The role of delivery methods on the perceived learning performance and satisfaction of IT students in software programming courses

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ABSTRACT

More and more information technology (IT) programs are offering distance learning courses to their students. However, to date, there are a very limited number of published articles in the IT education literature that compare how different methods of delivering distance course relate to undergraduate students' learning outcomes in IT software programming courses taught by the same instructor. Thus, we conducted a case study to assess the predictive relationships between distance course delivery method (face-to-face, satellite broadcasting, and live video-streaming) and students' perceived learning performance and satisfaction in IT software programming courses taught by the same instructor. The results suggested that the choice of delivery method was related to students' satisfaction and programming skill enhancement. However, we did not find a relationship between the delivery method and the students' perceived learning performance. Specifically, the participants in the face-to-face delivery method group were more likely to feel satisfied with the delivery method than the students using the other two delivery methods (i.e., satellite broadcasting and live video streaming).

Keywords: Distance learning, Computer programming, Learning goals & outcomes, Student performance, Student perceptions

1. INTRODUCTION

Technology-mediated distance learning has become an important way to deliver courses in higher education. Many institutions of higher education have established distance learning programs. An Internet search indicates that many universities (such as Washington State University and Oklahoma State University) have offered their Information Technology or MIS (Management Information Systems) programs either online or through other distance learning formats. Many information technology courses, including software programming courses, have been delivered to students at a distance via a variety of delivery methods such as live video streaming and televised broadcasting. For example, a face-to-face course can be broadcast live to students at different satellite campus and can also be streamed for live video-based access on the Internet. These distance learning formats offer students the opportunity to earn degrees at a distance without having to come to the main university campus (Chong, He, & Wu, 2012).

As distance learning becomes more prevalent and higher education institutes continue to expand and diversify distance course delivery methods, more and more educators and organizations have become concerned with the quality of distance education (Abdous, 2010; Rovai & Downey, 2010; Yang, 2010). For example, AACSB (the Association to Advance Collegiate Schools of Business) has recognized the growing importance of distance learning in business education and has formed a task force to develop guidelines to aid people who conduct reviews of quality and accreditation of distance learning programs (AACSB, 2007). It becomes critical to evaluate the effectiveness of these various distance course delivery methods in terms of students' learning performance and learning satisfaction (Abdous & Yoshimura, 2010). Educators who teach distance learning courses need to understand how different delivery

methods affect students' learning when students are exposed to different delivery methods in a technology-enhanced learning environment.

The main purpose of this case study is to examine the predictive relationship between delivery method and various outcome variables (i.e., delivery method satisfaction, programming skill enhancement, and expected final grade) in computer programming courses using multiple delivery methods (i.e., face-to-face, video streaming, and satellite broadcasting) after controlling for the students' previous uses of the same delivery method and computer programming experience level. The same software programming courses were simultaneously delivered to IT students via three different delivery methods. In addition, students were free to choose any of the delivery methods, based on their location and interests. The research questions of this case study are listed as follows:

1. How, and to what extent, can the delivery method predict student delivery method satisfaction after controlling for the students' delivery method experience level?
2. How, and to what extent, can the delivery method predict student delivery method satisfaction after controlling for the students' computer programming experience level?
3. How, and to what extent, can the delivery method predict student programming skill enhancement after controlling for the students' delivery method experience level?
4. How, and to what extent, can the delivery method predict student programming skill enhancement after controlling for the students' computer programming experience level?
5. How, and to what extent, can the delivery method predict the students' expected final grade after controlling for the students' delivery method experience level?
6. How, and to what extent, can the delivery method predict the students' expected final grade after controlling for the students' computer programming experience level?

As far as the significance of the study is concerned, the results of this case study will provide distance learning instructors, practitioners, and administrators with data regarding how delivery methods are related to students' perceived learning performance and satisfaction. To ensure the fairness and quality of distance learning courses for students, it is important for distance learning instructors, practitioners, and administrators to continuously assess different delivery methods, to understand the learning experience of distance learning students, and to make improvements as needed. The findings of this case study will potentially help institutions of higher education to develop strategies and methods both to mitigate the limitations of existing delivery methods and to improve the overall quality of distance learning courses.

