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Computer Based Assessments of Student Performance in Hybrid Classes: Does Class Size Really Matter?

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ABSTRACT

This paper reports the relationship between student performances evaluated using computer-based assessment (CBA) tools in large (500+ students) and small (35 students) classes. While large classes allow an efficient use of limited university resources, they are sometimes perceived as diluting the richness of a small classroom learning process, resulting in poorer student performance. Computer-based (including online) student assessments have the potential to familiarize students with technology assessment tools widely used by business recruiters and trainers, while also freeing up valuable in-class lecture time, lessening the administrative burden of grading and recording scores, and automatically providing statistical feedback to instructors and students on student performance. In this study, hybrid course formats (combining face-to-face lecture techniques with computer-based training and performance assessments) were used in two large and nine small classes teaching the same topics and using functionally identical CBA tools. The differences between pre-treatment (instruction) and post-treatment student CBA skill scores were statistically compared. The findings suggest there are no endemic student performance differences between large and small classes using computer-based assessment tools, and imply that the apparent administrative and educational benefits of computer-based assessments—especially for large classes—may override educational concerns.

Keywords computer-based assessment, learning, performance, class size

INTRODUCTION

Many lectures in introductory university courses are conducted in large classes to more easily absorb enrollment variations, provide economies of scale in terms of classrooms, and more efficiently use the skills of a professor—especially during times of shrinking financial support. A sizable portion of students and faculty, however, view this technique of instruction as unsatisfactory (Booms and Kaltreier, 1974). Large classes are criticized for lack of personalization, over-generalization of the content to students with various degrees of subject proficiency, lack of course flexibility, and high administrative maintenance resulting in poorer learning and performance results (Mason, 1996). School rankings comparing universities for administrators, parents, and students usually show class size criteria with the presumption that students in small classes get more personal attention and feel more comfortable to ask questions—while students in large classes feel lost in a crowd (Arias and Walte, 2004).

Computer-based instruction, however, can allow students to train at their own speed, cover only the materials they need or want to cover and to the depth they want, and can provide feedback to a professor on attempted and accomplished training. Combining traditional lecture methods with customized, computer-based instruction in a "hybrid" course can therefore mitigate many of these concerns by adding a certain degree of freedom to both students and instructor—and improving personalization, tailoring of content, increasing flexibility, and decreasing administrative maintenance. Furthermore, using computer-based assessment (CBA) tools can also help faculty more easily monitor student learning while simplifying course grading and administration.

The hybrid course format combines traditional instructional techniques, such as in-class lectures, with one or more computer-based modes of learning such as digital delivery of course content and monitoring student achievements and contributions (Leidner and Jarvenpaa, 1995). The hybrid format offers students and instructors better accessibility to course content, connectivity among students and with the instructor, and personalized location and time management. Instructors can pursue four major goals while constructing hybrid courses: creating a flexible and conducive atmosphere for learning in terms of time and location, freeing valuable in-class time for expanding the content of the covered material during lectures, personalizing task delivery to everyone, and easing class administrative management. Moreover, the hybrid format can familiarize students with technology assessment tools used by business recruiters and trainers.

The question of class size, however, remains. *Would students in small hybrid classes perform better than students in large hybrid classes?* In this study, student performance in two large and nine small classes in an introductory-level information technology course using CBA is statistically compared. If the results are not statistically different, class size can be inferred to be an insignificant factor.

In this paper, all classes used the hybrid format including online training and assessment, online course material distribution, online grade notification, online student topic discussions, online instant messaging between students and instructors, in-class computer skills demonstrations, and e-mail and an online web site for announcements—combined with traditional lectures and student live interaction. All classes covered the same material: Microsoft Office Word®, Excel®, PowerPoint®, and Access® skills.

The rest of the paper is structured as following. Section 2 is a review of previous research relative to this study, while Section 3 presents this research design and methodology. We describe the analytical design and methodology in Section 4 and the analytical results in Section 5. The results are discussed and conclusions drawn in Section 6, while the limitations of the research and the implications for future research are discussed in Section 7.

2. LITERATURE REVIEW

Previous literature relative to this study's research question is in two major areas: the relationships between class size and student performance, and using CBA and online tools in a hybrid course.

