Traditional versus Non-traditional Teaching: Perspectives of Students in Introductory Statistics Classes

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Authorization to Submit Thesis

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Abstract

Interest in distance learning (DL) as a class delivery method remains because it is flexible for students who cannot be present in class. Students also perceive they achieve quality education from distance learning. Despite the widespread of distance learning, lectures as a form of face-to-face (FTF) class delivery method remains the central mode of teaching and learning at most universities. This study aims to determine factors that retain face-to-face to improve distance learning education. The study also focuses on teaching approaches and classroom formats that help students learn the best and students' preferred way of learning statistics respectively. Multiple imputation was performed to replace missing values using the MICE package. A logistic regression analysis was used to determine factors related to students' preferred class delivery methods.

Results from this study show that, a lecture-based class is the teaching approach and classroom format that helps most distance and non-distance students learn the best. Also, most traditional and non-traditional students agree that they learn statistics better when the teacher explains the concepts in class. From the logistic regression analysis with multiple imputation, teaching approaches and classroom formats that help students learn the best was found to be significantly associated to their preferred class delivery method. Students who responded strongly agree with the statement 'I learn better when the teacher explains the concepts in class' as their preferred way of learning statistics was also found to be significant. Students with advanced performance in their last algebra course also had high GPAs.

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Chapter 1 Introduction

1.1 Introduction

There have been many studies evaluating teaching styles and techniques, but this study focuses on student's preferred class delivery methods. From 1998-2001, Johnson and Dasgupta (2005) surveyed introductory statistics students at the Washington State University (WSU) regarding their preferred class delivery methods. The survey was put together by students as a class project in 1997-1998 and few questions were added or changed over the time it was administered. Face-to-face which has a classroom setting with the professor giving a lecture with illustrations and projected slides while students listen, write notes, and ask questions was assumed as traditional and any other class delivery method such as distance learning where instructors and students do not meet as non-traditional. A stepwise logistic regression analysis was used to determine factors related to student's preference to class delivery methods.

In (Diaz and Cartnal 1999), students' learning styles in online health education classes was compared to equivalent on-campus using Grasha-Riechmann Students Learning Style Scales (GRSLSS). Their study shows that, students enrolled in an online distance learning course are likely to have different learning styles as compared to on-campus students. It was also found that distance learning students are more independent in their styles as learners while on-campus students are more dependent. The on-campus students normally work in class provided they can obtain benefits from working with others and meet most expectations of teachers, but online distance learners are driven by intrinsic motives and not by the reward structure of the class.

Hannay (2006) research examined why students prefer distance education and their perceptions of the quality and difficulty of those courses as compared to courses taught in the traditional classroom. The data from the research indicate that students strongly prefer distance education because it allows them to balance their other commitments more easily, thus due to convenience and not quality (Ponzurick et al. 2000). Also, students perceived that they achieve higher quality educational outcomes in the distance learning environment, but nearly a third of chief academic officers to the Babson 2011 survey also believed that distance learning outcomes are inferior or somewhat inferior to face-to-face (Fleming 2017).

While distance learning may be most appropriate at colleges and universities with large number of adult learners, commuters, and part-time students, there may be some educational advantages for institutions to integrate some of the best aspects of distance learning into traditional courses to build a "hybrid" learning environment (Hannay 2006). This may include interactive videos, emails and World Wide Web technologies. Koohang and Durante (2017) study indicated that overall students perceived that the Web-based distance learning activities or assignments of their hybrid program promoted learning.

There is also a perception that university students have changed dramatically in their modes of learning in recent years, mainly due to their widespread use of the internet as an information source (Kelly 2012). However, lectures remain the central mode of traditional teaching and learning at most universities. Other forms of traditional teaching may include discussion-type class and activities and group work-based class.

The motivation for this study is to find factors related to students' preferred class delivery methods using a questionnaire administered to introductory statistics classes at both WSU and University of Idaho (UI). There was an interest to know which teaching

approaches and classroom formats help students learn the best and their preferred way of learning statistics. Also pertinent to this study are if students' performance in their last algebra course is related to their current cumulative GPA and whether students' internet usage per week for studies, number of years since they graduated from high school, conversation and humor in classroom are associated to their preferred class delivery methods.

Chapter 2 Methods

2.1 Data Collection

The research for this study and the original study both originated from WSU in 1998-2001 (Johnson and Dasgupta 2005) and 2013. The questionnaire used by Johnson and Dasgupta included questions such as gender, class year, number of years since high school gradaution, access to internet, rating of math skills, ideal class size, SAT math score, mode of instruction preferred by students, perceived learning styles, attitudes of students towards the use of visual aids, hands-on-activities and others.

The questionnaire used at WSU was modified by excluding some questions and adding new ones. Included was ‘prefer not to say’ and ‘other (please specify)’ gender options for students who do not define themselves as male or female under the supervision of the LGBTQA office at the University of Idaho. Students’ math skill rating in 2013 using Likert scale was modified to ratings of their performance in last algebra course based on their experience. Also, mode of instruction preferred by students (style of classes) in 2013 was categorized into students’ preferred class delivery method and teaching approaches and classroom formats that help students learn the best. This was done to prevent mixing teaching styles and techniques with class delivery methods.

Initially students’ preferred class delivery method had face-to-face and distance learning options only, but Dr. David Yopp, professor of mathematics education at the University of Idaho, reviewed the questionnaire and distance learning was modified to hybrid options. Also in the survey, “I learn better when the teacher explains concepts in class,” “I learn better in class when I listen to classmates discussing and debating the topic” and “I learn better when I am in a group on a task that is designed to help us learn course material”

options were incorporated from Reid (1987) in students' preferred way of learning statistics. This was included to help students identify their perceptual learning styles preferences in statistics.

A pilot survey was conducted at the Statistical Assistance Center (SAC) of the University of Idaho (UI) for validity of the survey. Questionnaires were randomly given to STAT 251 (Statistical Methods) students who came to SAC for help. Few students were involved in the pilot survey and the questionnaire was finally modified based on their suggestions. Upon receiving permission from the Institutional Review Board at both Universities, questionnaires were administered to students by their instructors for data collection in Spring 2019 semester.

Also, a REDCap account was created for an online survey upon request from the REDCap administrator of UI. REDCap is a mature, secure web application for building and managing online surveys and databases. Using REDCap's streamlined process, a new survey was created using the Online Designer. Some advanced features in REDCap such as branching logic were included, and a simple survey link was sent to respondents. The survey had 22 questions and a total of 241 respondents.