2. LITERATURE REVIEW

Quite a few journal articles have been published regarding the relationship between distance course delivery methods and student learning outcomes (Abdous & Yen, 2010; Buckley, 2003; Carrol & Burke, 2010; Dutton, Dutton, & Perry, 2002; Euzent, Martin, Moskal, & Moskal, 2011; Jahng, Krug, & Zhang, 2007; Larson & Chung-Hsien, 2009; Naaj, Nachouki, & Ankit, 2012; Settle & Settle, 2007). Buckley (2003) compared the effectiveness of traditional classroom, web-enhanced, and web-based delivery methods in an undergraduate nutrition course and found no difference in student learning outcomes including midterm and final examination scores and course grades, or in students' self-reports of instructor preparation, instructor-student interaction, testing, course objectives and assignments, textbooks, and strengths and weaknesses of the course. Jahng, Krug and Zhang (2007) did a meta-analysis of student achievement comparison-related research published between 1995 and 2004 and found no significant difference in student achievement between Online Distance Education and Face-to-Face Education. Larson and Chung-Hsien (2009) assessed the effect of three delivery methods (i.e., face-to-face, blended, and online) on student grades in an introductory MIS course taught by the same instructor and found that student grades did not change across delivery modes. In a survey study of the relationships among delivery methods and learners' satisfaction and outcomes (Abdous & Yen, 2010), no strong relationship between delivery methods and students' learning satisfaction or outcomes was established. In another comparative study (Carrol & Burke, 2010) of two sections of an MBA organizational theory course (i.e., an online section and a face-to-face section), trivial differences in the results of the final examination and the student course evaluations were found between sections. Carrol and Burke (2010) concluded that neither delivery method was more effective than the other with regard to students' achievement or their perceptions of course effectiveness.

On the other hand, Means, Toyama, Murphy, Bakia, & Jones (2009) examined the comparative research on online-versus-traditional classroom teaching from 1996 to 2008 and found that "on average, students in online learning conditions performed better than those receiving face-to-face instruction." Dutton, Dutton, and Perry (2002) compared two large sections of a computer programming course and found that online students differed from lecture students in a number of important characteristics. In particular, they found that online students earned significantly higher exam grades than lecture students. Settle and Settle (2007) found that distance learning students were less satisfied than either traditional students or their peers in live sibling sections of the same introductory Java programming courses. Naaj, Nachouki, and Ankit (2012) surveyed 153 students enrolled in IT courses to understand their satisfaction with blended learning courses that use two delivery methods (i.e., face-to-face and videoconference learning). The results of their study suggested that students still preferred face-to-face courses even though they were satisfied with their grades and performance in blended learning courses.

The above literature review revealed that existing published research on the effectiveness of different delivery methods used in the same course is sometimes contradictory in its conclusions. In particular, we only found a small number of papers that compare distance course delivery methods simultaneously used in the same or similar courses

taught by the same instructor. Prior studies typically compared student perceptions and/or performances with two different course delivery methods (i.e., face-to face and web-based method). In section 3, we will describe a case study by providing first-hand evidence collected from IT undergraduate students taking IT software programming courses in three different course delivery formats taught by the same instructor. After reviewing published articles in several major IT educational journals, we did not find an identical study focusing on three delivery methods (face-to-face, satellite broadcasting, and live video-streaming) in the same IT courses and thus we are confident that our case study would make a new contribution to the IT education literature.

3. OUR CASE STUDY

3.1 Background

Our university has been involved in technology-delivered distance learning since the mid-1980s. Historically, course delivery has been conducted using interactive television via satellite broadcast from the main campus to sites around the country. In recent years, the number of delivery modes has been expanded to include two-way video, Internet, CD-ROM, and video streaming. The term "video streaming" refers to a means of delivering a live course to students by computer. Video streaming students may participate from any location. Nowadays, video streaming is becoming a popular trend in distance education and plays an increasingly important role in many distance learning programs (Hartsell & Yuen, 2006). At our university, many synchronous video courses are offered via video streaming for students who are unable to attend classes at the main campus or at one of the remote sites. Video streaming provides students with opportunities to attend satellite and two-way video courses in real time wherever they are, using their computers (Abdous, He, & Yen, 2012; Abdous & He, 2011; Abdous & Yen, 2010; He, 2013).

In order to meet the different needs of students, many courses have been broadcast from the main campus to different sites and have also been streamed for live video-based access on the Internet. Satellite students meet in a traditional classroom setting at a site (a community college, military base, or military ship at sea) where the broadcast is received, and, to participate, must be present at that site at the specified class time. In this environment, students are able to view the instructor on television via satellite and can speak with both the instructor and with other participating students in real time. At each remote site, student desks are equipped with microphones to enable students to interact with their instructor and classmates via an audio connection. But students who are unable to attend a class at a site at that specific time may attend the class in real time via a video streaming format, using their computers. In this environment, video streaming students are able to view the instructor only. Interaction takes place in real time directly with the instructor by the use of an Internet chat application. Figure 1 describes the delivery methods used in an IT computer programming course.

3.2 Method

3.2.1 Study Participants: There were 55 students in total - 26 IT undergraduate students in the Visual Basic. Net programming course and 29 IT undergraduate students in the Java programming course. Both programming courses were taught by the same instructor on the same day and covered similar object-oriented programming concepts and assignments. Students took the courses through a variety of delivery methods (i.e., face-to-face, video streaming, & satellite). With the approval of the university's IRB board, an anonymous online survey was distributed to these students about two weeks before the final exam. As a result, 44 students out of the 55 students completed the survey. The response rate was 80%.