2.1 Class size and student performance

While large classes are a feature of virtually all universities, they continue to draw fire. Large classes are linked to poor attendance (van Blerkom, 1992), low quality interaction with faculty and less time devoted to specific tasks resulting in poor student performance (Gatherer and Manning, 1998). Mason (1996) argues that normally insignificant problems—such as taking roll or writing notes on a blackboard—add up to a formidable administrative and teaching challenge. Large courses tend to have students with a wider range of skill sets, knowledge, and needs (Christopher, 2002). Hogan and Kwiatkowsky (1998), while studying the role of emotions in higher education, suggest lecturers reconsider how they deliver course content in large classes and utilize technical and administration solutions suggested earlier by large class size researchers (e.g., Gibbs and Jenkins, 1992; Andersen, 1994; and Newble and Cannon, 1995). Zimbaro (1992) pointed out that lecturers of large classes tend to oversimplify to provide entertainment for the class. Seigfried and Kennedy (1995) found that instructors, faced with limited time for grading, may assign less written homework or fewer problem sets—and that can negatively impact learning. Furthermore, Finn, Pannozoo and Achilles (2003), stated that once class sizes are reduced, major positive changes occur in student engagement in the classroom. While teaching economics, Arias and Walker (2004) found a strong negative relationship between class size and student performance calculated as exam point aggregate. They suggested that student ethics and proximity to an instructor in small classes help them understand economics concepts better.

On another hand, Papo (1999) surveyed 246 high level undergraduate students from various schools and found that students with previous experience with various class sizes did not perceive large classes to pose significant problems to their learning. Hancock (1996) found no significant difference in the performance among students in three large and six small classes on statistics. Hill (1998) investigated the effect of large sections of 120 students in accounting on their performance and perceptions in the introductory courses; the study did not discern statistically significant differences between student performance and sections size. Indeed, when attendance and university GPA were controlled, the large sections outperformed the small sections. She found that attendance was highly positively correlated with performance, while Amoroso (2004) found no correlation between performance in CBA and attendance at face-to-face lectures in a hybrid course. Prior research has also shown mixed results as of what influences students' performance in different class sizes due to research design trade-offs such as various ways to ascertain student performance: final grades and variations of it (cumulative exam score, percentage of aggregate exam grade, etc.) was used by Hill (1998); Thoennessen, et. al., (1996); Ricketts and Wilks (2002); and Siegfried and Kennedy (1995), while differences in pre-test and post-test scores were used by Booms and Kaltreider (1974); Schulmas and Simms (1999); and Amoroso (2004).

2.2 Courses with technology involvement

Two types of classroom information technologies are reviewed here: using technology to improve student learning, and using technology to improve student performance evaluation. A hybrid course provides teachers and students with face-to-face lectures and technology-enabled interaction for explanations, small group discussions, presentations, and individual assistance. This instructional format has been found to have many advantages over traditional lectures (Christopher, 2002). First, interaction between the professor and the students is regulated by the professor and occurs one-by-one; interaction via technology is controlled by the students and can occur in parallel. Second, students normally receive an advance copy of the lecture slides and the majority prefer to study at home rather than attend class; studying via technology can always be done "at home." Third, lecture—even while attended—may not have student attention necessary for learning; training provided through technology is more likely to keep a student's attention. Finally, people learn more by doing than by watching and listening. The hybrid format reduced classroom "down time" for teachers and students, and prepared students to use technology in many business areas (Emery, 2003). At the same time, online training may be a viable alternative to those from rural areas and students with nontraditional schedules.

Research has shown that the hybrid format can couple online homework with in-class, active learning exercises to improve attendance (Van Blerkom, 1992). Cameron (2003) used simulation in a hybrid course on networking, and found that it improved conceptual understanding and raised performance. Willett (2002) proposed using online discussions as a good substitute for in-class discussion, and Haggerty, Schneberger, and Carr (2001) found that online discussions lead to better cognition due to the increase in available time to reflect and respond. Cywood and Duckett (2003) discovered no significant differences between quantitative measures of online versus on-campus learning and suggest that there is no actual difference regarding learning. McGray (2000) demonstrated the potential of IT to enable an instructor to be more efficient and effective in broadening and deepening the learning process for business students in MIS. It has been shown that technology allows individuals to share tacit knowledge in a manner uninhibited by the time and location (Leidner and Jarvenpaa, 1993). Another study, by Caywood and Duckett (2003), looked at the performance of students on campus and online during one specific course; the results showed no significant differences in learning across environments and concurred with the previous studies.

