Interactive Teaching Methodology in a Large Finance Class

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This paper reports results of implementing interactive lecture methodology in teaching Finance classes. The use of web based pretests, as well as handheld electronic devices in class allows increasing class size to more than 300 students per class. Interactivity is designed using Zone of Proximal Development of Vygotsky. Empirical evidence shows significant improvements in academic performance, compared with performance from smaller classes taught using conventional lecture format.

INTRODUCTION

Affordability and effectiveness in higher education have been in public focus for several decades. Huber (1992), among others, provides a list of university deficiencies that arguably lead to high inflation in tuition and reduction in quality of undergraduate education. McPherson and Shulenburger (2008) offer various options to address the problem. One of the ways to make university education more cost effective is conducting lectures in a large classroom using interactive method of teaching which employs digital technology.

For last two years I have been using this format in teaching various finance classes of up to 340 students per class at Ryerson University. I use web-based pretest questions that cover required readings before the start of the class, as well as clickers in class. In this paper, I discuss this teaching approach and present evidence that supports usefulness of interactive teaching in the context of a large International Finance class. Empirical evidence shows significant improvements in academic performance for students, compared with performance from the same course taught using the conventional lecture format in a smaller class setting.

In Winter 2012 semester I taught two sections of International Finance class using conventional lecture format. The sections were scheduled at different times throughout the week, and the total number of students for all sections was 287. Academic performance was evaluated using two midterm tests and the final test, each test included questions of varying degrees of difficulty. During Winter 2013 semester, I taught the same material to one class of 341 students using interactive format. This format change presents a natural experiment which can be used to evaluate the efficacy of interactive teaching.

Interactivity is introduced through the use of pre-tests before class and clicker questions in class. First, each week students are asked to read the required chapter and answer several True/False questions covering the material. The level of difficulty for these questions is very low. The questions are designed in such a way that almost anybody who have read the chapter, and is therefore familiar with main concepts, should be able to answer correctly. Students find out the answers to these questions after the end of the lecture. In addition, I present several clicker questions for class discussions. Usually 15 or 20 minutes of lecture is followed by a clicker question. Students discuss these questions in groups, and after

the discussion each student submits answers using clickers. The level of difficulty for such questions is medium. Next, academic performance is evaluated using two midterm tests and the final test, analogous to the conventional course format. This variation in question difficulty follows work of Vygotsky (1978) on the Zone of Proximal Development (ZPD).

Empirical analysis was conducted using nonparametric methods and shows the following results. I detect significant increase in mean and median test performance, and significant reduction in variability of test performance for interactive teaching methodology. Greater proportion of students achieved more than 50% on the final test. Finally, midterm test performance is more correlated with final exam performance, and correlations exhibit greater degree of statistical significance.

This paper makes two contributions to the literature. First, I provide additional evidence that demonstrates extra benefit of interactive lecture format for teaching Finance. Second, I demonstrate successful application of ZPD methodology in a business school lecture setting. The paper is organized as follows. The next section reviews relevant literature. Section 3 describes data and methods. Section 4 presents empirical results and is followed by the conclusion.

LITERATURE REVIEW

Interactivity during lectures is usually implemented through various forms of classroom response systems. Many studies find that interactivity enhances learning experience and leads to better performance, attendance, and student engagement. Caldwell (2007) finds that clickers contribute to classroom experience by sustaining student attention, discovering student misunderstandings of the material, and creating conditions where students have to study assigned readings before class. Simpson and Oliver (2007) discover that most users of classroom response systems, including professors and students, are in favour of using such systems in classroom.

Salemi (2009) considers costs and benefits of using clickers in university education and finds that the benefits clearly outweigh costs. Heaslip et al. (2014) find that clickers enhance lectures because they make classes more enjoyable and improve student engagement.

At the same time, literature identifies several challenges that arise when instructors use classroom response system. These challenges include the necessity to use new technology, class discussion misadventures, and dislike of students towards being monitored, as outlined in Kay and LeSage (2009). Simpson and Oliver (2007) and Bruff (2009) note that the success of using classroom response systems depends on the skill and approach chosen by the instructor.

In order to overcome these challenges, I concentrate on teaching methodology. I view student learning from the perspectives of development psychology, proximal development, and applied behavioral analysis. Development psychology of Piaget (1973) implies that learning occurs in stages and each stage takes some time. Zone of Proximal Development, introduced by Vygotsky (1978), implies that it may be reasonable to ask students simple questions at the start of the lecture, but for more difficult questions some students may need hints from the instructor and such questions should be asked later into the lecture. Next, methods of applied behavioral analysis described in Greer (2002) suggest that learning occurs during continued interaction between students and the instructor; hence, lecture planning should include such multi stage interaction.

