses as less appropriate for computer conferencing than courses in disciplines with lower paradigm development (i.e., Organization Theory and Comparative Health Care Systems). Vaverek and Saunders conjectured that the technology-mediated learning environment offered a relatively lean medium of communication (Daft & Lengel, 1986), which made it difficult to exchange complex key course concepts to which they were being introduced (Vaverek & Saunders, 1993-1994). Even though there was a high level of agreement about core concepts in disciplines with highly developed paradigms, the students were unfamiliar with the complex concepts. Webster and Hackley (1997) supported this conjecture when they discovered that students reported higher learning outcomes if they perceived the technology used in the learning environment to be rich. Further, feedback in the TML environment was more delayed than in a face-to-face learning environment. That is, the need to understand key terms and concepts may have been more pronounced in courses in disciplines with high paradigm development. Failure to grasp this understanding in a timely manner may have frustrated students, hurt their performance, and lowered their satisfaction with the course. Hence, it is arguable that in courses in disciplines with a high paradigm development, student satisfaction with the course and student grades are lower than in courses with low paradigm development. Further, courses in disciplines with high paradigm development might have higher withdrawal rates than courses in disciplines with low paradigm development.

Bloom's Taxonomy and TML Environments

Paradigm development of a discipline is an important characteristic that can help explain outcomes in TML; another important characteristic of a course within a discipline is the level of the course. That is, each course can be placed on a continuum from introductory to advanced.

The extent to which a course is introductory or advanced may be understood using Bloom's taxonomy. Bloom's taxonomy (Bloom, Engelhart, Furst, Hill, & Krathwohl, 1956) emphasizes building higher level skills from the foundation of lower level skills. Synthesizing interrelated information transpires after mastery of concepts and principles, which occurs after the mastery of remembering facts. Based on the revised taxonomy (Anderson & Krathwohl, 2001) knowledge is built up from *factual knowledge* – basic elements students must learn to be acquainted with a discipline – to *procedural knowledge* – how to do something within a discipline. Cognitively, movement towards higher levels of knowledge proceeds along the dimensions of remembering facts, and understanding, applying, analyzing, evaluating and finally creating knowledge.

Course Level as a Moderator

TML environments are adaptable to different learning objectives based on Bloom's taxonomy (Chyung & Stepich, 2003). The increased structure and consensus regarding factual knowledge in high paradigm disciplines allows for easier dissemination and comprehension of critical terms, concepts, and methodologies, especially in more advanced courses. For example, with an understanding of circuits, advanced computer science courses can explore the different methods, materials, etc. used to create circuits, and TML can be leveraged for building simulations or by using CAD. In the advanced political science class, field studies of various forms of democracy might be required, which is more difficult to enable via TML. The notion of course level moderating the effects of paradigm development is consistent with the findings of Vaverek and Saunders (1993-1994) since most of the courses in their study were introductory courses. Hence, it is proposed that course level acts as a moderating variable in the relationship between student outcomes and paradigm development.

Research Model and Hypotheses

These relationships between student learning outcomes and learning environment and paradigm development, moderated by level of course, are represented in Figure 1 and serve as the basis for the general hypothesis and four specific hypotheses.

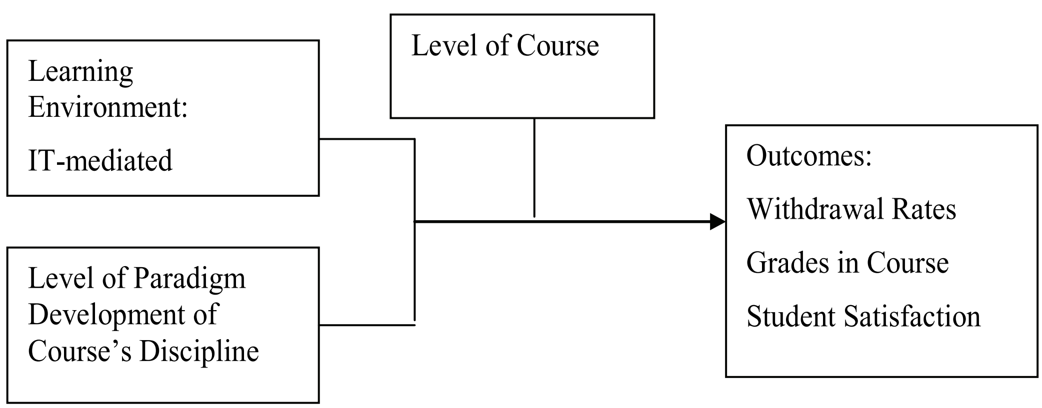

Figure 1. Research Model

Based on the above discussion we believe that paradigm development, moderated by course level, can help to explain the outcomes reported in prior TML research, and thus we hypothesize the following:

General Hypothesis. Level of course moderates the relationship between paradigm development and student performance in TML environments. In particular,

Hypothesis 1: In introductory courses in disciplines with low paradigm development, student outcomes (i.e., grades and satisfaction) are higher than in introductory courses with high paradigm development in TML environments.

Hypothesis 2: In introductory courses in disciplines with low paradigm development, withdrawal rate is lower than in introductory courses with high paradigm development in TML environments.

Hypothesis 3: In advanced courses in disciplines with low paradigm development, student outcomes (i.e., grades and satisfaction) are lower than in advanced courses with high paradigm development in TML environments.

Hypothesis 4: in advanced courses in disciplines with low paradigm development, withdrawal rate is higher than in advanced courses with high paradigm development in TML environments.

To demonstrate the impact of level of course on the relationship between student outcomes, in Figure 2 we contrast outcomes in introductory courses with outcomes in advanced courses that use WebCT.