2.2 Missing-data Imputation

2.2.1 Single and Multiple Imputation

There were 56 missing values in some of the observations. Dealing with missing values with approaches such as listwise deletion, pairwise deletion, and mean substitution can produce biased estimates and may either reduce or exaggerate statistical power leading to invalid conclusions (Cook 2005). Imputation is an alternative way of replacing missing

values which could be single or multiple. Single imputation involves less computation and provides the dataset with a specific number in place of the missing data. The basic idea of data analysis with multiple imputation as compared to single imputation is to create a small number of copies of the data, each of which has the missing values suitably imputed, and analyze each complete dataset independently (Royston 2018). Missing values are suitably imputed in multiple imputation because they are replaced on the average with values that are close to the correct value. While single imputation omits the differences between the imputed datasets, multiple imputation incorporates the uncertainty in the true value by including the variance of the imputation for the final estimate.

2.2.2 The MICE Package

MICE robust package in R was the form of multiple imputation used in replacing missing values in the dataset. MICE stand for Multivariate Imputation via Chained Equations. It operates under the assumption that given the variables used in the imputation procedure, the missing data are Missing At Random (MAR), which means the probability that a value is missing depends only on the observed values and can be predicted using them (Azur et al. 2012). With the MICE package, imputations were performed on variables with missing values individually specifying the imputation model for each. For the numerical variables, linear regression was used to predict continuous missing values using the Predictive Mean Matching (PMM) while logistic regression was used for categorical missing values when the variables are binary (i.e. 2 levels only). Bayesian polytomous regression was also used for factor variables having 2 or more levels.

The number of imputed datasets from the multiple imputation was five and the number of iterations taken for imputing missing values was seventy. Plots of parameters against the iteration number are often used for assessing convergence. Convergence normally occurs when the trace lines are able to intermingle and there are no trends (Buuren and Groothuis-Oudshoorn 2011). Also, convergence can be determined when the variation between the trace lines is not more than the variation within each trace line.

2.2.3 MICE Algorithm

Let the hypothetically complete data Y be a partially observed random sample from the multivariate distribution $P(Y|\theta)$. We assume that the multivariate distribution of Y is completely specified by θ, a vector of unknown parameters. The MICE algorithm obtains the posterior distribution of θ by sampling from the conditional distributions of the form;

$$P(Y_1|Y_{-1},\theta_1)$$
$$\dots$$
$$P(Y_p|Y_{-p},\theta_p) \quad [1]$$

The parameters $\theta_1,\theta_2,..,\theta_p$ are specific to the respective conditional densities. Starting from a simple draw from observed marginal distributions, the *t*th iteration of chained equations is a Gibbs sampler that successively draws

$$\theta_1^{*(t)} \sim P(\theta_1|Y_1^{obs},Y_2^{(t-1)},\dots,Y_p^{(t-1)})$$
$$Y_1^{*(t)} \sim P(Y_1|Y_1^{obs},Y_2^{(t-1)},\dots,Y_p^{(t-1)},\theta_1^{*(t)})$$
$$\dots$$
$$\theta_p^{*(t)} \sim P(\theta_p|Y_p^{obs},Y_1^{(t)},\dots,Y_{p-1}^{(t)})$$
$$Y_p^{*(t)} \sim P\left(Y_p\middle|Y_p^{obs},Y_1^{(t)},\dots,Y_p^{(t)},\theta_p^{*(t)}\right) \quad [2]$$

where $Y_j^{(t)} = (Y_j^{obs}, Y_j^{*(t)})$ is the *jth* imputed variable at iteration t (Buuren and Groothuis-Oudshoorn 2011).

For example, suppose we have X_1, X_2, X_3 variables. If X_1 has missing values, then it will be regressed on X_2 and X_3;

$$X_1 \sim \theta_0 + \theta_2 X_2 + \theta_3 X_3, \quad [3]$$

where θ_0, θ_2 and θ_3 are estimated parameters from the regressed model. The missing values in X_1will then be replaced by predictive values obtained from the regressed model. Replacing missing values in X_2 will be based on the previous imputed variable, X_1 in relation with X_3;

$$X_2 \sim \theta_0 + \theta_1 X_1 + \theta_3 X_3 \quad [4]$$

The steps in equation 3 and 4 would be repeated for each of the variables. The cycling process through each of these variables is known as iterations. At the end of each iteration, all missing values are replaced.

2.3 Model Description

The response variable (i.e. preferred_class) was students' preference to class delivery methods which students were given the options;

- Face-to-face (FTF) which may include some online materials
- Distance learning (DL) where instructors and students do not meet
- Distance learning with live meetings such as Bblearn, Zoom, Skype, etc.
- Distance learning with flexible interactions such as discussion boards, online forums, etc.

To determine factors related to students preferred class delivery method, a logistic regression was performed (Hosmer and Lemeshow 2000). Students' preferred class delivery method

was coded as ‘1’ indicating their preference to traditional (i.e. face-to-face) and ‘0’ indicating non-traditional. The logistic regression model;

$$log_e\left(\frac{p(y=1)}{1-p(y=1)}\right) = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \ldots + \beta_n x_n \quad \text{, where;} \qquad [5]$$

p(y=1) = probability of students preferring traditional class delivery methods

$\beta^{'s}$ = estimates or coefficients

$x^{'s}$ = explanatory variables or covariates

Table 2.1: Description of Explanatory and Response Variables used in Logistic Regression Analysis.

Variable Name	Description
Response Variable:	
preferred_class (Dichotomous)	Students' preferred class delivery method (traditional=1, non-traditional=0)
Explanatory Variables (Type):	
internet_for_studies (Numbers)	Average number of hours (0-168) students spend per week finding school related information on the internet
graduate_high_school (Numbers)	Number of years since student graduated from high school
algebra_course (Polytomous)	Students' performance in last algebra class 4 indicator variables are Advanced, Proficient, Basic, Below basic
teaching_approaches (Polytomous)	Teaching approaches and classroom formats that help students learn the best 3 indicator variables are; • A lecture-based class where the teacher/professor does most or all the talking • A discussion type class where the teacher/professor poses a question and the classroom community discusses the response • Activities and group work-based class where a small group of students is given a task and together develops a response
teacher_explains (Polytomous)	Students learn better when the teacher explains concepts in class 5 indicator variables are Strong agree, Agree, Undecided, Disagree, strongly disagree
classmates_discuss (Polytomous)	Students learn better in class when they listen to classmates discussing and debating the topic 5 indicator variables are Strong agree, Agree, Undecided, Disagree, strongly disagree
group_work (Polytomous)	Students learn better when they are in a group working on a task that is designed to help them learn course material 5 indicator variables are Strong agree, Agree, Undecided, Disagree, strongly disagree
conversation_humor (Polytomous)	Does conversation and humor have a place in the classroom 4 indicator variables are Yes, I cannot learn without it, it helps, it is not important, I learn better without humor

Chapter 3 Results

3.1 Descriptive Statistics of Students

There was a total of 241 participants. Out of the 241, 160 (66.4%) of the participants were from UI and 81 (33.6%) of the participants were from WSU in Table 3.1.