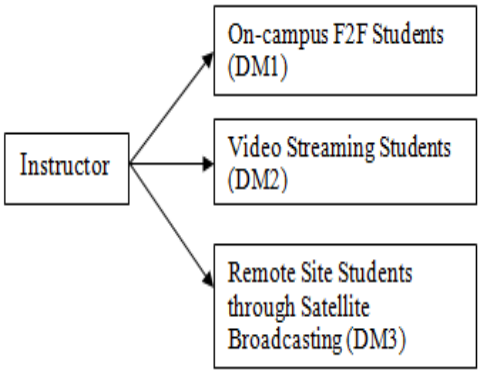

Figure 1. Delivery methods used in a distance learning programming course

3.2.2 Operationalization of Research Variables

Focal predictor variable

Delivery method: Course delivery method (DM) served as the focal predictor variable for various criterion variables in the research questions. The courses under the study used three distinct delivery methods: face-to-face (DM1), video streaming (DM2), and satellite broadcasting (DM3).

Online student survey: The online student survey was developed based on the survey items used in past studies (Abdous & Yoshimura, 2010; Abdous & Yen, 2010; He, 2011). The Likert survey items were finalized based on feedback from the previous respondents and were reviewed by a panel of experts to ensure the relevancy of the items for the research variables. The actual survey items of various research variables are listed in Table 1. More information regarding how research variables were measured is presented in the following sections.

Criterion variable 1: Delivery method satisfaction. Respondents were asked if they were familiar with the delivery method that they used via a 5-option scale (Strongly disagree; Disagree; Neither agree nor disagree; Agree; Strongly agree). Given the small sample size, the results were dichotomized into two outcomes: (1) satisfied (Agree or Strongly agree) or (2) unsatisfied with the delivery method in actual data analysis. The group that was unsatisfied with the delivery method was used as the reference group to form the odds in logistic regression.

Variable	Survey item
Delivery method satisfaction	I am satisfied with this delivery method.
Programming skill enhancement	The course has enhanced with my programming skills.
Expected final grade	What is your expected final grade in this course?
Delivery method experience level	How many times have you used this delivery method for your distance learning courses (before this semester)?
Computer programming experience level	What is your experience level with computer programming?

Table 1: Survey Items for Criterion Variables and Control Variables

Criterion variable 2: Programming skill enhancement. Respondents were also asked if the course enhanced their information technology (IT) skill via a 5-option scale (Strongly disagree; Disagree; Neither agree nor disagree; Agree; Strongly agree). In light of the small sample size, respondents were divided into two groups: (1) one that perceived programming skill enhancement from the course (Agree or Strongly agree) and, (2) the other that perceived no programming skill enhancement from the course.

Criterion variable 3: Expected final grade. Respondents selected one of the five options (i.e., A level, B level, C level, D level, and F) as their expected final grade in the course. As this anonymous survey study was conducted about two weeks before the final exam, we decided to use the expected final grade as a criterion variable. Expected final grade has been used in other educational studies to measure perceived learning outcomes (Wan, Wang, & Haggerty, 2008). In actual data analysis, the expected final grades were binary: (1) B or higher or (2) C or lower, due to the small sample size.

Control variable 1: Delivery method experience level. This variable operationalized how many times the current delivery method had been used by a respondent in the previous distance learning course(s). The higher the number, the more experienced the respondent, in the currently used delivery method.

Control variable 2: Computer programming experience level. The respondents rated their own computer programming level on a 4-option scale (Zero, A little bit experience, Some experience, and Advanced experience).

Data Analysis

IBM SPSS Statistics 19 was utilized to analyze quantitative data in the study. An alpha level of .05 was set for all the implemented significance tests.

Binary logistic regression. Due to the dichotomous results on the binary criterion variables, binary logistic regression models (King, 2008; Norusis, 2012) were fitted to address the research questions of interest. In a logistic regression model, the transformed outcomes, not the original outcomes, on the binary criterion variable as the natural log of the odds (i.e., the probability of the event divided by the probability of nonevent) or logits would be modeled as being linearly related to the predictor(s) in the model.

The use of logistic regression instead of ordinary least squares (OLS) regression for binary criterion variables avoided the negative implications of statistical assumptions (i.e., normality & homoscedasticity) violation and the predicted probabilities outside the theoretically permissible range of 0 to 1 (Cohen, Cohen, West, & Aiken, 2003).

