Analyzing the differences in problem-solving abilities between instructor-led and online learners

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Abstract

This paper presents a statistical analysis of problem-solving learning from online verses instructor-led database management systems courses at Metropolitan State University of Denver. Students in all versions of the course were required to submit three assignments that required them to respond to *ad hoc* inquiries into the data contained in electronic databases. The assignments were scored according to a common rubric. A two-tailed t-test of the differences in means of the online and instructor-led courses was conducted to evaluate student learning in the two different course delivery methods. Although online learners were provided with extensive resources to help them succeed in the course, learners in the instructor-led versions performed far superior to the online learners on the problem-solving assignments.

Keywords: Problem-solving measurement, Online courses, Instructor-Led courses

INTRODUCTION

Metropolitan State University of Denver supports a very large undergraduate program as well as a graduate program in several different areas including an MBA. MSU Denver offers a wide range of courses through its College of Business. Many of these courses are taught in an instructor-led conventional classroom format and/or as an online course. In the Computer Information Systems and Business Analytics (CISBA) Department, The Database Management Systems (DMS) course is taught in both the instructor-led and online formats every semester except for the summer session. The courses have identical objectives and expected student outcomes. One important course objective is the ability to respond to user inquiries and create queries run against a database to accurately respond to the inquiries. The creation of these queries is sometimes relatively simply but more commonly they are highly complex requiring the use of highly developed problem-solving skills. A large percentage of the DMS course is devoted to instruction into how to approach, analyze, and construct these queries.

Complex queries can be constructed in a variety of different formats and more than one alternative construct often will produce a correct result. However, some constructs are generally regarded as more "professional" or efficient than others. Learning how to properly approach and write these queries is an art that requires the development of high-level problem-solving techniques.

The online and instructor led versions of the DMS course have identical objectives and both versions required the same expected outcomes. The delivery method for teaching the online and instructor-led versions must differ though. The online version of the course relies on slides developed by the instructor as well as links to focused videos. Online students are not allowed to discuss assignments with other students but are provided with an online multithreaded discussion board allowing for peer interactions. The instructor is always available to the online students through email, phone, and live office hours. Instructor-led students are offered several live demonstrations conducted by the instructor and the instructor is available for in class individual help. Peer interactions are highly common and available in the instructor-led courses.

The problem-solving (query building) parts of the online and instructor-led courses are both assessed by three assignments. The assignments for the instructor-led and online versions are identical for each semester. However, the assignments are modified from semester to semester with the assignments being of comparable length, time required to complete, and difficulty level. Student scores received on these assignments will be the measure of attainment of mastery with respect to the problem-solving objective. Scores earned by the online students will be compared with the scores of the instructor-led students to measure differences in the problem-solving achievement between the two groups. All courses included in this study to develop the data set used were taught by the same instructor. This paper analyzes the problem-solving achievement of students in online sections with the achievement of students in the instructor-led sections of the DMS course for the time period beginning in the fall of 2011 through the fall of 2016. There were eleven semesters in which both the online and instructor-led versions were both taught concurrently.

BACKGROUND AND ANALYSIS

The DMS course is an upper level junior level course that provides the student with a broad background in an important area of the information systems' discipline. It is a required course for all students who major or minor in information systems at MSU Denver. The course

requires "learning" at many levels. Some modules require only basic cognitive skills such as working memory and verbal reasoning. Students must learn the various types of databases and the terminology that is used in describing each. The course also requires the student to develop much higher level, complex skills. Normalizing a set of data from a set of independent user views of the data that require an application of a basic step-by-step process. Students must use this process and make informed judgments at critical points in the process. Reasonable people may be product different results, any of which may be "correct" in the context of the process. The normalization process may be regarded as an example of a critical thought process. Finally, students must master the ability to respond efficiently to inquiries received rom almost anyone. These inquiries can be quite involved and require highly complex problem-solving skills. The DMS course contains a several weeks long module that is designed to teach students how to respond to user inquiries and to learn these complex skills.