Leidner and Jarvenpaa (1995) described using technology to support an objectivist model of learning in hybrid courses by facilitating the delivery of information via a technology-enhanced instructor console and by using CBA. They concluded that CBA allowed students to learn more effectively and efficiently because they were in control of the pace, time, and location. CBA feedback can be a critical part of learning; active involvement can lead to more effective learning than passive involvement. CBA enable instructors to collect, analyze, and use information about student learning as feedback to improve their teaching, and they enable students to demonstrate what they know (Ebert, May, Baltzli and Lim, 2005). According to Riffell and Sibley (2003), students responded that the most effective way to learn material was through online homework and email with instructors. Ricketts and Wilks (2001) suggested that well designed CBA can benefit students by improving their performances in assessments in the introduction of statistics in biology. CBA during this first year contributed to the student performance during the second year, and that students tested via CBA received higher grades.

Tuckman (2002) compared academic performance and learning in terms of grade point average in hybrid courses and traditional courses with the learning of a control group using the same textbook, content, and performance activities. The study showed that student skills using the combined classroom and computer-mediated model improved significantly more in academic performance than the students taught the same material by a conventional classroom approach. Noyes, Garland, and Robbins (2004) studied paper-based and computer-based assessments, comparing the test performances of undergraduate students taking each test type. Given the identical multiple choice questions, students who used CBA achieved better results than those taking paper-based tests, and students with higher scores were found to benefit the most from CBA. Moreover, CBA helped to improve long term recall of key concepts and resulted in higher scores than conventional exams (Bocij and Greasley, 1999).

Conversely, using CBA can present challenges with increased plagiarism and the cost of software licenses (Northcote, 2002). External collaborations (i.e., cheating) on online assessments have been shown to be problematic—as they are with traditional paper testing (Kozma, 2003).

3. RESEARCH DESIGN AND METHODOLOGY

The research question of this study is: *would students in small hybrid classes using CBA perform better than students in large hybrid classes using CBA?* The performance evaluation was done using CBA before (pre-test) and after (post-test) the treatment (hybrid class instruction). This basic research model is shown in Figure 1. The independent variable is class size, and the dependent variable is the difference in student performance using CBA after hybrid instruction. To maximize the variance due to class size, differences in the other factors shown in the model were minimized.

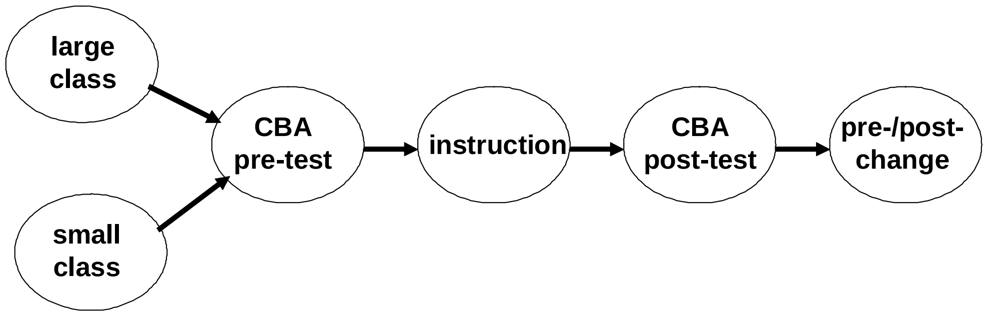

Figure 1. Research Factor Model

The pre-test CBA covered the same Microsoft Office topics and used the same type of software with the same testing characteristics. Students had received in-class instruction on the CBA software and given opportunities to train with the software outside the classroom for familiarization. Students were given a window of hours in which to independently take the pre-test CBA—in school computer laboratories or using any off-campus computer with the CBA software installed and having Internet access. The students were told before the pre-test that it would cover topics they hadn't yet received instruction on to see how much they already knew, and that they would receive course credit for taking the assessment. The pre-test CBA required students to perform everyday tasks using Microsoft Office Word®, Excel®, PowerPoint®, and Access® such as inserting a graphic in a Word® document, creating an IF function in Excel®, using a design template in PowerPoint®, and creating a query with numeric criteria in Access®. Of note, the CBA software did not grade the results of completing a task, it graded the *process* of creating the result. This type of test is much more stringent as the student cannot experiment or produce a result by exploring; the student must know how to accomplish the task and perform the steps in a pre-determined order. It was assumed, therefore, to be a more accurate gauge of actual student knowledge—and learning. The CBA software automatically scored each student and reported the results to the professor.