	LOW PARADIGM DEVELOPMENT	HIGH PARADIGM DEVELOPMENT
INTRODUCTORY COURSE	Higher Grades Higher Satisfaction Lower Withdrawal	Lower Grades Lower Satisfaction Higher Withdrawal
ADVANCED COURSE	Lower Grades Lower Satisfaction Higher Withdrawal	Higher Grades Higher Satisfaction Lower Withdrawal

Figure 2. Level of Course as Moderator in Technology-Mediated Learning Environment

Methodology

Procedures

To test the hypotheses, we used data gathered at a large, rapidly-growing metropolitan university in the Southeast of the USA. The university's student base consists of traditional students, approximately two-thirds of whom attend the university on a full-time basis. In the Spring 2004 semester at this University, a record number of 8,750 students enrolled in fully web-based courses, a 22 percent increase from the Fall 2003 semester. This enrollment in fully web-based courses represented almost six percent of the University's total enrollment for the semester. The data for this study were stored in an institutional database that tracked the performance of students in entirely web-based classes and in an institutional database with the student class evaluations. The institutional web-based classes database included data about the class (course number, section, year and semester offered), as well as information about each student enrolled in the class (i.e., grade in class, whether or not the student completed the class, age, grade point average [GPA] and SAT scores). The student class evaluation database had student responses for each class section; there were no student identifiers in this database. The research database was generated using the section number, course number, year and semester to link the student class evaluation database and the web-based classes' database. The data for this study gathered the responses of 13,167 students in 167 undergraduate classes from the spring semester 1997 through the spring semester 2003. We included only web-based courses in disciplines that could be clearly classified as having low or high level of paradigm development in the study and selected only undergraduate courses to avoid difficulty in correctly classifying level of course for graduate courses. Graduate courses are a priori advanced, yet some clearly provide introductory material.

Dependent Variables

The dependent variables—student satisfaction with the learning environment, grade earned, and student withdrawal rate—are averaged for each class. The independent variable is paradigm development and the moderating variable is course level. The research design controls for learning environment by including only courses whose mode of delivery was entirely IT-mediated (i.e., web-based). Statistical control is applied to a number of other control variables: average age, total SAT scores, University GPA, perceived teacher quality in each class, class size, and the year the class was taught. Measurement for all outcome variables, and for all control variables except class size and the year the class was taught, is at the individual level and aggregated to the class level. (Note: there may be one or more classes taught for each course.) Paradigm development, course level, class size, and year of the class are determined for each class. The unit of analysis is the *class*.

Student Satisfaction with the Learning Environment- average student rating (on 5-point Likert scale) on two questions included on the class evaluation surveys administered at the end of each semester for each section throughout the university. These two questions measure student satisfaction with learning environment ("Communication of ideas and information" and "Facilitation of learning"). These two items from the class survey were found to be the most important items that identified teaching excellence and effectiveness (Dzubian, Wang, & Cook, 2003), and thus were selected to capture information about student satisfaction with the learning environment. The items are scored from Excellent (1) to Poor (5). The Cronbach alpha for student satisfaction is .93, which means that the questionnaire items of student satisfaction have high reliability (well above the 0.70 acceptable level suggested by Nunally & Bernstein, 1994).

Student Grade- average grade earned by students in the section of the class in which 4.0=A, 3.0=B, 2.0=C, 1.0= D, 0.0 = F.

Withdrawal Rate– (Number of students who officially dropped the section of the class/ Number of students officially enrolled in the section on the twelfth class day) *100.

Paradigm Development – Categorization based on the research findings by Lodahl and Gordon (1972), Salancik, Staw and Pondy (1980), Pfeffer and Moore (1980), and Cheng (1984) were used to classify Physics and Chemistry, Biology, Mathematics, and Electrical Engineering as high paradigm development disciplines. Consistently ranked as low paradigm development disciplines were Sociology and Political Science (Lodahl & Gordon, 1972; Pfeffer & Moore, 1980; Salancik et al., 1980) and Anthropology and History (Pfeffer & Moore, 1980; Salancik et al., 1980); Pfeffer and Moore (1980) also placed English and Philosophy within the low paradigm development range. Table 1 indicates the disciplines used in this study, the number of sections of web-based undergraduate courses offered in each discipline, the number of students enrolled in courses in each discipline, the number of courses in the prerequisite chain for an undergraduate major and, if available, past classifications of the discipline supporting the coding as high or low paradigm development.

Since researchers in the past did not include some disciplines in studies of paradigm development (i.e., Management Information Systems, Computer Science, Nursing, Health Services, Social Work, Criminal Justice, Legal Studies, Psychology, and Vocational Education), the paradigm development for all disciplines in the study was validated. To validate paradigm development, consistent with past studies, the number of courses in the undergraduate prerequisite chain in each of the uncategorized disciplines at the University was determined: the shorter the chain, the lower the paradigm development (Pfeffer & Moore, 1980; Salancik et al., 1980). The Mann-Whitney test found a difference significant at the .001 level between chain length for low (mean = 3.11) vs. high paradigm development (mean = 7.25) disciplines, supporting the premise that chain length can be used to categorize disciplines by paradigm development.