Model specification. Several binary logistic models were specified to address various research questions with different criterion variables and control variables. In order to assess the unique predictive relationship between delivery method and various criterion variables controlling for each of the two control variables, the control variable and the focal predictor variable were hierarchically entered into the binary logistic model in SPSS to form two nested models, one as the baseline model and the other as the final model. For delivery method (DM) as the categorical focal predictor variable with three levels, two dummy variables (i.e., D(DM1) for face-to-face & D(DM2) for video streaming) were created internally in SPSS to use the satellite delivery group as the reference group. As to computer programming skill (CPS) level as the categorical control variable with four levels, three dummy variables (i.e., D(CPS1), D(CPS2), & D(CPS3)) were generated in SPSS using the advanced skill group as the reference group. Accordingly, as an illustrative example, the baseline model and the final model for the research question 2 were specified as the follows:

Baseline model

$$Log\ \left(\frac{Prob(DM\ satisfaction)}{Prob(no\ DM\ satisfaction)}\right) = \beta_0 + \beta_1 *D(CPS1) + \beta_2 *D(CPS2) + \beta_3 *D(CPS3)$$

Final model

$$Log\ \left(\frac{Prob(DM\ satisfaction)}{Prob(no\ DM\ satisfaction)}\right) = \beta_0 + \beta_1 *D(CPS1) + \beta_2 *D(CPS2) + \beta_3 *D(CPS3) + \beta_4 *D(DM1) + \beta_5 *D(DM2)$$

Significance test of the focal predictor. The χ^2 likelihood ratio test based on the difference in the -2 log-likelihood between the baseline model and the final model (King, 2008; Norusis, 2012) was implemented to assess the unique predictive utility of the delivery method for various criterion variables over and above the control variable. The χ^2 likelihood ratio test statistics follow a χ^2 distribution with the degrees of freedom as the difference between the number of parameters in both the baseline model and the final model. Once a focal predictor's unique predictive utility was established, in order to get a more concrete sense regarding how the predicted probabilities of the target event would vary across delivery method groups, the predicted probabilities of the target event were derived from the predicted logits at the lowest value on the control variable (i.e., no previous experience of a delivery method or no computer programming experience) for participants in different delivery method groups. The formula to convert predicted logits to predicted probabilities is (Cohen et al., 2003):

$$\hat{p}_i = \frac{e^{\beta_0 + \beta_1 + \beta_2 \ldots\ldots + \beta_k}}{1 + (e^{\beta_0 + \beta_1 + \beta_2 \ldots\ldots + \beta_k})}$$

Effect size index. As suggested by Menard (2002), the pseudo-R^2 computed as the proportional reduction in the -2 log-likelihood while moving from the baseline model to the final model was used as the effect size index. However, the value of the pseudo-R^2 should not be interpreted as the proportion of variance accounted for like the R^2 in OLS regression (Cohen et al., 2003).

Significance test of model goodness-of-fit. The Hosmer-Lemeshow test statistics (King, 2008; Norusis, 2012) were computed to assess the overall model goodness-of-fit. The fit of a model to the data can be conceptualized as how well the model describes the data (Hosmer & Lemeshow, 2000) or to what extent the predicted probabilities agree with the observed probabilities of the target event for the participants as a whole (Norusis, 2012). Given the small sample size in the study, the Hosmer-Lemeshow test results should be cautiously interpreted (Hosmer & Lemeshow, 2000).

Classification accuracy as model goodness-of-fit. The percentage of correctly classified cases based on predicted probabilities implied by the final logistic regression model and the cutoff of .05 (King, 2008; Norusis, 2012) was also computed as the supplementary index of model goodness-of-fit.

3.3 Results

3.3.1 Descriptive Statistics of Study Participants: Among them, 16 (36.36%) students were taught by the face-to-face delivery method, 21 (47.73%) students by the video streaming delivery method, and 7 (15.91%) by the satellite delivery method. The majority of the participants were male (n = 34, 77.27%), senior (n = 41, 93.18%) students. Their ages ranged from 21 to 48 years old with the mean as 27.91, the median as 25.50, and the standard deviation as 7.39. As to their employment status, 10 (22.73%) of them were unemployed, 19 (43.18%) of them employed part-time, and 15 (34.09%) of them were employed full-time. The participant information by delivery method was listed in Table 2.

	Delivery method							
Variable	Face-to-face		Video Streaming		Satellite		Total	
	n	%	*n*	%	*n*	%	*N*	%
Gender								
Female	2	12.50	6	28.57	2	28.57	10	22.73
Male	14	87.50	15	71.43	5	71.43	34	77.27
Academic Level								
Junior	0	0.00	3	14.29	0	0.00	3	6.82
Senior	16	100.00	18	85.71	7	100.00	41	93.18
Employment								
Unemployed	7	43.75	2	9.52	1	14.29	10	22.73
Part-time	9	56.25	6	28.57	4	57.14	19	43.18
Full-time	0	0.00	13	61.91	2	28.57	15	34.09

Table 2: Participant Information by Delivery Method

Descriptive Statistics of Research Variables

The descriptive statistics was computed for various criterion variables and control variables (see Tables 3 – 4).