Problem-solving has been a goal of educators for a long time. Some have argued that problem-solving is the single, most important goal of education (Ruscio and Amabile, 1999). Problem-solving can be defined in many ways. Anderson suggests that problem-solving is "any goal-directed sequence of cognitive operations" (Anderson 1980, p. 257). Mayer and Wittrock indicate that problem-solving should include a cognitive process, be goal directed, and the difficulty level should depend upon the person's knowledge and skills (Mayer and Wittrock, 1996). On point is the analysis from Shute and Wang that "Complex problems usually combine a mixture of basic rules and rules that require cognitive flexibility–the ability to adjust prior thoughts or beliefs and explore alternative strategies in response to changes in the environment" (Shute and Wang 2015, p.13). Considering the above definitions of problem-solving, the measurement used in the paper are the scores that students receive on a set of three assignments all related to retrieval and manipulation of the data in the tables of the database and the students' ability to response to an extensive variety of inquiries.

MSU Denver offers the DMS course in both an online and instructor-led format. Both the online version and the instructor-led version of the course was taught every semester for the time period used in this study. Although assignments were modified and updated from semester to semester, students in both the online and instructor-led courses were given identical assignments for each semester. The assignments from both the online and instructor-led courses were graded according to an identical rubric. Therefore, the assignment scores of online students would be comparable to the scores of the instructor-led students. The author was the instructor of record for all of the courses reported in this study and graded all of the assignments.

METHODOLOGY

Although both the instructor-led and online versions of the course are required to meet an identical set of objectives and course outcomes, the delivery methods are quite different. The instructor-led version meets twice each week and the primary delivery method is lecture. Students interact with the instructor and with each other. This lecture method is the classic delivery method for a course. For many, sitting through lectures is passive learning. Online students must become far more active learners than their classroom counterparts. Online students are provided a wide variety of resources including detailed slides, extensive reading material, videos, and many examples demonstrating querying techniques. Online students are encouraged to interact with the instructor and with other students on the course discussion page.

The instructor is available to the students by email, text messaging, and phone. Online students are encouraged to visit during the instructor's regularly scheduled on-campus office hours.

The different learning models of instructor-led verses online may be assessed by looking the performance of the two different groups on the problem-solving assignments completed by all of the students. The difference in the means of the two groups are tested for significance using a standard t-test on the difference on the means. The following presents the hypotheses used for testing if the means of the two groups significantly differ.

$$H_0: \ \mu_{il,i,j} - \mu_{ol,i,j} = 0$$

$$H_a: \ \mu_{il,i,j} - \mu_{ol,i,j} \neq 0$$

Where $\mu_{il,i,k}$ i represents the mean of the i^{th} assignment in the j^{th} semester for an instructor-led section and $\mu_{ol,i,k}$ i represents the mean of the i^{th} assignment in the j^{th} semester for an online section.

DATA

Data were gathered from student projects delivered to the instructor over the period fall, 2011 through fall, 2016. The projects required the students to implement two fully designed databases each consisting of six separate tables onto a centrally located Oracle database. The students were required to create the structure of each of the tables and to populate the tables with data. After the databases were created, the students were required to complete three extensive sets of problems and to submit the solutions through Blackboard Learn. Each set of problems was independent of the others and designed to assess proficiency in a particular area. The first assignment required students to construct rather basic *ad hoc* queries that retrieved data from a single table. The second, and probably the most difficult, assignment required students to construct complex *ad hoc* queries that retrieved data from multiple tables. The third assignment required students to create additional database objects, implement security, and write complex statements modifying table data and table structure. All assignments were scored on a 100 point maximum scale with an identical rubric being used for both the online and instructor-led sections. If a student did not complete an assignment, that student was eliminated from the study so there should be no bias for incomplete assignments. Also, in a few situations, a student would complete all of the assignments and then drop the course at a later time. Students who did not complete the course were also eliminated from the study even if they had completed all three of assignments.

Table 1 (Appendix) displays the data for each of the eleven sections of the instructor-led courses. Two hundred and twenty-one students in instructor-led sections participated in this study. The average score, the standard deviation, and the number of student participants in each section are shown for each semester. The third assignment had the highest average score (88.06) and the second assignment had the lowest average score (80.23). The data for the online sections shown in Table 2 (Appendix) include 254 student participants in the eleven online course sections over the time period. The online students demonstrated the highest average on the first assignment (73.17) and the lowest on the (64.97) on the second assignment. Also of note is that the standard deviation is higher for the online sections compared to the instructor-led sections for each of the three assignments and for almost all semesters.