3.1.1 Percentage of Gender, Year of Study and Average Age of Students

From Table 3.1-1, there were 74 (39.4%) male and 86 (60.2%) female students from UI while WSU had 21 (25.9%) male and 59 (72.8%) female students. There was 1 (1.2%) student from WSU who was not male or female. In Table 3.1-2, most participants from UI were freshmen (37.3%) followed by sophomores (31.1%) and the least were 5+year undergraduate students (2.1%), while at WSU, most participants were sophomores (32.1%) followed by freshmen (30.9%) and the least were graduate students (2.5%). The average age of students from UI was 20.44 (142 students) and that of WSU was 20.31 (81 students) from Table 3.1-3.

3.1.2 Percentage of Distance Students, Performance in Algebra Course and Students in the Honors Program

Percentage of distance students is found in Table 3.1-4. There were 6 (3.8%) distance students from UI while WSU had none in this study. 65 (40.9%) students from UI had an advanced performance in their last algebra class, and 62 (39.0%) of them were below basic while 39 (48.1%) students at WSU had an advanced performance and 27 (33.3%) were below basic in Table 3.1-5. The percentage of students in the honors program at UI was 16.6% while that of WSU was 18.5% from Table 3.1-6.

3.1.3 Students' Cumulative GPAs, Internet Usage for Studies and Number of Years since they Graduated from High School

On average, the current cumulative GPA for 154 students at UI was 3.37 and that of WSU was 3.4 for 80 students in Table 3.1-7. From Table 3.1-8, the average hours per week 155 students form UI use the internet for finding school related information was 12.28 while that of WSU was 15.54 for 81 students. The number of years since 159 students from UI graduated from high school was 2.78 and that of WSU was 2.71 for 81 students from Table 3.1-9.

3.2 Classroom formats and Preferred Way of Learning Statistics

Out of the 160 participants from UI, 6 of them were distance students. From Table 3.2-1, five out of the six distance students preferred a lecture-based class where the teacher/professor does most or all the talking as the teaching approach and classroom format that helps them learn best. Most students (97) who said no to the statement 'Are you a distance student?' also preferred lecture-based. None of the distance students preferred a discussion-type class where the teacher/professor poses a question and the classroom community discusses but 79 participants of the non-distance students preferred that.

With the preferred way for learning statistics from Table 3.2-2 to Table 3.2-4, survey responses were grouped into 'agree' and 'disagree' categories for discussion. The 'agree' category includes 'strongly agree' and 'agree' while the 'disagree' category includes 'strongly disagree' and 'disagree'. Students also had the 'undecided' option in each category for learning statistics. In Table 3.2-2, all distance students agreed to the statement 'I learn better when the teacher explains concepts in class' and 222 out of 232 participants who are

non-distance students also agreed. None of the distance students disagreed to this statement but five of the non-distance students disagreed. Also, five of the non-distance students were undecided.

From Table 3.2-3, a majority (56 percent) of students who were non-distance students agreed with the statement ‘I learn better in class when I listen to classmates discussing and debating the topic’ while 33 percent of the distance students agreed. Exactly half of the distance students disagreed with this statement and less than one quarter of non-distance students disagreed.

The majority (60 percent) of non-distance students agreed with the statement ‘I learn better when I am in a group working on a task that is designed to help us learn course material’ and exactly 50 percent of the distance students also agreed with this statement from Table 3.2-4. About less than one quarter for both distance and non-distance students disagreed to this statement.

3.3 Traditional versus Non-traditional Class Delivery Methods

From Table 3.3-1, most students in traditional (i.e. face-to-face) and non-traditional (i.e. distance students) agreed with the statement ‘I learn better when the teacher explains concepts in class’. Five of the traditional students disagreed with this statement but none of the non-traditional students disagreed. From Table 3.3-2, most students in both traditional and non-traditional preferred classes in the morning and the midday. In Table 3.3-3, most students think conversation and humor helps in the classroom.

3.4 Some Factors Related to Students' Preferred Class Delivery Methods

More than 200 students from Figure 3.1-1 and Figure 3.1-2 preferred traditional class delivery method while less than 50 students preferred non-traditional. Thus, about 89 percent of the students who participated in this survey preferred face-to-face. From Figure 3.2, students' age and number of years since students graduated from high school was found to be highly correlated (0.98). There was also a strong correlation (0.79) between students' age and their year of school at the university. To determine which factors or variables are related to students' preferred class delivery method, logistic regression analysis was conducted. Significance level (i.e. α) was assumed to be 10%.

3.4.1 Logistic Regression Analysis without Multiple Imputation

From Table 3.4-1, there were biased estimates due to missingness. The corresponding standard errors of the biased estimates were found to be extremely large as compared to the other errors. Also, from Table 3.6, the odd ratios of the biased estimates were large, and they have their lower confidence intervals to be 0 with undefined upper confidence intervals.

3.4.2 Logistic Regression Analysis with Multiple Imputation

In general, the missing values in the variables distance_student, graduate_high_school, algebra_course, university_year, honors_program, num_of_students, if_yes, teaching_approaches and teacher_explains were minimum. From Figure 3.4-1 to Figure 3.4-5, there was non-convergence in the variables listed above because their trace lines hardly mixed. There was healthy convergence in the variables age, internet_for_studies, high_school_gpa, current_gpa, classmates_discuss and group_work because their trace lines

properly mixed. So, we assume multiple imputation was properly done in replacing missing values. All the imputed datasets from Table 3.5 had p-values greater than 0.05. The pool command in R was used to combine results of all 5 models.