	Delivery method							
Variable	Face-to-face		Video Streaming		Satellite		Total	
	n	%	*n*	%	*n*	%	*N*	%
DM Satisfaction								
No	0	0.00	7	33.33	2	28.57	9	20.46
Yes	16	100.00	14	66.67	5	71.43	35	79.54
Programming Skill Enhancement								
No	2	12.50	5	23.81	4	57.14	11	25.00
Yes	14	87.50	16	76.19	3	42.86	33	75.00
Expected Final Grade								
C or lower	3	18.75	7	33.33	3	42.86	13	29.55
B or Higher	13	81.25	14	66.67	4	57.14	31	70.45
Programming Experience								
Zero	9	56.25	6	28.57	4	57.14	19	43.18
A Little Bit	3	18.75	5	23.81	2	28.57	10	22.73
Some	3	18.75	10	47.62	1	14.29	14	31.82
Advanced	1	6.25	0	0.00	0	0.00	1	2.27

Table 3: Descriptive Statistics of Categorical Research Variables by Delivery Method

Delivery Method				
	Face-to-face	**Video Streaming**	**Satellite**	**Total**
n	16	21	7	44
Mean	2.31	4.05	6.00	3.73
Median	1	4	6.18	3.50
SD	2.87	3.28	3.22	3.31
Minimum	0	0	1	0
Maximum	10	10	10	10

Table 4: Descriptive Statistics of Number of Previous Delivery Method Uses by Delivery Method (DM)

Overall, the participants in the face-to-face delivery method group were more likely to feel satisfied with the used delivery method. Furthermore, the percentage of participants who perceived the course as helpful in enhancing their programming skills was the highest in the face-to-face delivery method group. The participants in the face-to-face delivery method group were also more likely to expect better final grades. On average, the participants in the satellite broadcasting delivery method group had the highest number of the previous distance courses using the same delivery method (i.e., satellite broadcasting). As to the computer programming experience level, a higher proportion of participants in the video streaming delivery method group had at least some programming experience. On the other hand, more than half of the participants in the other two delivery method groups had no previous programming experience.

3.3.2 Logistic Regression Models: The results from logistic regression models for different research questions are listed in Tables 5 – 7.

Model Statistics						
B		**χ^2**	**df**	**Pseudo-R^2**	**H-L Test**	**df**
Research Question 1		10.89*	2	.24	7.72	8
Constant	20.88					
DME	.17					
D(DM1)	-20.81					
D(DM2)	-20.91					
Research Question 2		8.34*	2	.19	2.86	6
Constant	21.24					
D(CPE1)	.09					
D(CPE2)	-.25					
D(CPE3)	-.04					
D(DM1)	-20.45					
D(DM2)	-20.31					

Table 5: Logistic Regression Models with Delivery Method Satisfaction as the Criterion Variable (N = 44)

Note. χ^2 = The chi-square likelihood ratio test of the difference in the -2 log-likelihood between the baseline model and the final model; *H-L test* = Hosmer-Lemeshow test statistic; DME: Delivery method experience level; D(DM1) = Dummy variable for the face-to-face delivery method group; D(DM2) = Dummy variable for the video streaming delivery method group; D(CPE1) = Dummy variable for the *zero* computer programming experience group; D(CPE2) = Dummy variable for the *a little bit* computer programming experience group; D(CPE3) = Dummy variable for the *some* computer programming experience group.
*$p < .05$.

Model Statistics						
B		**χ^2**	**df**	**Pseudo-R^2**	**H-L Test**	**df**
Research Question 3		6.31*	2	.13	5.99	8
Constant	1.64					
DME	.16					
D(DM1)	-1.07					
D(DM2)	-2.93					
Research Question 4		4.79	2	.10	1.66	6
Constant	1.85					
D(CPE1)	.49					
D(CPE2)	-.27					
D(CPE3)	19.35					
D(DM1)	-.65					
D(DM2)	-2.24					

Table 6: Logistic Regression Models with Programming Skill Enhancement as the Criterion Variable (N = 44)

Note. χ^2 = The chi-square likelihood ratio test of the difference in the -2 log-likelihood between the baseline model and the final model; *H-L test* = Hosmer-Lemeshow test statistic; DME: Delivery method experience level; D(DM1) = Dummy variable for the face-to-face delivery method group; D(DM2) = Dummy variable for the video streaming delivery method group; D(CPE1) = Dummy variable for the *zero* computer programming experience group; D(CPE2) = Dummy variable for the *a little bit* computer programming experience group; D(CPE3) = Dummy variable for the *some* computer programming experience group.
*$p < .05$.