Finally, several studies, for example Caldwell (2007) and Carnaghan and Webb (2007) document resistance of students to graded interaction per se, this includes resistance to such things as attendance checks and negative feedback. Tools to overcome resistance are available from negotiations literature and improvisation literature. Ury (1993) and Fisher et al. (2011) suggest to address concerns logically. Bergren et al. (2002) suggest to work around difficult situations.

DATA AND METHOD

I evaluate the effect of interactive lecture format on student learning using test performance data from International Finance course taught at Ryerson University during Winter 2012 and Winter 2013 semesters. Course content was identical and delivered by the same instructor.

TABLE 1
DESCRIPTIVE STATISTICS FOR EXAM PERFORMANCE, 2012

	MIDTERM1	MIDTERM2	FINAL
Mean	15.21	17.31	10.86
Median	16	18	11
Maximum	20	20	19
Minimum	6	4	3
Std. Dev.	2.83	2.57	2.93
Skewness	-0.75	-1.87	-0.16
Kurtosis	3.25	8.26	2.88
Observations	281	277	287

TABLE 2
DESCRIPTIVE STATISTICS FOR EXAM PERFORMANCE, 2013

	PRETESTS	CLICKERS	MIDTERM1	MIDTERM2	FINAL
Mean	79.39	78.16	14.23	16.14	11.53
Median	84.29	83.22	14	17	12
Maximum	98.57	100	20	20	19
Minimum	5.71	4.76	6	3	5
Std. Dev.	19.53	17.74	2.70	2.87	2.55
Skewness	-2.19	-2.06	-0.40	-1.29	0.16
Kurtosis	7.87	7.56	2.95	4.98	3.03
Observations	369	355	343	334	341

During Winter 2012 semester lectures were carried out using the conventional format where students come to class, listen to the instructor, and take notes. This format included two midterm tests and the final test, all multiple choice questions. The first midterm covers first 40% of the material, the second midterm covers next 40% of the material, and the final test covers all material taught in the course. During Winter 2013 semester lectures were delivered using interactive format. It involved pretests before class and clicker questions during class, in addition to two midterms and the final test. Pretests included several True/False questions on required reading, were available from the Blackboard course page, and were due any time before the start of the corresponding class. Clicker questions were in-class discussion questions where students had to solve problems or answer conceptual questions and were free to work individually or in groups. Each student was responsible for his or her own answers that were sent to the instructor via clicker device.

Descriptive statistics for student performance are presented in Tables 1 and 2. Table 1 presents results from the conventional lecture format during Winter 2012. Mean Midterm 1 score is 15.21, mean Midterm 2 score is 17.31, and mean Final score is 10.86. The maximum possible score in all tests was 20, which

makes it easier to compare across tests and years. The average final test score is lower than those from the midterms. I hypothesize that this is due to the amount of tested material, each midterm covers 40% of the material and the final covers all required reading. Students are likely better able to concentrate on few chapters for the midterm rather than the whole textbook for the final, hence the difference in test performance.

Table 2 presents performance statistics for the interactive semester. Mean midterm 1 score is 14.23, mean midterm 2 score is 16.14, and mean final score is 11. 53. I use final test performance as the main indicator of success. The final test covers all course material and has the highest weight in grade calculations. Comparison of Table 2 with Table 1 reveals that final test performance is slightly higher in 2013 than that in 2012. Next, median final test score is higher median of 12 out of 20 in 2013 versus median of 11 out of 20 in 2012. I also see reduction in standard deviation of final test results, 2.55 in 2013 versus 2.93 in 2012.

In order to check whether estimated performance differences have statistical significance, I conduct a series of nonparametric tests. The first null hypothesis of no difference in mean final exam scores is tested against the alternative hypothesis of significant difference in mean test scores using the t-test. For robustness checks, I also perform Satterthwaite-Welch t-test, Anova F-test, and Welch F-test for the difference in mean values between performance distributions in 2012 and 2013. To test for median equality, I utilize Wilcoxon/Mann-Whitney test, and for robustness checks I also use Wilcoxon/Mann-Whitney (tie-adj.), Kruskal-Wallis, Kruskal-Wallis (tie-adj.), van der Waerden median equality tests. Finally, in order to check equality of variances, I employ F-test, and for robustness checks I conduct Bartlett, Levene, Brown-Forsythe variance equality tests. For all estimated correlations I conduct t-tests to check if they are significantly different from zero.