From the results of logistic regression with multiple imputation (Table 3.4-2) most variables were found not to be significant but teaching approaches and classroom formats that help students learn the best was found to be significantly associated to their preferred class delivery method (p-value = 0.0937). Students who responded strongly agree with the statement ‘I learn better when the teacher explains the concepts in class’ as their preferred way of learning statistics was also found to be significant (p-value = 0.0198) in the model. Though students’ performance in their last algebra course was found not to be significant, those with advanced performance have high cumulative GPAs from Figure 3.3.

Table 3.1: Descriptive Statistics of Students.

	UI (160 (66.4%))	WSU (81 (33.6%))
Table 3.1-1: Gender		
Male	74 (39.4%)	21 (25.9%)
Female	86 (60.2%)	59 (72.8%)
Other		1 (1.2%)
Table 3.1-2: Year of Study		
Freshman	65 (37.3%)	25 (30.9%)
Sophomore	49 (31.1%)	26 (32.1%)
Junior	29 (19.9%)	19 (23.5%)
Senior	11 (7.1%)	6 (7.4%)
5+year undergraduate	2 (2.1%)	3 (3.7%)
Grad student	4 (2.5%)	2 (2.5%)
Table 3.1-3: Average Age of Students		
Average Age	20.44	20.31
(# of students)	142	81
Table 3.1-4: Distance Students		
No	152 (96.2%)	81 (100%)
Yes	6 (3.8%)	0 (0%)
Table 3.1-5: Algebra Course		
Advanced	65 (40.9%)	39 (48.1%)
Proficient	28 (17.6%)	14 (17.3%)
Basic	4 (2.5%)	1 (1.2%)
Below basic	62 (39.0%)	27 (33.3%)
Table 3.1-6: In the Honors Program		
Yes	25 (16.6%)	15 (18.5%)
No	134 (83%)	66 (81.5%)
Table 3.1-7: Average Cumulative GPA of Students		
Current GPA	3.37	3.4
(# of students)	154	80
Table 3.1-8: Internet Usage for finding school related information		
Internet Use	12.28	15.54
(# of students)	155	81
Table 3.1-9: Number of years since student graduated from High school		
Years	2.78	2.71
(# of students)	159	81

Table 3.2: Classroom formats and Preferred Way of Learning Statistics.

Table 3.2-1: Cross tabulation between Distance students and classroom formats.			
	lecture	class_discussion	group_work
No	97	79	56
Yes	5	0	1

Table 3.2-2: Cross tabulation between Distance students and preferred way of learning statistics (teacher_explains).					
	strongly agree	agree	undecided	disagree	strongly disagree
No	144	78	5	3	2
Yes	4	2	0	0	0

Table 3.2-3: Cross tabulation between Distance students and preferred way of learning statistics (classmates_discuss).					
	strongly agree	agree	undecided	disagree	strongly disagree
No	42	89	59	37	5
Yes	0	2	1	3	0

Table 3.2-4: Cross tabulation between Distance students and preferred way of learning statistics (group_work).					
	strongly agree	agree	undecided	disagree	strongly disagree
No	54	86	45	32	14
Yes	3	0	2	0	1

Table 3.3: Traditional versus Non-traditional Class Delivery Methods.

Table 3.3-1: Cross tabulation between Preferred class delivery method and way of learning statistics (teacher_explains) .					
	strongly agree	agree	undecided	disagree	strongly disagree
Non-traditional	12	14	0	0	0
Traditional	136	67	5	3	2
Table 3.3-2: Cross tabulation between Preferred class delivery method and time for classes.					
	morning	midday	afternoon	evening	doesn't matter
Non-traditional	7	17	0	1	1
Traditional	55	148	8	0	4
Table 3.3-3: Cross tabulation between Preferred class delivery method and conversation and humor.					
	Yes	helps	not_important	learn_better	
Non-traditional	5	18	2	1	
Traditional	62	145	7	1	

Table 3.4-1: Logistic Regression Analysis without Multiple Imputation.

	Estimate	Std. Error	Pr(>|z|)
Intercept	2.03421	1.11233	0.06740
internet_for_studies	-0.00557	0.01316	0.67200
graduate_high_school	-0.07195	0.05265	0.17170
algebra_courseBasic	-0.66471	0.59906	0.26720
algebra_courseProficient	-0.27364	0.51935	0.59830
teaching_approaches	0.62754	0.35040	0.07330*
teacher_explainsDisagree	15.99301*	2144.67174	0.99410
teacher_explainsStrongly agree	1.13989	0.47115	0.01550*
teacher_explainsStrongly disagree	16.02368*	2796.38390	0.99540
teacher_explainsUndecided	14.96836*	1753.14673	0.99320
classmates_discussDisagree	-0.38443	0.62197	0.53240
classmates_discussStrongly agree	-0.06316	0.74433	0.93240
classmates_discussStrongly disagree	-0.71905	1.26313	0.56920
classmates_discussUndecided	0.05547	0.58855	0.92490
group_workDisagree	0.05472	0.68572	0.93640
group_workStrongly agree	-0.01323	0.67078	0.98430
group_workStrongly disagree	-0.23736	0.92140	0.79670
group_workUndecided	0.19970	0.62449	0.74910
conversation_humor	-0.59151	0.39101	0.13030

NB: 9 observations deleted due to missingness.

Table 3.4-2: Logistic Regression Analysis with Multiple Imputation (Pooled Estimates).

	Estimate	Std. Error	Pr(>|z|)
Intercept	0.88940	0.10690	0.00000
internet_for_studies	-0.00050	0.00130	0.68320
graduate_high_school	-0.00990	0.00600	0.10030
algebra_courseBasic	-0.04770	0.05710	0.40460
algebra_courseProficient	-0.01120	0.04650	0.81060
teaching_approaches	0.04980	0.02960	0.09370*
teacher_explainsDisagree	0.15380	0.18460	0.40580
teacher_explainsStrongly agree	0.10540	0.04490	0.01980*
teacher_explainsStrongly disagree	0.17890	0.23120	0.43990
teacher_explainsUndecided	0.08240	0.14630	0.57400
classmates_discussDisagree	-0.05070	0.06210	0.41580
classmates_discussStrongly agree	-0.01000	0.06290	0.87320
classmates_discussStrongly disagree	-0.08190	0.14550	0.57380
classmates_discussUndecided	0.00880	0.05290	0.86850
group_workDisagree	0.00840	0.06710	0.90040
group_workStrongly agree	-0.00140	0.05790	0.98110
group_workStrongly disagree	-0.01280	0.09110	0.88810
group_workUndecided	0.01030	0.05880	0.86070
conversation_humor	-0.05770	0.03880	0.13790

Table 3.5: Goodness of Fit Test.