Model Statistics						
B		**χ^2**	**df**	**Pseudo-R^2**	**H-L Test**	**df**
Research Question 5		2.89	2	.05	10.20	8
Constant	1.17					
DME	.15					
D(DM1)	-1.05					
D(DM2)	-1.78					
Research Question 6		1.57	2	.03	5.53	6
Constant	1.32					
D(CPE1)	.24					
D(CPE2)	.73					
D(CPE3)	19.89					
D(DM1)	-.89					
D(DM2)	-1.06					

Table 7: Logistic Regression Models with Expected Final Grade as the Criterion Variable (N = 44)

Note. χ^2 = The chi-square likelihood ratio test of the difference in the -2 log-likelihood between the baseline model and the final model; *H-L test* = Hosmer-Lemeshow test statistic; DME: Delivery method experience level; D(DM1) = Dummy variable for the face-to-face delivery method group; D(DM2) = Dummy variable for the video streaming delivery method group; D(CPE1) = Dummy variable for the *zero* computer programming experience group; D(CPE2) = Dummy variable for the *a little bit* computer programming experience group; D(CPE3) = Dummy variable for the *some* computer programming experience group.
*$p < .05$.

3.3.3 Results by Research Questions

Research Questions 1 & 2

The results supported the unique predictive relationship between delivery method and delivery method satisfaction, after controlling for delivery method experience level, $\chi^2(2, N = 44) = 10.89$, $p < .05$, Pseudo-$R^2 = .24$. In addition, the results of the Hosmer-Lemeshow test suggested an adequate fit of the specified model to the data, $\chi^2(8, N = 44) = 7.72$, $p > .05$. Namely, the specified model could sufficiently describe the relationship among research variables. The percentage of correctly classified cases in the delivery method satisfaction group and the no delivery method satisfaction group was as high as 79.55% and corroborated the conclusion from the Hosmer-Lemeshow test statistics. As to the predicted probabilities of delivery method satisfaction implied by the final logistic regression model for students with no experience of the same delivery method, it was 99.99% in the face-to-face group, 51.72% in the video streaming group, and 49.23% in the satellite broadcasting group.

The unique predictive relationship was also supported between delivery method and delivery method satisfaction, after controlling for computer programming experience level, $\chi^2(2, N = 44) = 8.34$, $p < .05$, Pseudo-$R^2 = .19$. The model fit was sufficient, based on the results of the Hosmer-Lemeshow test, $\chi^2(6, N = 44) = 2.81$, $p > .05$. Around 79.50% of the 44 participants were correctly classified into two delivery method satisfaction groups. The model fit indices enhanced the validity of the conclusion from the chi-square likelihood ratio test statistics. According to the final logistic regression model, the probabilities of delivery method satisfaction were predicted to be 99.99% for students with no programming experience in the face-to-face group, 68.87% in the video streaming group, and 71.70% in the satellite broadcasting group. While inspecting the frequencies and percentages of students satisfied with the delivery method used, as shown in the contingency table, 16 students in the face-to-face group (100.00%), 14 in the video streaming group (66.66%), and 5 in the satellite broadcasting group (71.43%) were satisfied. The students in the face-to-face group seemed to be more satisfied with the course delivery method.

All in all, delivery method was related to student delivery method satisfaction for students with the same levels of delivery method experience and computer programming experience. Students in the face-to-face group were likely to feel satisfied with the delivery method and, in contrast, students in the video streaming group were least likely to be satisfied.

Research Questions 3 & 4

The results supported the unique predictive relationship between delivery method and programming skill enhancement, after controlling for delivery method experience level, $\chi^2(2, N = 44) = 6.31$, $p < .05$, Pseudo-$R^2 =$

.13. Furthermore, the results of the Hosmer-Lemeshow test supported an adequate fit of model to data, $\chi^2(8, N = 44) = 5.99$, $p > .05$. The percentage of correctly classified cases in the programming skill enhancement group and in the no programming skill enhancement group was 81.80%. The final logistic model predicted that the probabilities of perceived Programming skill enhancement for students with no previous use of the same delivery method were 83.69% for the face-to-face group, 63.88% for the video streaming group, and 21.59% for the satellite broadcasting group.

The results failed to support the unique predictive relationship between delivery method and Programming skill enhancement, after controlling for computer programming experience level, $\chi^2(2, N = 44) = 4.79$, $p > .05$, Pseudo-R^2 = .10. The model fit was sufficient based on the results of the Hosmer-Lemeshow test, $\chi^2(6, N = 44) = 1.66$, $p > .05$ and the percentage of correctly classified students was 77.30%.