RESULTS

This section compares test performance achieved during conventional lecture format during Winter 2012 semester with test results attained after interactive teaching during Winter 2013 semester. Empirical results suggest that interactive teaching brings about improvements in average and minimum test scores, reduces variability and introduces positive skewness into the distribution of test scores. I also find that midterm test results are better predictors of final test performance under interactive teaching format.

I use final exam score as the main outcome variable because the final test covers all course information and has the highest weight in determining the final grade. Table 1 presents test scores from the semester with conventional lecture delivery. Average final test score in 2012 is 10.86 out of 20, minimum test score is 3, standard deviation is 2.93 and skewness is -0.16. Table 2 presents performance parameters for the interactive lecture format. Average final test score in 2013 is 11.53 out of 20, minimum score is 5, standard deviation is 2.55, and skewness is 0.16. The reader can clearly see a positive change in performance distribution in terms of average and minimum scores, a reduction in volatility of results, and a change from negative to positive skewness of the final test results distribution.

Figure 1 shows histograms of final test scores. We see that FINAL2013 distribution is shifted to the right compared with FINAL2012 distribution, which indicates performance improvement. How such performance improvement is translated into grading can be seen from Table 3, which compares test score distributions with grading ranges. The left part of Table 3 presents conventional grading range in terms of percentage of correct test answers. For example, if a student achieves Exam Score of 17 (out of 20), this students gets 85% of questions correct and ends up in A range in terms of the final grade. In 2012 I had 1.74% of students who were able to achieve 85% of answers correct, while in 2013 I had 2.35% of students with such performance. Examination of Table 3 reveals that the proportion of students below F (fail) range decreases in 2013 compared with 2012, and the proportion of students getting into above F (pass) grading range increases. Therefore, we observe evidence that improvement in average scores is not only due to good students getting better, but also due to students who would likely have failed the course under the conventional lecture format but passed the course under interactive format.

I use a series of nonparametric tests in order to evaluate statistical significance of this performance improvement. Table 4 presents results of testing for equality in distribution parameters between 2012 and 2013 final test scores. I test for equality in means, medians, and standard deviations and reject the null hypothesis of equality at 5% level of significance for each of these parameters. In particular, the t-value for the mean equality test is 3.0637 with the corresponding p-value of 0.0023, which rejects the null of mean equality. I compute Wilcoxon/Mann-Whitney median equality test statistic of 2.5493 with p-value