The instruction covered the same Microsoft Office topics, teaching basic to intermediate level skills. In the traditional lecture sense, all the classes met on a weekly basis in a classroom, all used a textbook devoted to Microsoft Office, and all classes used a professor to explain and demonstrate skills using the traditional lecture method. As hybrid classes, however, they also all offered online training with feedback and practice assessments, online course material distribution (e.g., lecture slides, handouts, and readings), online grade feedback, online student topic discussions, online instant messaging among students and with the instructors, in-class computer skills demonstrations using overhead projectors and writing-pad desktop monitors, and e-mail and online course announcements. Students did not sit in front of computers for practicing during class; it was understood by the students that they were expected to practice outside the classroom.

The post-test CBA was conducted similarly to the pre-test using the exact same tasks (but not necessarily the same material) as the pre-test. The CBA software was the same, the test time period was the same, and the demanding nature of testing procedures was the same. All students again had the option of taking the assessment on school computers or their own. All pre-test and post-test CBA scores were raw scores; they were not curved. The difference between a student pre-test and post-test CBA score is the research dependent variable.

The only significant difference was the size of the classes, the independent variable. Two classes had over 445 undergraduate students each and were each taught by one professor in a large auditorium, while nine classes had under 35 undergraduate students each and were each taught by one professor in a traditional classroom with desks and chairs. Both types of classrooms had the same multimedia technology for instruction.

To isolate the effect of class size on CBA performance, this study sought, therefore, to minimize all other effects shown in Figure 1. The null and alternate hypotheses are:

H_0: the CBA improvement scores came from the same populations; they have the same means.

H_A: the CBA improvement scores came from different populations; they do not have the same means.

4. ANALYTICAL DESIGN AND METHODOLOGY

The independent variable was class size, and the dependent variable was the difference between the pre-test and post-test CBA scores (an improvement was positive, a decrease was negative). Although not direct factors in this research, other CBA scores were also analyzed for possible explanation of results: each pre-test and post-test scores, as well as each assessment on individual topics (Word, Excel, PowerPoint, and Access). SPSS® for Windows was used to analyze the data.

The numeric scores from 1,173 students in 11 classes (2 large, 9 small) were grouped by instructor and the semester into five groupings. Groups 1 and 2 were the two large classes, group 3 consisted of five small classes, group 4 contained the scores of three small classes, and group 5 was a single small class. We did not assume that the samples had a normal distribution (necessary for ordinary analysis of variance), and therefore used the more robust Kruskal-Wallis H non-parametric test to see if there were statistically significant differences between the ranked means of each group. The Kruskal-Wallis test is a one-way analysis of variance test better suited than ANOVA for K independent samples. All raw scores are ranked, numbered, and then replaced by their rankings. The rankings are then summed and averaged to compare means. The test statistic is H; if H exceeds the critical value for H at the chosen significance level, then there is evidence to reject the null hypothesis in favor of the alternate hypothesis. In SPSS, the critical value is approximated using a Chi-square distribution with k (the number of groups minus one) degrees of freedom. The Chi-square critical test value for df=4 and α=.05 is 9.488.

5. RESULTS

The descriptive statistics for the pre_post dependent variable are shown in Table 1. The mean ranks for all the dependent variables (including the "pre_post" variable cited in our hypotheses as the "improvement" variable) are shown in Appendix 1. Of note, the mean ranks of the "pre_post" scores for the five groups appear remarkably similar except for the mean ranking of group 5. The mean rankings of the large class in group 1 (449.13) and the mean rankings of the five small classes in group 3 (449.52) were particularly similar, differing by less than one hundredth of one percent.

pre_post	Mean		16.1651	0.54485
	95% Confidence Interval for Mean	Lower Bound	15.0954	
		Upper Bound	17.2347	
	5% Trimmed Mean		15.6922	
	Median		15.0000	
	Variance		219.382	
	Std. Deviation		14.81155	
	Minimum		-37.00	
	Maximum		80.00	
	Range		117.00	
	Interquartile Range		17.00	
	Skewness		0.524	0.090
	Kurtosis		0.986	0.180

Table 1. Pre_Post Descriptive Statistics

The Kruskal-Wallis test statistics for the nine independent variables are shown in Figure 2. The key test statistic is the "pre_post" Chi-Square H value: 7.460. Since that is *not* more than the Chi-square critical test value 9.488, we *cannot reject* the null hypothesis that the samples are all from the same population. (It doesn't prove the means are identical; but by *not* being able to reject the hypothesis that they're equal, it supports the conclusion they are at the stated confidence value.) Of note, the H values for the pretest and posttest samples are each larger than the critical test statistic and would be evidence for rejecting a hypothesis that they are from the same population.