Among those students, 14 students in the face-to-face group (87.50%), 16 in the video streaming group (76.19%), and 3 in the satellite broadcasting group (42.86%) perceived the course as helpful in enhancing their programming skills. The actual percentages of students perceiving the course as enhancing their programming skills did not change across delivery method groups as sizably as their counterparts did in student delivery method satisfaction.

In conclusion, the findings regarding the predictive relationship between delivery method and student Programming skill enhancement were mixed and were not as definitive as those for the predictive relationship between delivery method and student delivery method satisfaction. While holding different control variables constant, the above relationship could change from statistically nonzero to zero. In specific, for students with the same computer programming experience level, perceived course usefulness was not related to delivery method.

Research Questions 5 & 6

The unique predictive relationship between delivery method and expected final grade, after controlling for delivery method experience level, was not found, $\chi^2(2, N = 44) = 2.89$, $p > .05$, Pseudo-R^2 = .05. The results of the Hosmer-Lemeshow test supported an adequate fit, $\chi^2(8, N = 44) = 10.20$, $p > .05$. The percentage of correctly classified cases in the Programming skill enhancement group and in the no Programming skill enhancement group was 70.50%. Both model fit results validated the conclusion regarding the unique predictive relationship between delivery method and expected final grade. That is, for students with the same delivery method experience levels, expected final grades did not change with delivery methods.

Moreover, the results failed to support the unique predictive relationship between delivery method and expected final grade, after controlling for computer programming experience level, $\chi^2(2, N = 44) = 1.57$, $p > .05$, Pseudo-R^2 = .03. The model fit was sufficient based on the results of the Hosmer-Lemeshow test, $\chi^2(6, N = 44) = 5.53$, $p > .05$ and the percentage of correctly classified students was 70.50%. For students with the same computer programming experience levels, the expected final grade was not related to course delivery method.

The frequencies and percentages of students expecting to obtain a final grade of B or higher were 13 students (81.25%) in the face-to-face group, 14 (66.67%) in the video streaming group, and 4 (57.14%) in the satellite group. The actual percentages of students expecting to get a final grade of B or higher were similar in both the video streaming and satellite groups. Relative to the other two delivery method groups, the percentage of students with higher expected final grades was higher. However, the differences in expected final grades among delivery method groups were not supported by the related chi-square ratio test results.

In summary, among students with the same delivery method experience or computer programming skill, there was no predictive relationship between delivery method and student expected final grade. Similar percentages of students expected a better final grade in each delivery method group.

Qualitative Question

A qualitative question was also included in the survey: "What issues do you encounter with this delivery method?" Both the satellite broadcasting students and the video streaming students reported that they had experienced technical issues such as intermittent audio, low volume, fuzzy video, and poor screen display due to low resolution, to name a few issues. Nine distance students reported that technology issues also hindered the communication with the instructors and with other students from time to time. Three of them indicated that it was hard to be engaged when watching a screen on TV or computer. Two video streaming students reported that it was easy to be distracted by kids or other family members when they watched the lecture on their computer at home. They also reported the loss of personalization caused by the technology-enhanced delivery methods.

4. DISCUSSION

A computer programming course such as Visual Basic.Net or Java programming is usually included in the IT curriculum of most universities and colleges. Students in any class will usually possess a variety of levels of programming experience prior to their registration in a programming course. To compound the issue, as more students take programming courses at a distance, teaching a programming course can be especially difficult in a distance format because communication is generally more time-consuming for instructors, since their students are in a variety of locations. Meanwhile, distance students usually have a harder time getting help from other students or finding a study partner. Although distance learning technology has made great progress in recent years, achieving reliable, efficient, and high-quality communication and interaction among the instructor and students at a distance is not always a smooth process, due to various technical outages and administrative issues encountered from time to time. As a result, in reality, technology-enhanced delivery methods are not always sufficient to meet the specific needs of faculty and students in a distance learning course. The qualitative comments from students also proved that technical issues did occur from time to time. Overall, the interaction between distance students and the instructor was not as effective as

the interaction between local students and the instructor in the face-to-face classroom settings. These factors probably explain why students in the face-to-face group were more likely to feel satisfied with the delivery method than students using the other two delivery methods. In particular, students in the video streaming group were least likely to be satisfied. However, our study did not find significant difference in students' expected final grades across delivery methods. This indicates that other factors such as students' motivation, prior programming experience and skills, instructors' teaching skills and commitment, and course design have played certain roles in determining students' perceived learning outcomes (Liaw, 2008; Lu, Yu, & Liu, 2003; Sun et al., 2008; Wan, Wang, & Haggerty, 2008; Zhang, Zhang, Stafford, & Zhang, 2013).

5. LIMITATIONS

There are several limitations to this study. First, the sample size of the study is small. As the student populations in the two courses involved in the study are relatively small, we had to combine survey answers in performing the analyses. This may affect the statistics used to reach our conclusions. Due to the relatively small sample size, the results should not be overgeneralized.