FIGURE 1
HISTOGRAMS OF FINAL EXAM PERFORMANCE, 2012-2013

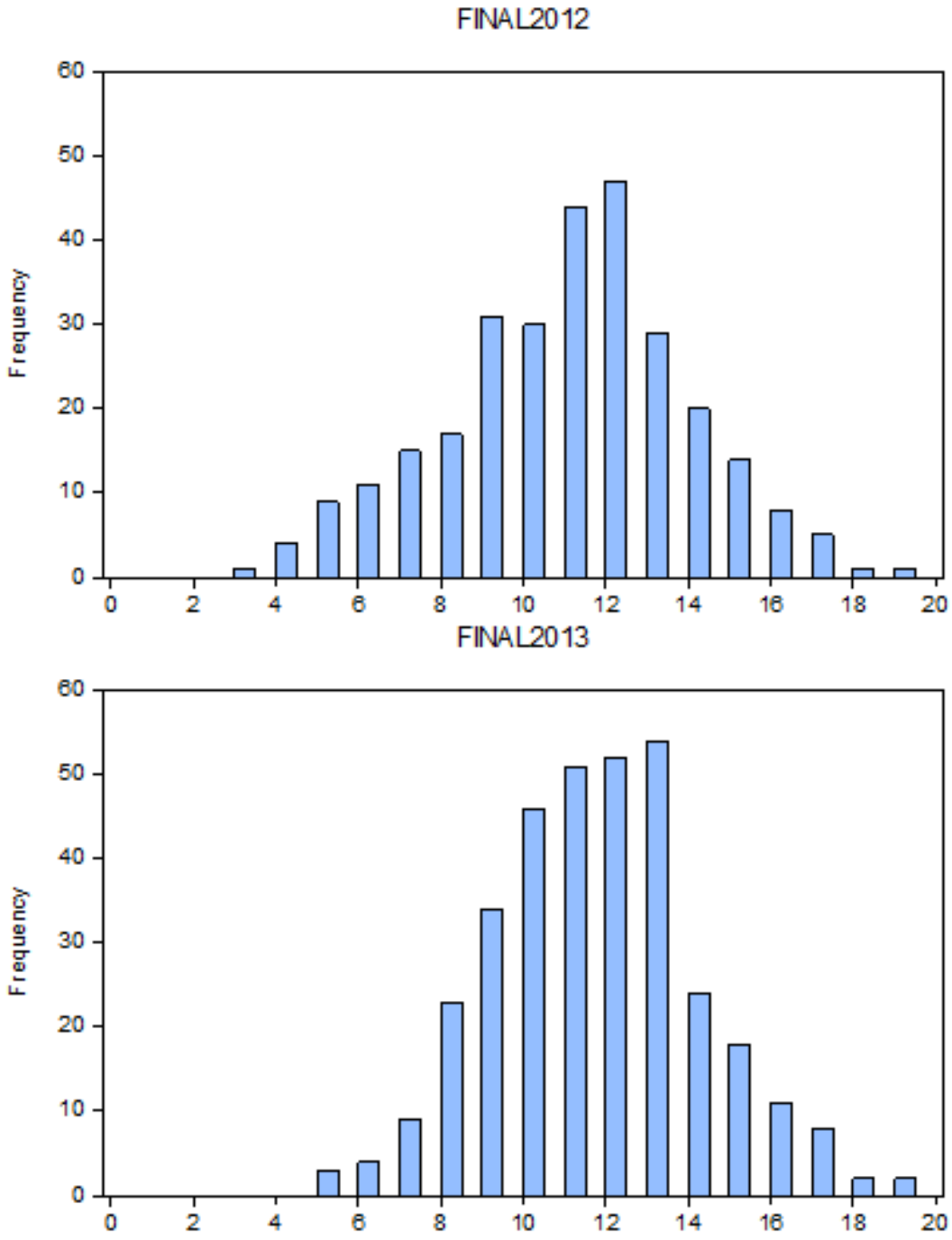

TABLE 3
FREQUENCY OF EXAM PERFORMANCE IN RELATION TO GRADING SCHEME

Grade Range	Exam Score	Correct answers, %	Proportion of class, %	
			2012	2013
A	20	100	0.00	0.00
	19	95	0.35	0.59
	18	90	0.35	0.59
	17	85	1.74	2.35
	16	80	2.79	3.23
B	15	75	4.88	5.28
	14	70	6.97	7.04
C	13	65	10.10	15.84
	12	60	16.72	15.25
D	11	55	14.98	14.96
	10	50	10.45	13.49
F	9	45	10.80	9.97
	8	40	5.92	6.74
	7	35	5.23	2.64
	6	30	3.83	1.17
	5	25	3.14	0.88
	4	20	1.39	0.00
	3	15	0.35	0.00
		Total, percent	100.00	100.00

of 0.0108, and variance equality F-test statistic of 1.3298 with p-value of 0.0127. These test results reject null hypotheses of equality in distribution parameters. I conduct alternative tests as robustness check and obtain similar results.

Next, I investigate whether any significant relationship exists between midterm tests and final test results. Prom the perspective of the instructor, midterm tests are designed to provide interim assessment of student learning. From the perspective of students, a midterm test offers a chance to test knowledge at the same level of rigor as the final test. Analysis of midterm results may indicate whether or not any changes in study approach are needed so that the student gets a passing mark. This particular course contains two midterm tests. The first midterm covers the first 40% of the required material, the second midterm covers the next 40%, and the final test covers all required material. Table 5 presents correlations between midterm tests during Winter 2012 semester. The estimated correlation between midterm#1 and the final test is 0.1937, significant at 1% level. The estimated correlation between midterm#2 and the final test is 0.1019 and significant at 10% level.

These correlations are lower than correlations from the course with interactive teaching format in 2013 presented in Table 6. In particular, the correlation between test#1 and final is 0.2182, the correlation between midterm test#2 and the final is 0.1613, and both correlations are significant at 1% level. The reader can witness improvements in correlations and their significance, indicating that during the interactive teaching format midterms were better predictors of final test performance.

The results point at clear benefits of using interactive lecture format. First, I find evidence that interactive lectures improve test performance. Second, I find evidence that midterm test become better predictors of final test scores.