Table 1: Disciplines Included in Study

Discipline	# Courses (# Sections of course)	# Students	# Courses in Prerequisite Chain	Past Classifications
HIGH PARADIGM DEVELOPMENT (HPD) (coded as '1')				
Biology	1 (1)	25	9	Lodahl & Gordon (1972); Pfeffer & Moore (1980)
Computer Science	1 (19)	3,258	6	
Nursing	3 (6)	188	7	
Health Services	9 (53)	3,018	7	
Totals – HPD	14 (79)	6,489	Mean = 7.25	
LOW PARADIGM DEVELOPMENT (LPD) (coded as '0')				
Criminal Justice	4 (31)	2,202	3	
English	4 (10)	257	3	Pfeffer & Moore (1980)
Political Science	5 (8)	236	2	Lodahl & Gordon (1972); Salancik, Staw & Pondy (1980); Pfeffer & Moore (1980)
Legal Studies	1 (8)	362	4	
Management Information Systems	1 (5)	1,814	3	
Psychology	1 (4)	147	3	
Sociology & Anthropology	5 (16)	1,310	3.5	Lodahl & Gordon (1972); Salancik, Staw & Pondy (1980); Pfeffer & Moore (1980)
Vocational Education	1 (6)	350	3	
Totals – LPD	22 (88)	6,678	Mean = 3.111	
OVERALL TOTALS	36 (167)	13,167		

Course Level – Introductory courses are the first or survey course in each of these disciplines, coded as '0'. Advanced courses have at least two prerequisites and/or are described as advanced in the course catalog. Advanced courses were coded as '1'. To determine the course level (i.e., introductory or advanced), the catalog descriptions for all course included in the analysis were examined and prerequisites were determined. Then two researchers separately coded the courses. The course classification was then verified by the course instructor via e-mail. As a result of instructor feedback 5 courses were reclassified. Cohen's original kappa (Cohen, 1960) for the coding was .66 after the verification, which indicates substantial agreement since the kappa coefficient falls into the range of 0.6 to 0.79 (Landis & Koch, 1977).

Control Variables

Control of learning environment was provided through a research design that only included courses that used WebCT as the TML environment. Because the data gathered was from an institutional database, it was possible to incorporate more control than is typically possible in lab experiments or field studies. Class size was used to statistically control for any effects due to large class enrollments (Arbaugh & Duray, 2002; Hiltz & Wellman, 1997); SAT score and prior university GPA were used to control for ability because research indicated that they relate to performance (Higgs & Wood, 1999; VandeWalle. Cron, & Slocum, 2001). Perceived teacher quality was used to minimize effects associated with the instructor in the WebCT environment, including the instructor's facility with WebCT. Likewise the year in which the course was taught was used to minimize differences from the use of various versions of WebCT during the time period of this study. In addition, age was used to control for student maturity and experience. The controls are operationalized as follows:

Learning Environment – technology-mediated classes in which the students are dispersed and the delivery is entirely over the web using WebCT. The WebCT classes were prepared by a support staff person who worked with the class instructor during and after the instructor had completed a semester-long training session on using WebCT effectively for online learning. Standard templates were used to develop the classes. The communication support provided by WebCT is high and includes chat rooms, a whiteboard, e-mail capabilities, and discussions via WebCT's bulletin board feature. Thus, students can provide input anonymously and communicate synchronously and asynchronously with other students and faculty. The system maintains complete records of online discussions. Although WebCT has a calendar feature, its process support could be considered low to medium because it does not promote agenda setting or enforcement. Little support is provided for information processing through WebCT. Students can submit assignments, take quizzes or check their grades and course content. However, system features are not available to help them in evaluating or aggregating course content information.

Age–average age of students in the class section at the semester beginning.

Total SAT–average total SAT composite score for students enrolled in the class section.

GPA–average University GPA of students enrolled in the class section at the beginning of the semester in which the class was taken.

Perceived Teacher Quality–average student rating (on 5-point Likert scale) on an overall class evaluation question included on the class evaluation surveys administered at the end of each semester in each section throughout the university. The question "Overall assessment of instructor?" was scored from Excellent (1) to Poor (5). Overall student satisfaction served as a proxy for the quality of the teacher.

Class size–number of students enrolled in class on the twelfth class day.

Year –academic year in which the class was taught. The data base included classes taught from Fall 1997 through Spring 2003. Year served as a proxy variable for technical changes in content delivery that occurred over the six years that the study covered.

The results of our analysis to assess direct and interaction effects, based on MANCOVA and univariate analyses, are discussed next. The results of the hierarchical moderated regression analysis to test for interaction effects follow.

Results

Descriptive statistics for student grade, student satisfaction, and withdrawal rate by course level (i.e., introductory or advanced) and by paradigm development (i.e., high or low) are provided in Table 2.

Table 2: Descriptive Statistics

	Paradigm	Course Level	Mean	Standard Deviation (std dev)	N
Student Grade	Low Paradigm	Introductory	2.9180	.47444	69
		Advanced	3.0762	.39655	10
		Total	2.9380	.46603	79
	High Paradigm	Introductory	3.2987	.33906	18
		Advanced	3.5170	.22432	33
		Total	3.4400	.28705	51
Withdrawal Rate	Low Paradigm	Introductory	.1178	.09432	69
		Advanced	.2430	.11424	10
		Total	.1336	.10496	79
	High Paradigm	Introductory	.0819	.05722	18
		Advanced	.0375	.03614	33
		Total	.0531	.04909	51
Student Satisfaction	Low Paradigm	Introductory	1.9649	.42771	69
		Advanced	2.4834	.31074	10
		Total	2.0306	.44802	79
	High Paradigm	Introductory	2.4377	.60923	18
		Advanced	1.8187	.33070	33
		Total	2.0372	.53425	51