RESULTS

Table 3 (Appendix) displays the results for Assignment 1. In all eleven semesters, the students in the instructor-led sections scored higher than the students in the online sections. The greatest differential in the two versions came in the spring semester, 2013 where the students in the instructor-led section scored almost thirty points higher than the online students. In five of the semesters, the average score of online students were within ten points of the average score of the instructor-led students. The highlighted rows in Table 3 indicate that the difference in average scores between the two groups was statistically significant. Also, the mean (86.37) for all semesters shown in the last row of Table 1 is significantly higher than the overall mean of the online students (73.17). There does not appear to be a trend in the difference in mean scores from fall, 2011 through fall, 2016.

Table 4 (Appendix) displays the results for the second (and most difficult) assignment. In all but one semester, the instructor-led students performed better than the online students. Only in the spring, 2012 did the online students outperform the instructor-led students and they did so by a difference in the mean score of almost eighteen points. In the fall, 2013, instructor-led students performed at a much high level (41.61 points) compared to the online students. However, in the last three years of the study, the differential between the two groups has become very small. In four of the eleven semesters studied, the differential between the two groups was statistically significant. Also, the overall student mean (80.23) shown in the last row of Table 4 is significantly higher than the overall mean (64.97) of the online students.

Finally, Table 5 (Appendix) presents the results for Assignment 3. Assignment 3 had the highest average score for the instructor-led students. In two of the eleven semesters (fall, 2011 and spring 2016), the online students scored a slightly higher mean score than the instructor-led students. However, the instructor-led students generally had a higher mean score. In four semesters, the difference between the mean scores was statistically significant. Also, the instructor-led student mean score for all semesters (88.06) was significantly higher than the online mean score for all semesters (71.44).

CONCLUSIONS

The results of the study clearly indicate that students learn problem solving skills much better when receiving live instruction. Even with the best efforts are made to provide online learners with overwhelming quantities of resources, live, face-to-face interaction with instructors is superior. The difference in the means for Assignment 1 was 13.20 and the difference grew to 15.26 for Assignment 2, and finally the difference rose to 16.62 for Assignment 3. This rising differential in the means of instructor-led learners verses online learners provides some evidence that the differential becomes more exacerbated as the course progresses to high levels of complexity.

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APPENDIX

Table 1
Instructor-Led Assignment Statistics

	Assignment 1		Assignment 2		Assignment 3		
	Average	Std. Dev.	Average	Std. Dev.	Average	Std. Dev.	n
F2016	77.59	30.55	79.48	40.14	86.21	35.09	29
S2016	88.44	16.43	75.00	35.69	75.85	13.03	16
F2015	98.21	4.55	75.00	36.28	80.36	35.94	15
S2015	98.33	2.46	91.25	28.77	100.00	2.46	12
F2014	84.11	30.31	94.46	19.88	93.75	21.71	28
S2014	78.64	38.67	83.41	35.30	85.00	34.85	22
F2013	88.33	20.41	82.92	28.36	90.83	25.52	24
S2013	90.88	17.16	84.71	32.95	88.24	33.21	17
F2012	92.06	9.02	79.12	38.94	92.65	24.63	17
S2012	86.36	20.48	72.27	42.33	95.45	21.32	21
F2011	82.25	26.03	61.75	45.08	78.00	40.47	20
Total n							221
AVERAGE	86.37	24.52	80.23	35.72	88.06	29.01	

Table 2
Online Assignment Statistics

	Assignment 1		Assignment 2		Assignment 3		
	Average	Std. Dev.	Average	Std. Dev.	Average	Std. Dev.	n
F2016	75.43	35.99	72.13	38.27	56.61	49.27	29
S2016	78.44	30.22	74.64	36.37	77.17	40.53	23
F2015	76.96	30.96	73.53	43.16	73.53	45.82	18
S2015	71.70	37.41	65.97	44.63	75.35	41.67	24
F2014	75.54	39.87	71.38	44.58	65.22	44.99	23
S2014	75.00	34.41	65.48	47.75	71.43	46.29	21
F2013	65.04	35.33	41.30	47.37	68.48	46.60	23
S2013	60.96	39.22	50.88	48.58	73.68	45.24	19
F2012	67.28	32.60	55.25	46.52	62.96	49.21	27
S2012	80.07	26.97	90.22	28.94	88.77	30.53	22
F2011	80.50	34.33	57.00	48.03	81.00	37.69	25
Total n							254
AVERAGE	73.17	34.33	64.97	44.34	71.44	43.89	

