A STUDY OF STUDENTS' ATTITUDES CHANGE AND PERFORMANCE IMPROVEMENT IN A FLIPPED CLASS

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This article reports lessons learned from implementing flipped classes at Michigan State University. A pre-, post- attitude survey and an assessment instrument were administered in two sections of a calculus based introductory statistics course. Class enrollment was 48 for each section. The attitude survey includes learning styles, beliefs, attitudes, cognitive competence and value. The assessment instrument consists of 20 multiple-choice questions and written justifications of answers. The results of the attitude surveys indicate positive changes in students' attitudes towards statistics. A factor analysis is conducted to analyze the patterns of learning styles. Four different patterns are identified. An analysis of the post-assessment performance indicates students' performances were not affected by learning styles.

BACKGROUND

Introductory statistics is one of many core courses undergraduate students take to fulfill university quantitative course requirements or as a pre-requisite for upper level courses in a wide range of disciplinary majors. The significance of statistics in these areas is unquestionable. Nevertheless, many students lack enthusiasm, and, in general, struggle to grasp core concepts of statistics. Researchers have identified several factors that contribute to this challenge, among which we mention here affective and attitudinal factors, and instructional methods (Mills, 2004). In regard to attitudes, some studies show a direct relation between attitudes toward statistics and the development of statistical thinking skills, the ability to apply statistics outside of the classroom, enrollment and persistence in statistics related courses and achievement (Gal, Ginsburg, & Schau, 1997). Other studies link negative attitudes toward statistics to poor performance in class (Waters, Martelli, Zakrajsek, & Popovich, 1988). Hence, creating a positive attitude towards statistics and reducing the fear of statistics by promoting the value of statistics in the classroom can be one of several steps instructors can take to help students in statistics courses (Garfield & Ben-Zvi, 2007).

Moreover pedagogical approaches that engage students in the learning process (GAISE, http://www.amstat.org/education/gaise/), and create classroom environments that take different learning styles into consideration (Magel, 1998), have positive impact on students' understanding of statistical concepts. Group work, working with real data, more data and less formula, intensive use of technology, etc. are some approaches suggested by researchers to improve statistics education. In general the research indicates that students who are taught in the active learning environment tend to demonstrate higher academic achievement, better high-level reasoning and critical thinking skills, deeper understanding of learned material, greater motivation to learn and achieve, and more positive attitudes toward subject areas (Felder & Brent, 2009). Consequently researchers continuously work on designing new and improving existing active learning pedagogical approaches. One of these "new" pedagogical approaches is the flipped classroom model that gained momentum, not only for teaching introductory statistics (Winquist & Carlson, 2014; Schwartz et al., 2016; Peterson, 2016), but also for many other undergraduate courses, such as computer engineering (Redekopp & Ragusa, 2013), history (Gaughan, 2014) and chemistry (Seery, 2015). For a review of implementing flipped class for statistics and biostatistics courses, one may refer to Schwartz, et al. (2016). In a flipped classroom model, the objective is to reverse this traditional order of instruction. Lecture notes, video clips, etc. are posted on a course website, and students are expected to read these before coming to class. Classroom time is spent on other activities such as group discussions, working on problems using technology, taking quizzes, etc. The instructor facilitates and guides these discussions instead of delivering facts. Many of the literatures mentioned above reported change towards more positive attitudes and better motivation. Some studies found improvement of content knowledge learned (Peterson, 2016 ; Schwartz, 2014). Peterson (2016), for example, studied the effects of a flipped class for teaching introductory

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statistics by investigating students' satisfaction based on students' evaluation on college-issued end-of-term student evaluations between a flipped class and a lecture format class. He concluded that there was a statistically significant difference on the questions of 'Clear explanation', 'Instructor's feedback helpful' and 'Overall quality of the course'. Lee (2016) reported a reduction of below average grades from 25% to less than 5% (for grades less than C or withdrawal from a course). However it is not clear that this reduction is due to the improved achievement of knowledge of each individual or due to the improved achievement for all team members from the group activities.