MANCOVA Results

The relationship between paradigm development and each outcome was tested by running MANCOVA for the dependent variables (student satisfaction, student grade, withdrawal rate) with the independent variables (paradigm development, course level), and with the covariates (age, total SAT, university GPA, perceived teacher quality, class size, and year). Univariate normality of each dependent variable was assessed using Shapiro-Wilk's test. While the results of Shapiro-Wilk's test are significant for student grade, withdrawal rate, and student satisfaction, further examination of skewness, kurtosis, and the normal probability plots suggests that the assumption of normality is met. The Levene test of equality of error variances is insignificant for withdrawal rate and student satisfaction, supporting the assumption that the error variances are equal across groups. However, the Levene test of equality of error variances is significant for grade. Finally, the linearity and multicollinearity among dependent variables were examined using Bartlett's test of sphericity and VIF. The results of Bartlett's test indicate a significant level of correlation ($p \leq .01$) between the three dependent measures and VIF values less than 10. Though not every assumption was completely met for this study's dataset, the areas in which data diverge from assumptions do not have a mate,rial effect on the outcomes. For example, with respect to the non-multivariate normality, Stevens (1992) indicates that "deviation from multivariate normality has a small effect on Type I error" (p. 247). And while the equality of error variances for grade is not supported, only an approximation of equivalence is necessary for the assumptions to hold. Therefore, a multivariate test of significance was conducted to examine Wilks' lambda for paradigm development, course level, and paradigm development*course level (see Table 3). Wilks' lambda ranges between 0 and 1, with values close to 0 indicating the group means are different and values close to 1 indicating the group means are not different (equal to 1 indicates all means are the same). That is, a significant difference is obtained from Wilks' lambda by getting small calculated values. An approximate F-statistic derived from Wiks' lambda is used to test for the significance of the overall MANCOVAs. Approximate F-statistics and degree of freedom (df) are shown in Table 3. Paradigm development, course level, and their interaction are all highly significant at the 1% level. Not surprisingly, all covariates except Year (a proxy for the different versions of WebCT) and class size are significant.

Table 3: Multivariate Test of Significance

Effect	Wilks' Lamda	F STATISTIC	Degree of Freedom (Df)	Significance Level (p)
Paradigm Dev.	.788	10.591	3.000	.000
Course Level	.784	10.814	3.000	.000
Paradigm Dev. *Course Level	.835	7.754	3.000	.000
Covariates				
Age	.816	8.872	3.000	.000
Class size	.967	1.324	3.000	.270
Total SAT	.778	11.253	3.000	.000
University GPA	.575	29.065	3.000	.000
Perceived course quality	.124	276.771	3.000	.000
Year	.987	.530	3.000	.662

Univariate Analyses Results

As a consequence of the significant multivariate test (See the significance level in Table 3), univariate tests analyzing the variance for each variable are also reported (see Table 4). Grades are significantly higher for students taking courses in disciplines with high paradigm development (mean = 3.44, std dev = 0.287) than in low paradigm development disciplines (mean = 2.94, std dev = 0.466) (F statistic=9.417, $p \leq .003$). The difference is significant. Student satisfaction is not significantly lower in high paradigm courses (mean = 2.04, std dev = 0.534) than in low paradigm courses (mean = 2.03 std dev = 0.448) (F statistic=1.421, $p \leq .236$). Withdrawal rate is significantly lower in high paradigm courses (mean = 0.05, std dev = 0.049) than in low paradigm courses (mean = 0.13, std dev = 0.105) (F statistic=17.829, $p \leq .01$). In terms of course level, only the withdrawal rate is significantly different (F statistic = 31.230, $p \leq 0.01$). The interaction between paradigm and course level is significant for both withdrawal rate and satisfaction (F statistic = 20.748, $p \leq 0.01$ and F statistic = 4.079, $p \leq 0.046$, respectively). The only covariate that is significant for Grade is GPA (F statistic = 14.129, $p \leq 0.01$). Only Class Size and Year are insignificant as covariates when considering withdrawal rate and satisfaction.

Table 4: Selected Results of Between-Subjects Effects

Source	Dependent Variable	Type III Sum of Squares	Degree of Freedom (df)	Mean Square	F Statistic	Significance level (p)
Corrected Model	Grade	12.786(a)	9	1.421	10.600	.000
	Withdrawal	.782(b)	9	.087	26.116	.000
	Satisfaction	27.755(c)	9	3.084	170.217	.000
Intercept	Grade	.002	1	.002	.013	.908
	Withdrawal	.003	1	.003	.806	.371
	Satisfaction	.016	1	.016	.860	.356
SAT	Grade	.000	1	.000	.001	.974
	Withdrawal	.085	1	.085	25.708	.000
	Satisfaction	.192	1	.192	10.594	.001
GPA	Grade	1.894	1	1.894	14.129	.000
	Withdrawal	.202	1	.202	60.847	.000
	Satisfaction	.109	1	.109	6.022	.016
Age	Grade	.070	1	.070	.523	.471
	Withdrawal	.046	1	.046	13.788	.000
	Satisfaction	.238	1	.238	13.162	.000
Class Size	Grade	.131	1	.131	.977	.325
	Withdrawal	.002	1	.002	.615	.435
	Satisfaction	.042	1	.042	2.342	.129

Source	Dependent Variable	Type III Sum of Squares	Degree of Freedom (df)	Mean Square	F Statistic	Significance level (p)
Year	Grade	.001	1	.001	.008	.927
	Withdrawal	.003	1	.003	.858	.356
	Satisfaction	.015	1	.015	.817	.368
Perceived Teacher Quality	Grade	.480	1	.480	3.582	.061
	Withdrawal	.021	1	.021	6.221	.014
	Satisfaction	14.290	1	14.290	788.779	.000
Paradigm Devel-opment	Grade	1.262	1	1.262	9.417	.003
	Withdrawal	.059	1	.059	17.829	.000
	Satisfaction	.026	1	.026	1.421	.236
Course Level	Grade	.139	1	.139	1.038	.310
	Withdrawal	.104	1	.104	31.230	.000
	Satisfaction	.064	1	.064	3.513	.063
Paradigm * Course Level	Grade	.269	1	.269	2.009	.159
	Withdrawal	.069	1	.069	20.748	.000
	Satisfaction	.074	1	.074	4.079	.046
Error	Grade	16.082	120	.134		
	Withdrawal	.399	120	.003		
	Satisfaction	2.174	120	.018		
Total	Grade	1306.488	130			
	Withdrawal	2.535	130			
	Satisfaction	567.320	130			
Corrected Total	Grade	28.868	129			
	Withdrawal	1.181	129			
	Satisfaction	29.929	129			