Secondly, we made an assumption that the two programming courses used in this study (a VB class and a Java class) were equivalent in terms of usefulness in measuring students' perceived learning performance and satisfaction. Although the two programming courses were taught by the same instructor and covered similar object-oriented programming concepts and assignments, there was some difference between the courses. Thus, this could be a potential limitation of the study.

Thirdly, this study focuses on IT undergraduate students taking distance learning programming courses in three different delivery methods. Clearly, there are other course delivery approaches such as a work-on-your-own and taking a comprehensive examination approach. This study only compared the three delivery methods without considering other approaches. This is certainly a limitation.

Fourthly, the study uses an anonymous questionnaire survey and relies on participants to honestly report their learning experiences. It is very difficult to verify and determine the accuracy of their self-reported experiences. This study used student perceptions in measuring the teaching effectiveness of the three delivery systems instead of actual student performance as measured by final grades or examination scores. This is certainly a limitation with this study. We did not use the actual final exam grade as a dependable variable in this study because we want to keep students' participation in this anonymous survey to be completely voluntary. The university IRB committee also had concerns that using students' actual final grades could potentially identify students who completed the survey. Despite these limitations of the study, these results add to the literature regarding the effectiveness of different delivery methods and provide useful insights into the research questions raised by the study.

6. IMPLICATIONS AND RECOMMENDATIONS

This study reveals that IT students in the face-to-face group were more likely to feel satisfied with the delivery method than IT students using the other two delivery methods (i.e., satellite broadcasting and video streaming). The results also reveal that there were quite a few technical issues that affected students' learning experience across the existing distance learning delivery methods. Compared with the students in the face-to-face group, the distance students encountered many more technical issues and problems during the semester. Thus, there is a need for distance learning (DL) practitioners to constantly monitor their technology-enhanced course delivery systems in order to identify, solve, and prevent technical issues and problems (Abdous & He, 2011). On the other hand, these technical issues and problems also provide an opportunity for DL practitioners to improve the existing technology-enhanced delivery methods.

Based on what we learned from this study and from our practical experience in teaching distance students using the three delivery methods, we offer the following recommendations to mitigate the quality issues with distance learning delivery and to improve distance students' learning experiences:

- Each university's distance learning unit should offer a mandatory orientation session to students who are new to the chosen distance delivery methods before the class starts. Video streaming students need to get the required software installed and tested on their computers before the class begins. Relevant tutorials should also be provided to help students become familiar with the use of the chosen distance delivery methods.
- Instructors who are new to the distance delivery methods should be sufficiently trained in understanding how to teach effectively with the distance delivery methods, as well. Instructors need to develop a pedagogy that fits the chosen delivery method (AACSB, 2007).
- Students are recommended to watch the recorded lectures. The university's distance learning program should make the recorded lectures available for students in the distance course as soon as the lecture ends. The recorded lectures will help students who experienced technical issues during the live lecture session. Gorissen, Bruggen & Jochems (2012) also found that students who watched recorded lectures had a significantly higher chance of passing the exams.
- The university's distance learning unit needs to continuously monitor and review technology used for distance course delivery. As the information and communication technologies evolve, distance course delivery methods need to be updated to reflect key trends in the development of distance learning technologies (AACSB, 2007; He, Cernusca, & Abdous, 2011).

7. CONCLUSION

This case study made contributions to the knowledge base of distance learning in the IT field by providing first-hand evidence collected from IT undergraduate students taking IT

software programming courses in a variety of distance learning delivery formats. It is noted that most prior studies comparing student perceptions and performances across course delivery methods are focused on courses in other disciplines such as education, humanities and health care. Our study is specifically focused on the IT courses. In addition, different from many prior studies, our study focuses on three delivery methods (face-to-face, satellite broadcasting, and live video-streaming) simultaneously used in the IT courses taught by the same instructor. Many prior studies (Buckley, 2003; Dutton, Dutton, and Perry, 2002) conducted the comparison by dividing students into different course sections such as one face-to-face section and one web-based section and they did not really use different delivery methods in the course at the same time. Thus we believe that our case study has a valuable contribution to the IT education literature (He, Yuan, & Yang, 2013). Quantitative data in our case study reveals that delivery method is related to students' delivery method satisfaction and Programming skill enhancement, although we did not find any relationship between delivery method and students' expected final grade. Qualitative data indicates that distance students (either at remote sites or via video streaming) sometimes experience technical issues such as audio delay, poor video quality, and low screen resolution which can negatively affect their learning experience. As for future research, we plan to further explore the relationships among delivery methods, expected final grade, and students' actual final grades. We will also explore the dynamics and interactions across different delivery methods and examine how different interactions patterns across delivery methods impact students' learning experience, outcomes, and satisfaction.

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