TABLE 4
EQUALITY TESTS FOR DISTRIBUTION PARAMETERS IN FINAL EXAM PERFORMANCE, 2012-2013

	FINAL2012	FINAL2013	Equality test	Test Statistic
Mean	10.86	11.53	t-test[a]	3.0637***
				(0.0023)
Median	11	12	Wilcoxon/Mann-Whitney[b]	2.5493**
				(0.0108)
Std. Dev.	2.93	2.55	F-test[c]	1.3298**
				(0.0127)

Notes
p-values in parentheses.
*** indicates 1% significance, ** indicates 5% significance,* indicates 10% significance levels.
[a] additional mean equality tests, such as Satterthwaite-Welch t-test, Anova F-test, and Welch F-test, were conducted and produced similar results.
[b] additional median equality tests, such as Wilcoxon/Mann-Whitney (tie-adj.), Kruskal-Wallis, Kruskal-Wallis (tie-adj.), van der Waerden, were conducted and produced similar results.
[c] additional variance equality tests, such as Bartlett, Levene, Brown-Forsythe, were conducted and produced similar results.

I interpret these results in the following way. First, interactive lecture format gives more frequent chances for students to test their understanding of the material and adjust learning accordingly. Second, group discussions of clicker questions likely generate more interest and thus have positive effect on knowledge retention. Third, smaller increments in learning, coupled with answering questions after discussion with peers, likely results in faster learning. This result is to be expected in the frameworks of zone of proximal development and applied behavioral analysis. Fourth, students whose main perception mechanism is kinesthetic likely find interactive method of instruction easier and more intuitive because they learn by doing. See Stankov et al. (2001) and Lujan and DiCarlo (2006) for the discussion of various perception and learning modes.

CONCLUSION

The need for high quality and affordable university education is a well-established requirement for economic growth and technological progress. This paper presents evidence that both academic performance and class size can be increased by introducing interactivity in teaching business classes. I was the first to start teaching Finance at Ryerson University using interactive methodology based on pretests and clickers. After two years of using the methodology I am happy to report that this experience has been a success.

TABLE 5
CORRELATIONS FOR MIDTERM AND FINAL TEST RESULTS, 2012

	MIDTERM1	MIDTERM2	FINAL
MIDTERM1	1		

MIDTERM2	0.4855***	1	
	(0.0000)	---	
FINAL	0.1937***	0.1019*	1
	(0.0014)	(0.0953)	---

Note: p-values for t-test in parentheses.
*** indicates 1% significance, ** indicates 5% significance,* indicates 10% significance levels.

TABLE 6
CORRELATIONS FOR QUIZ AND TEST RESULTS, 2013

	PRETESTS	CLICKERS	MIDTERM1	MIDTERM2	FINAL2013
PRETESTS	1				

CLICKERS	0.6215***	1			
	(0.0000)	---			
MIDTERM1	0.2748***	0.1089**	1		
	(0.0000)	(0.0448)	---		
MIDTERM2	0.3219***	0.2223***	0.3623***	1	
	(0.0000)	(0.0000)	(0.0000)	---	
FINAL	0.1488***	0.0223	0.2182***	0.1613***	1
	(0.0059)	(0.6828)	(0.0001)	(0.0032)	---

Note: p-values for t-test in parentheses.
*** indicates 1% significance, ** indicates 5% significance,* indicates 10% significance levels.

The methodology involves assigning reading and requiring students to answer several easy web based questions before the start of each class. Next, each lecture segment of 15-20 minutes is followed by a clicker question that students discuss in groups and then send their answers for grading. The difficulty of these questions is medium. Finally, midterm and final exams are administered in a usual format; each test is a combination of questions from all difficulty levels. Any student resistance to interactive methodology is addressed by the instructor using negotiation or improvisation tools.

Empirical evidence shows clear improvements in academic performance for students taught using interactive lecture format. Average and median test scores are significantly higher, compared with the regular lecture format. Dispersion of grades, measured by sample standard deviation, is significantly lower. Additionally, midterm test scores exhibit greater correlations with the final test score.

These results imply that interactivity in lectures is a very effective tool that should be utilized in university setting. Electronic devices such as clickers, or smartphone applications that work like clickers, allow to instantly check students' understanding of the material and to modify lecture flow accordingly. Integration of electronic devices into large class teaching methodology allows to significantly increase class size. This, in turn, can make university education more affordable without sacrificing quality.

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