Hierarchical Moderated Regression Analysis Results

The role of course level as a moderating variable was examined using three separate regression models (Sharma, Durnad, & Gur-arie, 1981) to isolate the direct effect of each dependent variable from the interaction effect.:

(Eqn 1) Outcome (i.e., Satisfaction, Grades, Withdrawal) = a + $b_1$paradigm

(Eqn 2) Outcome (i.e., Satisfaction, Grades, Withdrawal) = a + $b_1$paradigm + b_2 course level

(Eqn 3) Outcome (i.e., Satisfaction, Grades, Withdrawal) = a + $b_1$paradigm + b_2 course level + $b_3$paradigm* course level

Hierarchical moderated regression analyses performed on all three outcomes to determine the nature of the moderating effect yields a significant R square (R^2) and R square change (ΔR^2) for withdrawal rate and student satisfaction only. Table 5 reports the results of the hierarchical regression analysis for moderated regression analysis for withdrawal rate and student satisfaction, the dependent variables demonstrating a moderator effect. According to Sharma et al. (1981), a moderator variable is one in which b_2 from equation 2 = 0, and b_3 from equation 3 is not equal to 0 must be satisfied. However, Carte and Russell (2003) argued against simply looking at the beta coefficients and suggested, instead, the importance of testing the significance of the R square change (ΔR^2) from the various equations. We report the Sharma et al. (1981) beta results, the R square change (ΔR^2) and the F-Statistics in Table 5.

Table 5: Results of Hierarchical Moderated Regressions

	Betas (Eqn 1)	Betas (Eqn2)	Betas (Eqn 3)	R square (R^2)	R square change (ΔR^2)	Degree of Freedom (df)	F statistics
WITHDRAWAL RATE							
Paradigm Development	b1 = .023	b1 = 039***	b1= .131***	.484			
Course Level		b2 = -.067***	b2 = -.009	.553	0.069		
Paradigm Development x Course Level			b3 = -.139***	.637	0.084	(1,120)	29.62***
STUDENT SATISFACTION							
Paradigm Development	b1 = -.015	b1 = -.036	b1 =.031	.908			
Course Level		B2 = -.058	b2 =.010	.910	.002		
Paradigm Development x Course Level			b3 = -.144**	.922	.012	(1,120)	19.69***
*** $p \leq .01$ ** $p \leq .05$ *$p \leq .10$							

In Table 5, we see that both b_2 (-.067) from equation 2 and b_3 (-.139) from equation 3 are significant at the 1% level for withdrawal rate. This result indicates that course level is both a quasimoderator variable (Sharma et al. 1981) as it interacts with the predictor variable paradigm, and a predictor variable.

The R square change (ΔR^2) (.084) and F statistic (29.62, $p \leq .01$) also support the hypothesis that course level moderates the relationship between paradigm development and withdrawal rate. This moderating effect can be seen in Figure 3 where withdrawal rate is highest for advanced low paradigm courses (mean =.243) and for introductory low paradigm courses (mean =.118). Withdrawal rate is lowest for advanced high paradigm courses (mean =.038) and introductory high paradigm courses (mean =.082). These results support Hypotheses 2 and 4.