Imputed Datasets (m)	χ-squared	p-value
1	8.2974	0.405
2	4.9324	0.7648
3	5.0538	0.7518
4	6.3958	0.603
5	4.4521	0.8142

Table 3.6: Odd Ratios and Confidence Intervals based on Table 3.4-1.

	Odd Ratios	0.025	0.975
Intercept	7.646	0.888	71.738
internet_for_studies	0.994	0.972	1.025
graduate_high_school	0.931	0.840	1.037
algebra_courseBasic	0.514	0.160	1.733
algebra_courseProficient	0.761	0.272	2.134
teaching_approaches	1.873	0.965	3.861
teacher_explainsDisagree	8824186.282	0.000	NA*
teacher_explainsStrongly agree	3.126	1.255	8.089
teacher_explainsStrongly disagree	9099013.472	0.000	NA*
teacher_explainsUndecided	3167213.672	0.000	NA*
classmates_discussDisagree	0.681	0.202	2.394
classmates_discussStrongly agree	0.939	0.234	4.736
classmates_discussStrongly disagree	0.487	0.051	11.205
classmates_discussUndecided	1.057	0.337	3.516
group_workDisagree	1.056	0.288	4.484
group_workStrongly agree	0.987	0.276	4.070
group_workStrongly disagree	0.789	0.146	6.274
group_workUndecided	1.221	0.370	4.442
conversation_humor	0.553	0.252	1.192

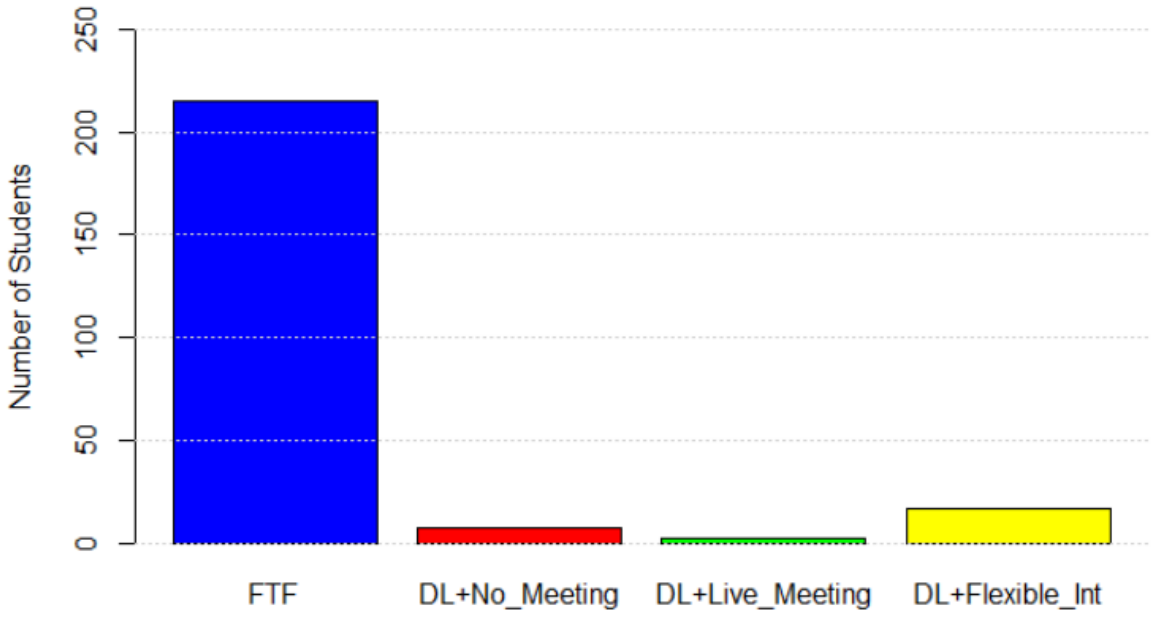

Figure 3.1-1: Bar plot of number of students with their preferred class delivery method (3 forms of Non-traditional).

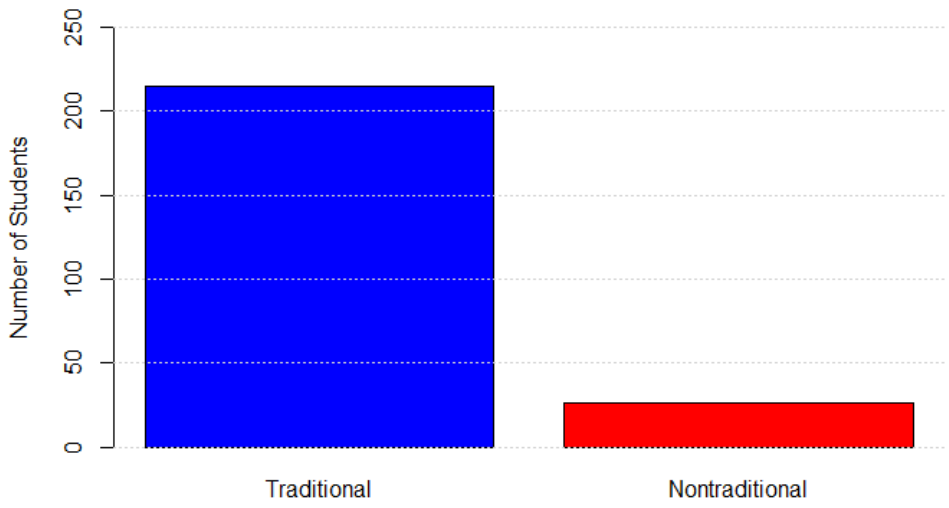

Figure 3.1-2: Bar plot of number of students with their preferred class delivery method (Non-traditional Combined).