Test Statistics[a,b]

	pretest	excel	internet	access	pwrpoint	posttest	exam_1	exam_2	pre_post
Chi-Square	212.040	158.417	13.129	213.354	44.838	196.441	8.124	287.480	7.460
df	4	4	4	4	4	4	4	4	4
Asymp. Sig.	.000	.000	.011	.000	.000	.000	.087	.000	.113

a. Kruskal Wallis Test

b. Grouping Variable: class

Figure 2. Kruskal-Wallis H Test Statistics

6. DISCUSSION AND CONCLUSION

The research question examined in this study was: *would students in small hybrid classes perform better than students in large hybrid classes?* From the literature review described in Section 2, there are seemingly opposing thoughts and research results on the efficacy of large versus small classes as well as the mitigating factor of using technology in a "hybrid" class to minimize the apparent, deprecating effects of large classes. An underlying question behind this paper's research question is *can technology—including computer-based assessments—reduce the effects of class size to the point of no discernible difference?* Without having to verify whether the previously reported ill effects of large class size are true, this study simply sought to support a hypothesis that there was no student performance difference in large or small hybrid classes—for any reason. And that hypothesis was supported by the data from 1,173 students in two large classes (greater than 445 each) and nine small classes (less than 35 students). In answer to the research question, the results of this research would suggest that *students in small hybrid classes do not perform better than students in large hybrid classes, or vice versa.*.

The implications of this result can be significant. Large classes offer considerable economies of scale for universities, giving much greater efficiencies of classroom and instructor assets. One large class of 450 students is the student equivalent of over twelve classes of less than 35 students—immensely increasing the economic revenue from students for the same professorial cost and one twelfth of the classroom cost. The longstanding issue with large classes that anecdotally have restrained large classes is the ill effect they have on student performance. If it can be shown that student performance is not different between large and small classes, arguments against large classes would seem to have little justification. Furthermore, if information technology (including CBA) is used to minimize the reported ill effects of large classes, then the further intrinsic benefits of classroom technology may add even more to the economic efficiency benefits of large classes.

7. LIMITATIONS AND FUTURE RESEARCH

This study had only one independent variable: class size. The results of this research, while significant in their implications, do not identify the individual factors that support *why* the results occurred. It was enough for this very large data collection effort (1,173 students in 11 classes) to conclude that there is no appreciable difference in student performance between large and small classes, but follow-on research should identify which class size factors (e.g., gender, student year, GPA, self-efficacy, and others) have a greater effect on student performance. Specifically, which information technologies have the greatest effects on countering previously researched findings on the ill effects of larger class size.

One limitation of this study is that the methodology did not control for differences in instructors and lecture material, even though differences were minimized. But answering the research question did not depend on identifying and controlling all mitigating factors; answering the research question only depended on showing there was no evidence of differences in student performance. Of note, the statistical tests suggested that there were significant differences in the pre-test scores and in the post-test scores, but not in the improvements. This suggests that significantly different students were enrolled in the large and small classes—yet improved the same amount after instruction. The effects of having similar students in both types of classes could be investigated.

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Appendix 1. Kruskal-Wallis Variable Rankings

Ranks

	class	N	Mean Rank
pretest	1	488	650.31
	2	445	669.77
	3	140	302.85
	4	77	300.39
	5	23	331.43
	Total	1173	
excel	1	488	484.40
	2	445	686.19
	3	140	731.68
	4	77	339.46
	5	23	792.70
	Total	1173	
internet	1	488	588.60
	2	445	607.97
	3	140	595.72
	4	77	472.36
	5	23	478.13
	Total	1173	
access	1	488	672.84
	2	445	435.11
	3	140	805.58
	4	77	434.27
	5	23	885.22
	Total	1173	
pwrpoint	1	488	610.69
	2	445	619.26
	3	140	518.65
	4	77	367.56
	5	23	610.89
	Total	1173	
posttest	1	488	655.42
	2	445	658.86
	3	140	313.28
	4	77	314.23
	5	23	324.15
	Total	1173	
exam_1	1	488	561.41
	2	445	594.77
	3	140	648.84
	4	77	578.80
	5	23	630.65
	Total	1173	
exam_2	1	488	470.86
	2	445	541.30
	3	140	871.09
	4	77	986.98
	5	23	866.96
	Total	1173	
pre_post	1	372	449.13
	2	355	481.35
	3	109	449.52
	4	57	411.24
	5	21	369.52
	Total	914	