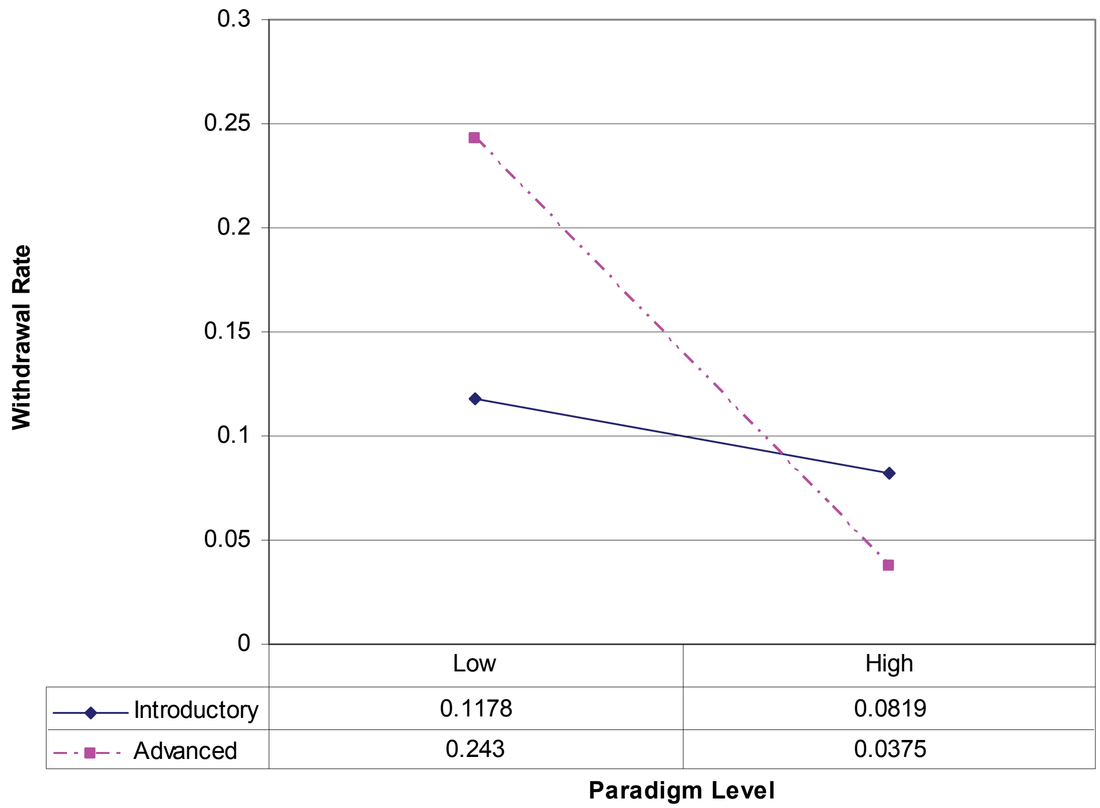

Figure 3. Interaction of Level of Paradigm and Level of Class on Withdrawal Rate

An examination of student satisfaction, from Table 5, shows that b_2 (-.058) from equation 2 is not significant at the usual significance level (significance level p=.266) while b_3 (-.144) from equation 3 is significant at the 5% level (significance level p=.046). The change (.012) and F statistic (19.69, $p \leq .01$) demonstrate that the interaction between course level and paradigm development for student satisfaction moderates the relationship and is in the hypothesized direction since the highest level of satisfaction is coded with a '1' and the lowest level is coded with a '5'. This moderating effect can be seen in Figure 4 where student satisfaction scores are lowest (i.e., higher satisfaction) for advanced high paradigm courses (mean =1.82) and for introductory low paradigm courses (mean =1.96). The student satisfaction score is highest (i.e., indicating lower satisfaction) for advanced low paradigm courses (mean =2.48) and introductory high paradigm courses (mean =2.44). The result relationships are in the direction predicted by Hypotheses 1 and 3.

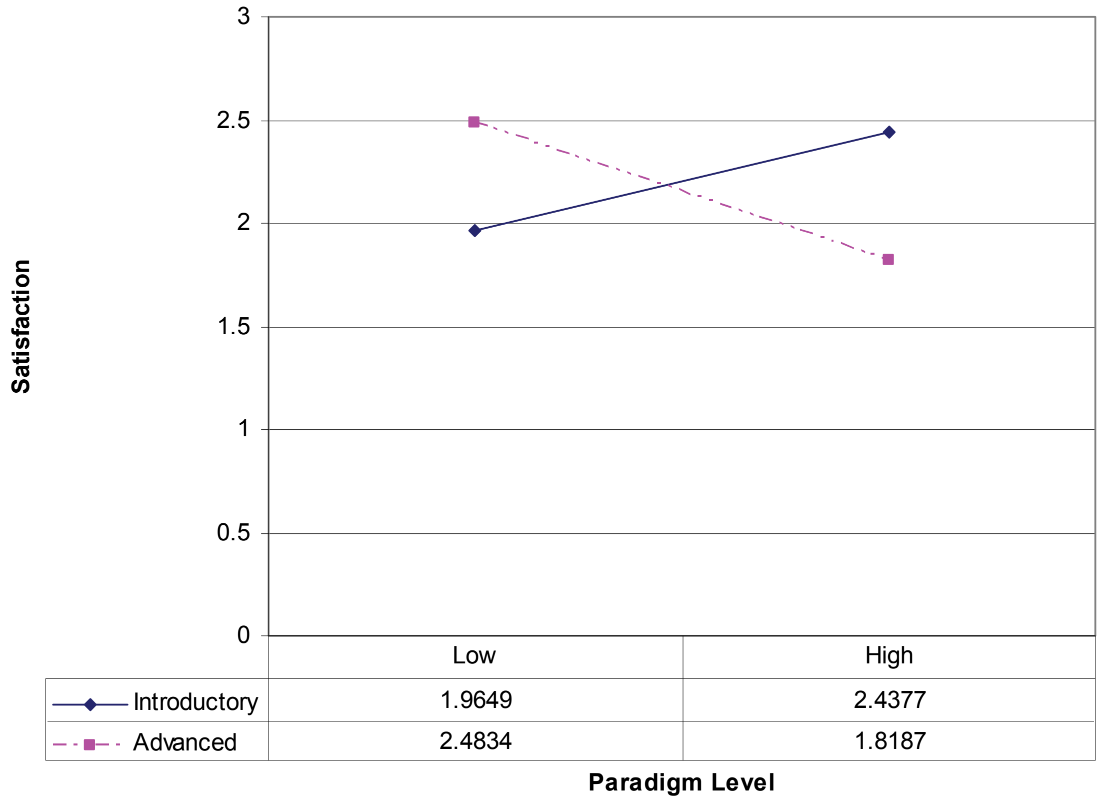

Figure 4. Interaction of Level of Paradigm and Level of Class on Satisfaction.

Discussion

Information Technology can be used more effectively for some courses, but not others. Using a large sample of classes taught over a six-year period, we find that student performance in technology-mediated learning environments is significantly greater for courses in disciplines with high paradigm development than for courses in disciplines with low paradigm development. Also, in the high paradigm courses, withdrawal rate is significantly lower, and an even stronger significant relationship emerges when we include the hypothesized moderating effect of course level on the relationship. Further, the hypothesized significant relationship emerges when we include the moderating effect of course level on the relationship with student satisfaction.

As in the studies by Vaverek & Saunders (1993-1994) and Benbunan-Fich & Hiltz (2002), students are more satisfied (but not significantly so) in the less technical, low paradigm courses. The use of course level as a moderator in this relationship explains the seemingly contrary findings of Vaverek & Saunders (1993-1994) about the desirability of using IT in teaching courses in low-paradigm disciplines. In particular, students are clearly more satisfied in introductory, low-paradigm courses offered in TML environments than in advanced courses in these same disciplines. The reverse is true for high-paradigm courses: Students are more satisfied in the advanced courses. When assessing student satisfaction, investigating only level of paradigm development masks some important differences.