Table 3
Two Sample T-Test Results For Assignment 1

	Instructor-Led		Online					
	Mean		Mean		Difference			
	$\mu_{il,1,j}$	n	$\mu_{ol,1,j}$	n	$\mu_{il,1,j} - \mu_{ol,1,j}$	T-Value	P-Value	D.F
F2016	77.59	29	75.43	29	2.16	0.25	0.81	54
S2016	88.44	16	78.44	23	10.00	1.33	0.19	35
F2015	98.21	15	76.96	18	21.25	3.43	0.00	17
S2015	98.33	12	71.70	24	26.63	3.47	0.00	23
F2014	84.11	28	75.54	23	8.56	0.85	0.40	40
S2014	78.64	22	75.00	21	3.64	0.33	0.75	40
F2013	88.33	24	65.04	23	23.30	2.75	0.01	34
S2013	90.88	17	60.96	19	29.92	3.02	0.01	25
F2012	92.06	17	67.28	27	24.77	3.73	0.00	31
S2012	86.36	21	80.07	22	6.29	0.88	0.38	40
F2011	82.25	20	80.50	25	1.75	0.19	0.85	42
Total n		221		254				
AVERAGE	86.37		73.17		13.20	4.88	0.00	458

Highlighted rows are significant at alpha = .05

Table 4
Two Sample T-Test Results For Assignment 2

	Instructor-Led		Online					
	Mean		Mean		Difference			
	$\mu_{il,2,j}$	n	$\mu_{ol,2,j}$	n	$\mu_{il,2,j} - \mu_{ol,2,j}$	T-Value	P-Value	D.F
F2016	79.48	29	72.13	29	7.36	0.71	0.48	55
S2016	75.00	16	74.64	23	0.36	0.03	0.98	32
F2015	75.00	15	73.53	18	1.47	0.43	0.67	30
S2015	91.25	12	65.97	24	25.28	2.05	0.05	31
F2014	94.46	28	71.38	23	23.09	2.3	0.03	29
S2014	83.41	22	65.48	21	17.93	1.4	0.17	36
F2013	82.92	24	41.30	23	41.61	3.63	0.00	35
S2013	84.71	17	50.88	19	33.83	2.47	0.02	31
F2012	79.12	17	55.25	27	23.87	1.83	0.07	38
S2012	72.27	21	90.22	22	-17.94	-1.65	0.11	36
F2011	61.75	20	57.00	25	4.75	0.19	0.85	42
Total n		221		254				
AVERAGE	80.23		64.97		15.26	4.16	0.00	472

Highlighted rows are significant at alpha = .05

Analyzing the differences

Table 5
Two Sample T-Test Results For Assignment 3

	Instructor-Led		Online					
	Mean		Mean		Difference			
	$\mu_{il,3,j}$	n	$\mu_{ol,3,j}$	n	$\mu_{il,3,j} - \mu_{ol,3,j}$	T-Value	P-Value	D.F
F2016	86.21	29	56.61	29	29.60	2.63	0.01	50
S2016	75.85	16	77.17	23	-1.32	-0.15	0.89	28
F2015	80.36	15	73.53	18	6.83	0.86	0.40	30
S2015	100.00	12	75.35	24	24.65	2.89	0.01	23
F2014	93.75	28	65.22	23	28.53	2.79	0.01	30
S2014	85.00	22	71.43	21	13.57	1.08	0.29	37
F2013	90.83	24	68.48	23	22.36	2.03	0.05	33
S2013	88.24	17	73.68	19	14.55	1.11	0.28	32
F2012	92.65	17	62.96	27	29.68	2.65	0.01	40
S2012	95.45	21	88.77	22	6.69	0.85	0.40	39
F2011	78.00	20	81.00	25	-3.00	-0.25	0.80	39
Total n		221		254				
AVERAGE	88.06		71.44		16.62	4.93	0.00	444

Highlighted rows are significant at alpha = .05