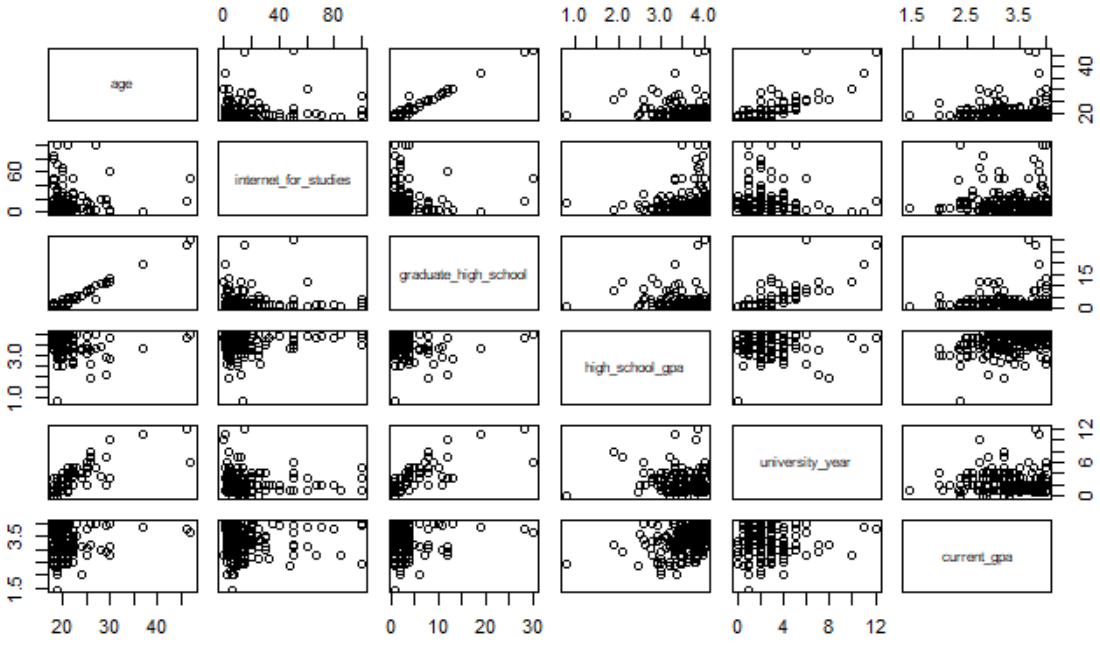

Figure 3.2: Scatter plot for numerical variables.

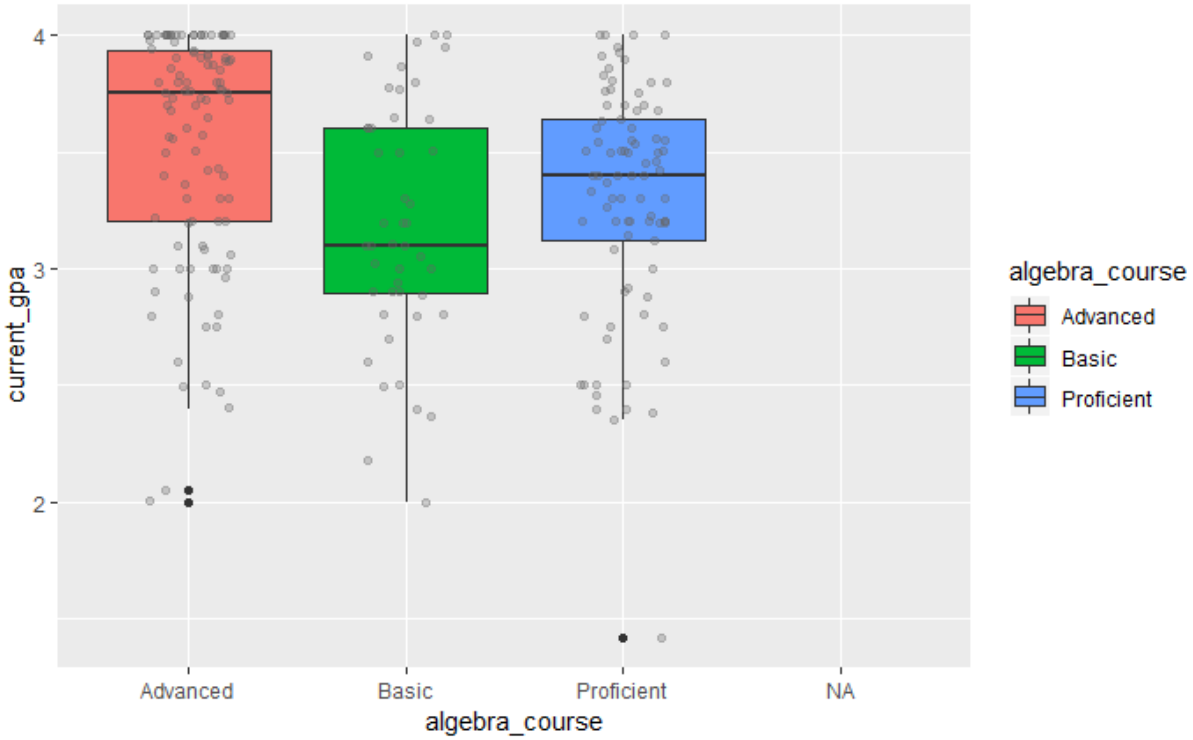

Figure 3.3: Boxplot of students' current GPAs with performance in their last algebra course.

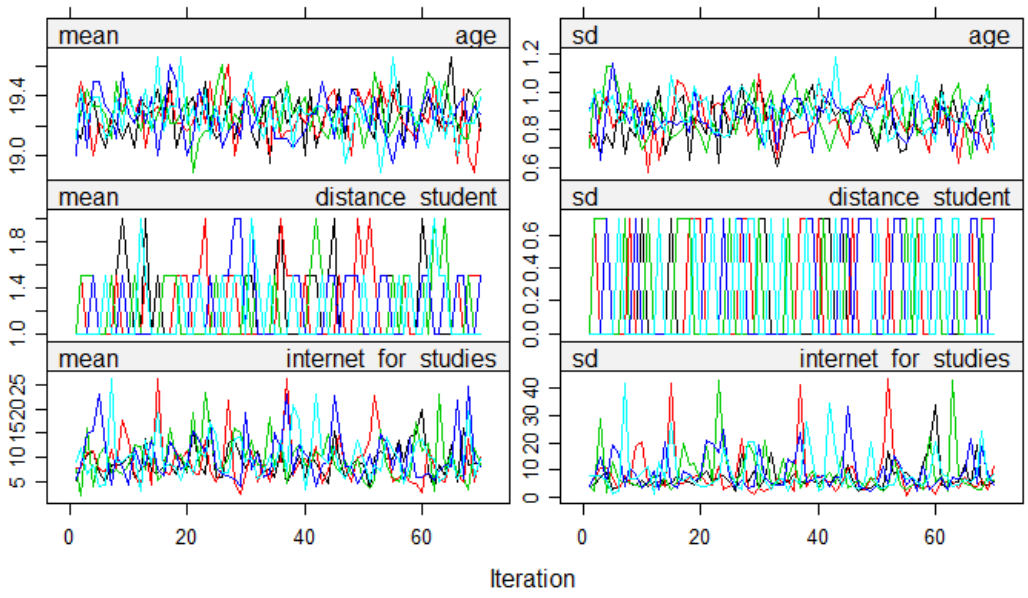

Figure 3.4-1: Non-convergence in distance_student, healthy convergence in age and internet_for_studies.