Probably the most notable findings of this study relate to the impact of paradigm development on the withdrawal rate in technology-mediated learning environments. The use of course level as a moderator in this relationship tempers Webster and Hackley's (1997) findings concerning the high withdrawal rate in technology-mediated learning environments. They reported, "… in one course students told us that the technology had scared off many students: one location dropped to 4 students from 14." Our findings suggest that students in courses in disciplines with high levels of paradigm development may not be scared off as easily as those in low-paradigm disciplines at any level, but especially in the more advanced courses.

These findings have important practical implications for Management Information Systems (MIS) education. MIS clearly does not have a single paradigm that characterizes such high-paradigm disciplines as physics and chemistry (e.g., Hassan, 2006). Further, there is considerable debate about its core. Defining the core of a discipline is a task that is easy to do in disciplines with a high-level of paradigm development. We operationalized level of paradigm development with an approach that has been commonly used in past research, course sequencing in departments (e.g., Pfeffer & Moore, 1980; Salancik et al., 1980). The short chain of only three prerequisites at the university in which the study was conducted is consistent with viewing MIS as a low paradigm discipline. Our findings indicate that for such programs, the TML environment approach may not be as effective in terms of supporting satisfaction and learning and may in fact lead to higher withdrawal rates for more advanced, highly technical courses. On the other hand, the outcomes should be successful for technology-mediated introductory MIS courses. In our study, only one MIS course has been entirely web-based, the introductory undergraduate business core course. The mean (standard deviation) for student grades, withdrawal rate and student satisfaction are 2.96 (0.29), 0.085 (0.055), and 2.80 (0.55), respectively, suggesting the appropriateness of using IT for the introductory MIS course. The MIS classes were not significantly different from the other courses in low paradigm disciplines in terms of grades and withdrawal rates.

We are surprised that relatively few web-based courses in high paradigm disciplines were taught at the University over the six- year period of our study. Looking at the entire database of all courses in all disciplines (not just high and low paradigm development disciplines), only an approximate four percent of the participating disciplines (i.e., 4 out of 95) and the total number of the web-based sections (i.e., 79 out of 2021) are in high paradigm development disciplines.

To try to better understand why the high-paradigm disciplines were not better represented in our sample, we placed follow-up calls with the department chairs or the faculty whom the chairs recommended that we contact in their department. The Departments of Mathematics, Computer Science, Physics, and Biology were contacted to further explore why their departments (in high-paradigm disciplines) had not developed more courses that were entirely web-based. While they had only offered one undergraduate course in the past, the Computer Science department now has been charged by its Dean to place more classes online. The Physics department felt that it was important for their students to work in the labs with equipment and so the department was hesitant about using courses that were entirely web-based. Further, the Physics departmental spokesperson said that there were not enough graphics available to faculty teaching the TML courses to easily convey much of the material in physics courses. Finally the Biology Department had offered one course that was totally web-based, but has ceased offering it because it wants it students to work in the labs.

The response of the Mathematics department chair was particularly revealing. He said that it was important to allow face-to-face contact with the students when they had questions. His focus was entirely on the introductory courses, where our model suggests that TML environments are not as appropriate. In math courses there is the added difficulty of having to use a special symbol set to write equations. Software is available to make this easier for the faculty and students, but the chair thought that the costs were still too high to incorporate it into courses that are entirely web-based. Media Synchronicity Theory suggests that media with more natural system sets, such as face-to-face communications, can support interactive discussions better than less natural symbol sets such as mathematical symbols (Dennis, Fuller, & Valacich, in press). Hence, the math teachers could be expected to find it more difficult to communicate with their students online.

Our discussions with the department chairs and faculty in high-paradigm disciplines demonstrate that professors may be averse to teaching such courses because of concerns about the appropriateness of technology-mediated delivery. If so, our findings suggest that some of their concerns may be ill-founded: Students in disciplines with high levels of paradigm development perform better in their web-based courses than students in courses with low levels of paradigm development. However, they would need to target TML environments for advanced courses in these disciplines, especially those that do not require lab equipment.

Perhaps, the University technology support staff needs to work more closely with professors in such fields as Mathematics and Physics to persuade them to use the TML environment. In working with faculty in disciplines with high levels of paradigm development, it may be especially important to identify the advanced courses for which the technology would be suitable and to stress the need for faculty to provide timely feedback to students in introductory classes who might withdraw or do poorly in the course because they do not understand basic concepts. Further, the technology support staff members need to make software available that makes it easier for faculty to use graphics and mathematical symbols. If such software is already available at the university, the faculty need to be alerted about its potential use in courses.

Heavy emphasis on online discussions among students during in the TML environment courses that we studied could provide an alternative explanation for the lower proportion of classes in disciplines with high paradigm development. This University adopts a constructivist model in TML environment training so that learning takes place as students construct knowledge—active discovery *supported* by the instructor. Since the terms and concepts of low level paradigm fields are less developed/agreed upon, there is a greater necessity for student interaction to support their construction of knowledge, often through discussions with their peers. In contrast, under the objectivist model, learning takes place as the student absorbs the knowledge of the instructor. No interactivity is necessary between the students and their classmates. Therefore it might be argued that the greater the paradigm development, the less need for interaction (other than that of instructor to student). Hence, faculty in disciplines with high paradigm development may view web-based courses as less appropriate since they do not value discussion among students. In these situations there may not be a good fit with teaching styles, or responsiveness and enthusiasm of the instructor for the technology platform (Hornik, Johnson & Wu, 2007; Sarker & Nicholson, 2005). University technical staff may need to alter their training programs to focus on ways of interacting with equipment instead of other classmates.

Of course, faculty teaching in either high or low paradigms may resist using the technology because they recognize that it may be more difficult to prepare material for the course, it requires more effort to interact with students during the course, or it may lead to undesirable use of course materials (Sarker & Nicholson, 2005). Universities that wish to encourage more teaching in TML environments will need to incentivize faculty by recognizing the considerable efforts to develop and teach these course with merit increase and other forms of recognition. Further, universities must take an active role in protecting faculty's intellectual property.