Our goal in this paper is to study the effect of pedagogical approach, in particular the flipped model on students' attitude towards statistics. A commonly used framework for implementing a flipped class can be found in Bishop & Verleger (2013). This framework consists of two components; one is human interaction through student-centered learning by implementing interactive classroom activities, and the other is adopting teaching pedagogy by utilizing proper computer technology. For a review on the framework and/or implementation of flipped classes at higher education, one may refer to Bishop & Verleger (2013), Faculty Focus (2015) and DeLozier & Rhodes (2016). The 2016 GAISE College Report recommended the pedagogical approach for teaching statistics by 'integrating real data with a context and a purpose', 'fostering active learning', 'using technology to explore concepts and analyze data', and 'using assessments to improve and evaluate student learning'. Flipped classroom approach appears to naturally incorporate these components.

THE METHOD

In spring 2017 we implemented a flipped classroom model in a calculus based introductory statistics course (STT 231) for science majors at Michigan State University (MSU). All students were enrolled at the Lyman Briggs College (LBC), a residential college within MSU whose mission is to provide a platform where its students experience interdisciplinary teaching and learning environment to bridge the sciences and humanities. LBC students are pursuing a career in the sciences or the study of sciences. Two sections, each with 48 students, participated in this study. Classes were taught for 15 weeks, with 3 hours per week, on a Monday-Wednesday schedule lasting for eighty minutes. Topics included univariate and bivariate data analysis, linear regression, probability, random variables, discrete and continuous probability distributions, sampling, estimation and hypothesis testing. Lecture notes were posted on a course website and students were expected to read them before coming to class. During the first twenty minutes of class, students worked on class activity worksheets in groups of four. The worksheet problems were designed to test students' understanding of the material they read before class. The worksheets were graded out of ten points, 4 points for completion and six points for accuracy.

We administered a survey similar to the *Survey of Attitudes Toward Statistics (SATS)* *(*SATS-28; Schau, 1992; Schau, Stevens, Dauphinee, & Del Vecchio, 1995) to collect students' responses on attitudes towards statistics. The survey questions collected information based on factors such as *learning styles*, *beliefs, attitudes*, *cognitive competence* and *value*. We summarize the six items of learning style related questions and conduct a factor analysis to identify the factor patterns of learning styles. We compare the pre and post-survey attitudes using the McNemar test statistic to investigate whether there is a statistically significant change of students' beliefs and attitudes towards statistics, their perceptions of cognitive competence and their view of values of statistics.

The assessment performance collected included a pre and post assessment instrument. The pre-assessment consisted of fifteen questions: 13 multiple-choice and 3 open ended questions. The post-assessment consisted of twenty questions: 18 multiple-choice and 2 open-ended questions. The 13 multiple questions in the pre-assessment were part of the post-assessment questions. We summarize the assessment performances and conduct a regression model to investigate the effects of learning styles on students' performance.

AN ANALYSIS OF STUDENT LEARNING STYLES

We begin our analysis by summarizing some demographic information of students who completed the course in these two classes. The summary is given in Table 1.

Table 1: Demographic information of student respondents from the two classes

	Grade	Grade Point Average		Gender		Stat course is		# years high school math	
Freshman	3 (3.4%)	2.00-2:50	1 (1.2%)	Female	65 (74.7%)	Required	79 (90.8%)	1	3 (3.4%)
Sophomore	54 (62.1%)	2.51-2.99	2 (2.3%)	Male	22 (25.3%)	Elective	8 (9.2%)	2	0
Junior	24 (27.6%)	3.00-3.49	14 (16.3%)					3	9 (10.3%)
Senior	6 (6.9%)	3.50+	69 (80.2%)					4	75 (86.2%)

The demographic information in Table 1 is common for LBC students where the majority is female, taking STT 231 in their sophomore or junior year of college. Students coming to LBC are high achieving and motivated students, and it is not a surprise that quite a large portion of them have a grade point average of 3,5 or higher. Many take the course as requirement for their major.

Self-reported learning styles based on seven survey questions from post-attitude survey are summarized in Table 2. The inter-item correlation coefficients among these seven items are ranging from -.126 to .318 with most of them being between -.100 to .100. Thus, the inter-item correlations are relatively small.