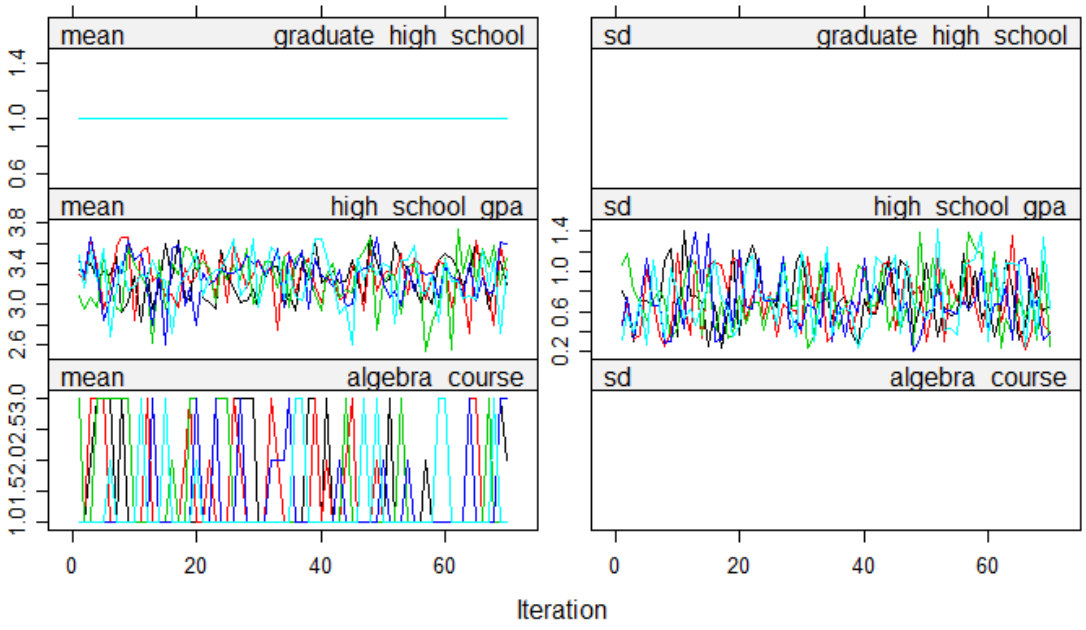

Figure 3.4-2: Non-convergence in graduate_high_school and algebra_course, healthy convergence in high_school_gpa.

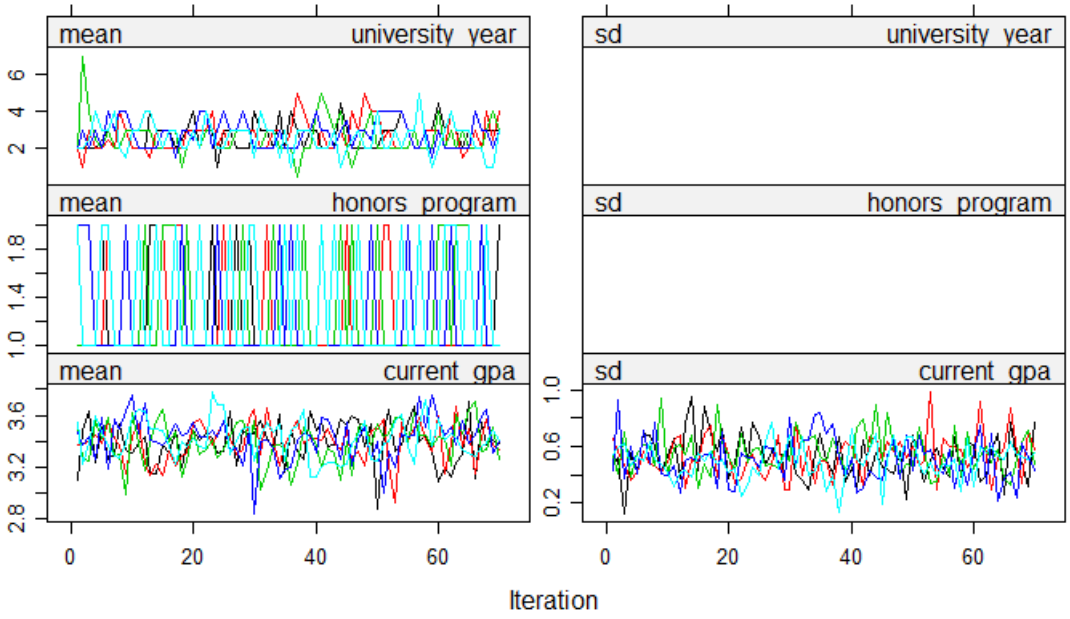

Figure 3.4-3: Non-convergence in university_year and honors_program, healthy convergence in current_gpa.