Limitations

This study is not without limitations. While virtually all of the MANOVA assumptions were met, grade did not meet the assumption for homoscedasity. Thus, the results of MANOVA related to grade must be viewed critically. However as mentioned above, violations of the assumptions have been found to not have a material effect on the results (Stevens, 1992). Another limitation in this research involves control variables. Studies of student withdrawal in TML environments suggests that the number of previous technology-mediated courses taken by students reliably discriminates between students who drop out compared to those who remain in either web-based or videoconferencing courses (Osborn, 2001; Wang & Newlin, 2002). Future studies should control for the number of previous technology-mediated courses and the reasons for student withdrawals. Also, future research should incorporate ratio scales and should explore the reasons for lower adoption rates in courses with high paradigm development. Other types of TML environments and characteristics should also be studied, such as Blackboard or Persyst (Ginsberg, Shiau, & Sampieri, 2000). This study clearly demonstrates that educational technology is more important for certain courses when considering paradigm development. The findings from this study suggest that future research should explore what aspects of the technology cause these differences across paradigm development and course level to occur.

Conclusion and Recommendations

This paper investigates the effect of paradigm development and course level on the outcomes of web-based technology-mediated learning (TML) environments in order to ascertain if these external factors can help explain student outcomes. Using an institutional database of student outcomes, we examined data from over 13,000 students in 167 undergraduate courses from the years 1997 – 2003. Using this data we explored which types of courses are best suited for delivery using web-based technologies. We find that some courses are clearly more suitable for TML environments than others. Tests of our hypotheses suggest just which types of courses are more suitable. In particular, our results suggest that student grades are significantly higher and withdrawal rates lower for courses with high paradigm development (e.g., Biology, Computer Science) than for courses with low paradigm development (e.g., Sociology, English). Even stronger relationships emerge when including the hypothesized moderating effect of course level (introductory or advanced). In introductory TML courses in disciplines with lower paradigm development, grades and student satisfaction are higher (Hypothesis 1) and withdrawal rates are lower (Hypothesis 2) than in introductory TML courses in disciplines with high paradigm development. In contrast, in advanced TML courses in disciplines with low paradigm development, grades and student satisfaction are lower (Hypothesis 3) and withdrawal rates are higher (Hypothesis 4) than in advanced TML courses with high paradigm development in TML environments.

As more TML programs are developed, these findings highlight the importance of creating programs in high paradigm development disciplines. We found amazingly few course offerings in these disciplines during the six-year period of our study. Given the findings of improved student outcomes, more advanced TML courses in these disciplines should be developed, especially those that do not have lab requirements.

In creating and enhancing TML programs we have the following suggestions for University administrators, faculty and students. These are outlined below:

University administrators

- University administrators should recognize that TML environments require considerable technical support. They should hire adequate staff to support faculty in their efforts to develop new courses. For example, technical support staff could be assigned to work with faculty who have proposed new web-based courses.
- University administrators should provide incentives for faculty to develop web-based courses. Faculty could be given release time to develop courses and could be recognized for their considerable efforts at developing and offering courses when faculty are evaluated and merit is determined.

- University administrators should recognize and protect the intellectual property of faculty who develop TML courses.
- University administrators should make funding available for needed technology, such as software to make it easier to use graphics and mathematical symbols.

Faculty

- Faculty should recognize that TML environments are not appropriate for all courses. Thus, faculty in disciplines with low levels of paradigm development should target introductory courses, and faculty in disciplines with high levels of paradigm development should target the more advanced courses. Since many science classes need students to work in labs, these classes may require a mixed format with both an online and a lab component.
- Faculty must be available to provide prompt feedback to students. This is especially critical in courses where students need to master elementary concepts before they can move on to more advanced concepts.

Students

- Students may wish to seek out introductory, entirely web-based courses in low-paradigm disciplines and advanced courses that are entirely web-based in high-paradigm disciplines, because these formats may be particularly appropriate for their learning.
- Students need to make sure they ask for help from the faculty members as soon as they realize that they do not understand key concepts.

To maximize the return on new TML initiatives, a focused program for creating new online courses for advanced high paradigm development courses (e.g., Computer Science) and introductory courses in low-paradigm disciplines should lead to less withdrawal, higher satisfaction, and increased academic performance. It will require, however, the concerted efforts of administrators, faculty and students.

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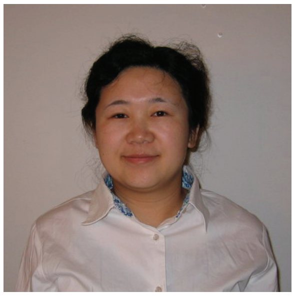

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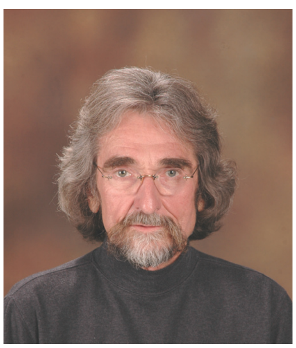
Patsy Moskal is the Associate Director for the Research Initiative for Teaching Effectiveness at the University of Central Florida (UCF) where she has been a faculty member since 1989. She received an Ed.D. from UCF specializing in Instructional Technology and Research Methods and holds BS and MS degrees in computer science. Since 1996, she has served as the liaison for faculty research of distributed learning and teaching effectiveness at UCF. Patsy specializes in statistics, graphics, program evaluation, and applied data analysis. She has extensive experience in research methods including survey development, interviewing, and conducting focus groups and frequently serves as an evaluation consultant to school districts, and industry and government organizations. She has co-authored a number of book chapters and journal articles on research in online and blended courses.



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