Table 2: Descriptive summary of student self-reported learning styles

I learn better by	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
taking a lot of class notes	37(42.5%)	41(47.1%)	9(10.3%)	0	0
reading textbook	3(3.4%)	22(25.3%)	29(33.3)	28(32.2%)	5(5.7%)
step-by-step instruction	58(66.7%)	25(28.7%)	4(4.6%)	0	0
cooperative group work	28(32.2%)	40(46.0%)	17(19.5%)	2(2.3%)	0
taking a lot of quizzes	6(6.9%)	26(29.9%)	41(47.1%)	13(14.9%)	1(1.1%)
working on real world projects	3(3.4%)	21(24.1%)	38(43.7%)	24(27.6%)	1(1.1%)
doing a lot of homework	7(8.0%)	45(51.7%)	23(26.4%)	12(13.8%)	0

Table 2 indicates over 90% of students prefer learning by 'taking a lot of class notes' and by 'step-by-step instruction'; while only about a quarter of students prefer 'working on real world projects'. A factor analysis was conducted to classify these items. Four factors were identified using *varimax* rotation. The four factors explain 75% of total variation. The Cronbach Alpha item consistency measure of the seven items is 0.374. The low measure of consistency is partly due to the small number of items. Table 3 summarizes the results from the factor analysis. The rotated factor loadings are reported in the table, which are used to identify and describe each factor. Among the four learning styles, self-study, procedure and active learning styles are not surprising. However, it is surprising to see that 'step-by-step instruction' and 'participate in cooperative learning' are positively correlated and are grouped as a factor. One interpretation might be that the students preferring 'step-by-step instruction' might have benefited from small group discussions and step-by-step explanations from other team members.

COMPARISON OF PRE-AND POST-ATTITUDES

Among the survey items, we identify 12 items that relate to students' attitudes and beliefs about statistics, three items about cognitive competency and six items about students' perception of the values of statistics. We compare their responses between pre- and post-survey using the McNemar test. Prior to performing the comparison, we redefine the five categories into three categories due to the fact that some categories have zero response. The McNemar test is invalid if the response categories are not matched. The new definitions are: 'Agree' is defined to include the categories of 'Strongly Agree' and 'Agree', "Neutral" is Neutral and "Disagree" includes the categories of ‘Strongly Disagree’ and ‘Disagree’. Table 4 summaries the results of McNemar test for some selected interesting items.

Table 3: Summary of factor analysis on learning styles

Factor Identified	Items associated with the factor: Learning better by	Factor 1: Self-Study	Factor 2: Procedure	Factor 3: Drill	Factor 4: Active Learning
Self-study Style	reading textbook	0.858	.026	-0.50	.135
	taking a lot of class notes	0.564	.454	.092	-.219
Procedure Style	Step-by-step instruction	.140	0.805	.097	-.142
	Participating in cooperative learning	-.108	0.718	-.092	.530
Drill Style	Taking a lot of quizzes	-.052	.085	0.578	.111
	Doing a lot of homework	.586	-.044	0.909	.163
Active Learning	Working on real world projects	.124	-.067	.578	0.867

Table 4: Comparison of attitudes and beliefs between Pre and Post surveys using McNemar test

		Agree	Neutral	Disagree	McNemar Test (p-value)
I feel intimidated when I have to deal with Math formulas	Pre	23(26.4%)	15(17.2%)	49(65.3%)	.027*
	Post	15(17.2%)	11(12.6%)	61(70.1%)	
I would like to take more advanced statistics course in the future	Pre	6(6.9%)	26(29.9%)	55(63.2%)	.002**
	Post	15(17.2%)	31(35.6%)	41(47.1%)	
Statistics is computationally intensive	Pre	39(44.8%)	39(44.8%)	9(10.3%)	.001**
	Post	23(26.4%)	36(41.4%)	28(32.2%)	
Statistics is different from Mathematics	Pre	29(33.3%)	24(27.6%)	34(39.1%)	.046*
	Post	45(51.7%)	16(18.4%)	34(39.1%)	
I think that this Statistics requires strong Math background	Pre	42(48.8%)	30(34.9%)	14(16.3%)	.001**
	Post	27(31.4%)	20(23.3%)	39(45.3%)	
I think that this statistics course require a lot of memorization	Pre	27(31.0%0	36(41.4%)	24(27.6%)	.010*
	Post	22(25.3%)	21(24.1%)	44(50.6%)	
I think that this Statistics course is interesting	Pre	45(51.7%)	27(31.0%)	15(17.2%)	.005**
	Post	63(72.4%)	15(17.2%)	9(10.3%)	

*: Significant at 5% level, **: Significant at 1% level.