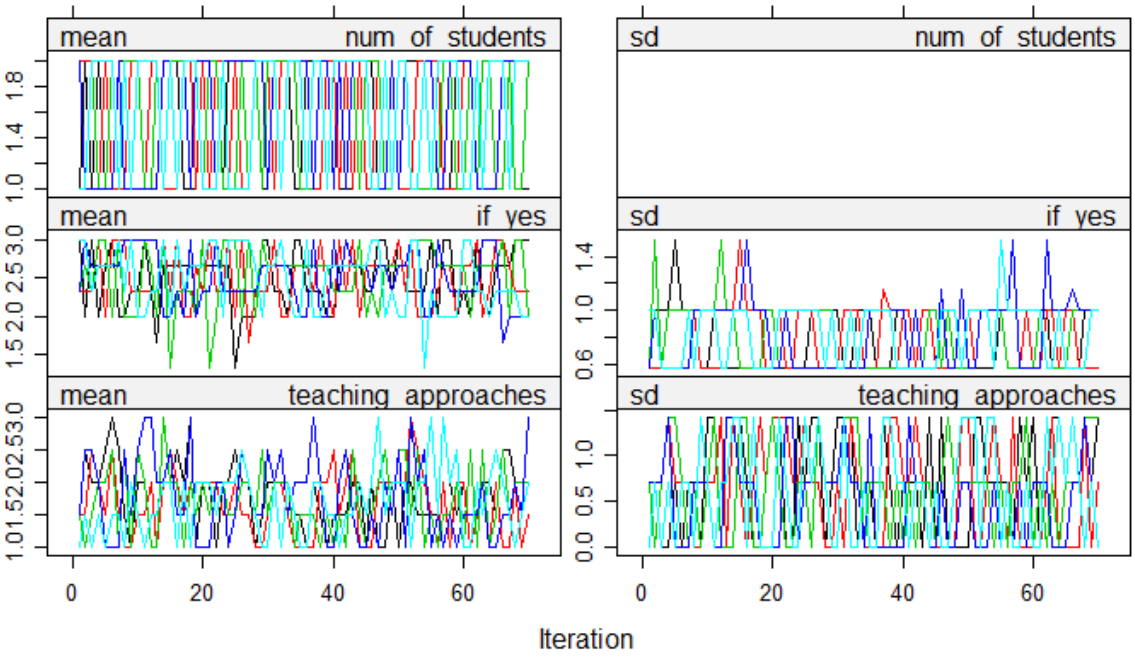

Figure 3.4-4: Non-convergence in num_of_students, if_yes and teaching approaches.

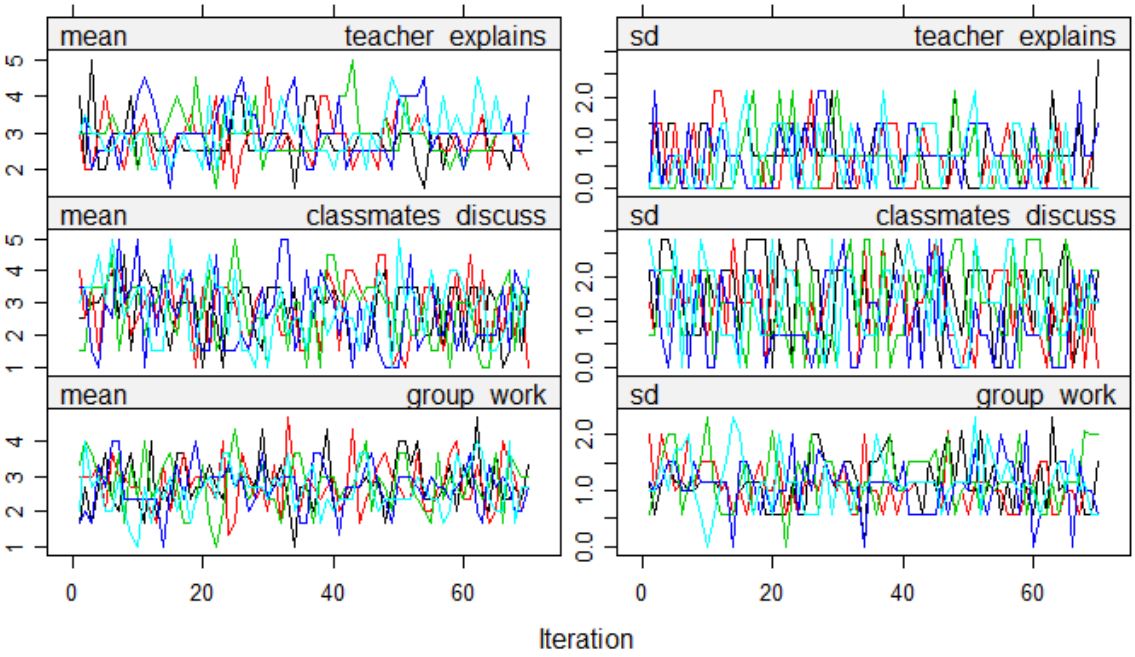

Figure 3.4-5: Non-convergence in teacher_explains, healthy convergence in classmates_discuss and group_work.

Chapter 4 Discussion

4.1 Discussion

The undergraduate population at WSU from the college factual in 2019 is comprised of 12,023 males and 13,254 females, while that of UI is 4,968 males and 4,917 females. In general, there were more students from UI than WSU in this study and most participants from both universities were female. Only one student from WSU was not male or female. Most of the students were freshmen and sophomores for both universities. The average age of students from UI was higher than WSU. Out of the 160 participants from UI, 6 of them were distance students. The percentage of students in the honors program at WSU was higher than UI. Also, the percentage of students from WSU with advanced performance in their last algebra course was higher than UI. Students with advanced performance in algebra course were found to have high cumulative GPAs in this study. On average hours per week, more students from WSU use the internet for finding school related information than UI.

Students' preferred teaching approaches and ways of learning statistics was of interest. Both distance and non-distance students seem to mostly prefer a lecture-based class where the teacher/professor does most or all the talking. Though no distance student prefers a discussion-type class where the teacher/professor poses a question and the classroom community discusses but quite several of non-distance students prefer that. With the preferred way for learning statistics, both distance and non-distance students agree that, they learn statistics better when the teacher explains the concepts in class.

Most students from the survey prefer traditional class delivery methods to non-traditional. Both also agree they learn better when the teacher explains the concepts in class.

They all prefer classes in the morning and the midday. From this study, students think conversation and humor helps in the classroom.

The main goal of this study was to find factors related to students' preferred class delivery methods. Students' age and number of years since students graduated from high school was found to be highly correlated (0.98). Also, there was a strong correlation (0.79) between students' age and their year of school at the university. Due to missingness, estimates from the logistic regression analysis without multiple imputation were biased. After multiple imputation, the p-values from the goodness of fit tests for the imputed datasets were greater than 0.05 which implies all models were fitted correctly. Convergence was also healthy in general. From the logistic regression with multiple imputation, teaching approaches and classroom formats that help students learn the best was found to be significantly associated to their preferred class delivery method (p-value = 0.0937). Also, students who responded strongly agree with the statement 'I learn better when the teacher explains the concepts in class' as their preferred way of learning statistics was also found to be significant (p-value = 0.0198). We are certain of valid conclusions from the multiple imputation due to unbiasedness and accurate statistical power.

4.2 Limitations

Though the study conducted was generally informative, but few distance students were involved. Also, the turn-out of students from WSU was lower as compared to UI. For future studies, similar surveys should be conducted to check the trend of students' preference to class delivery methods.

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