The comparisons of the items listed in Table 4 show clear evidence that the flipped class changed students’ attitudes and beliefs positively after taking the class. Other items that are not listed also show similar results. Among the items, we are particularly happy to find the positive changes in “I would like to take more advanced statistics course in the future”, “Statistics is different from mathematics’, and ‘I think this statistics course is interesting’. This is a very positive and important effect of teaching a statistics course in a flipped class setting.

Besides the positive change of students’ beliefs and attitudes towards statistics, Table 5 summarizes the McNemar test to compare the cognitive competence and their view of value of statistics between pre and post class survey.

The change of perception about their cognitive competence and views of values of statistics are also positively changed between pre and post survey. In particular, students significantly changed their view about statistics to be less complicated, less difficult and less useless (or more useful) after taking this flipped class. These positive changes are very encouraging.

Table 5: Comparison of cognitive competence and value between pre and post survey

		Agree	Neutral	disagree	McNemar Test (p-value)
Statistics is too complicated	Pre	3(3.4%)	23(26.4%)	61(70.1%)	.003**
	Post	2(2.3%)	7(8.0%)	78(89.7%)	
This statistics course is difficult	Pre	31(35.6%)	44(50.6%)	12(13.8%)	.000**
	Post	14(16.1%)	31(35.6%)	42(48.3%)	

Statistics is a worthwhile part of my field of study	Pre	62(71.3%)	17(19.5%)	8(9.2%)	.189
	Post	72(82.8%)	11(12.6%)	4(4.6%)	
I use statistics in my everyday life	Pre	44(50.6%)	25(28.7%)	18(20.7%)	.024*
	Post	60(69.0%)	19(21.8%)	8(9.2%)	
Knowledge of statistics will make me more employable	Pre	67(77.0%)	19(21.8%)	1(1.1%)	.215
	Post	71(81.6%)	12(13.8%)	4(4.6%)	
Statistics course is useful only to people whose careers are science-related	Pre	13(15.1%)	17(19.8%)	56(65.1%)	.020*
	Post	16(18.6%)	6(7.0%)	64(74.4%)	
This statistics is useless for me.	Pre	10(11.5%)	16(18.4%)	61(70.1%)	.000**
	Post	2(2.3%)	4(4.6%)	81(93.1%)	

*: Significant at 5% level, **: Significant at 1% level.

EFFECTS OF LEARNING STYLES ON PERFORMANCE

In this section, we investigate the effects of different learning styles described in Table 3 on students' performance. The means and standard deviations of the pre- and post-assessment scores (in percentage) for students who completed the course are summarized in Table 6.

Table 6: Descriptive summaries of pre- and post-assessment scores

	N	Mean	S.D.
Pre-test	86	48.75	14.38
Post-test	86	59.04	12.93

Regression modeling technique is applied to investigate if there is a significant difference between gender and if there is a significant effect of each learning style factor. The post-assessment score is the response variable. The pre-assessment score is treated as a co-variate to adjust the post-score. The general regression procedure in SPSS is applied to build the model. The p-values of the F-test from the regression model are summarized in Table 7.

Table 7: Results of the regression model

Factors	Pre-score	Gender	Self-study	Procedure	Drill	Active-learning
p-value	.020*	.432	.541	.360	.871	.647

From Table7, we notice that the only significant factor is the pre-scores, which is anticipated. Students who did well in the pre-test did also well in the post-test. After adjusting the effect of the pre-score, the model indicates that gender difference is not statistically significant, neither is any of the four learning styles on their performance at end of the semester. This is a positive consequence for the flipped class approach.

CONCLUSION

This paper investigates if students' attitudes have changed and if students' learning styles affect their performance in an introductory statistics course taught using a 'hybrid' flipped class approach at Michigan State University. Our findings from an attitude survey indicate that students' attitudes, beliefs, perception of cognitive competence towards learning statistics and their views of values of statistics have all changed significantly in a positive way. We notice that the flipped class approach allowed an inviting, a motivating and a more active classroom environment where students with different learning style fit in and feel comfortable in the learning process. Moreover, in the flipped class model, their performance is robust to the types of learning styles. However there are some drawbacks noticed. (1) In the factor analysis of learning styles, we only have seven items and 87 cases. The Cronbach Alpha indicates the item consistency is not high. (2) Since students in the class were not assigned randomly, nor did we have a control group of non-flipped class, the findings should not be generalized to general population of students at different institutions. We will continue to collect data in different semesters to study the effectiveness of flipped classes for teaching introductory statistics.

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