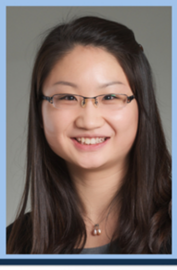

Role of homework, quizzes and i>clickers in student performance: A preliminary analysis for Introductory Chemistry

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Introduction

Learning management systems (LMS) have been used to present course content at the University of Alberta for over 14 years. New technologies, such as online quizzes, online homework and i>clickers, have gradually replaced traditional in-class quizzes. However, the effectiveness of these technologies to enhance learning is not clear.

Goals

1) To investigate if outcomes in online quizzes, online homework and i>clickers correlate with final exam performance.
2) To contrast the above correlation coefficients.
3) To compare the correlation coefficients of quiz outcomes and final exam performance for students with different educational backgrounds.

Previous Work

The effectiveness of online quizzes have been measured by conducting satisfaction surveys.[1] Alternatively, the average final exam grades of students taking online quizzes were compared with those of students who took in-class quizzes.[2] Online quizzes enabled students to control their study pace[1] and saved valuable class time. Moreover, online quizzes increased the exam performance to a level equivalent to that of in-class quizzes, if conducted under conditions that prevented plagiarism.[2]

Using Spearman's rank correlation (R), Kibble reported that voluntary online quizzes scores were significantly correlated with exam performance, $R(37) = 0.67$, $p < 0.01$, in a medical class of 41 students who had at least 4 years of college education.[3]

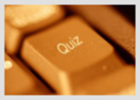
Blanco used Moodle quizzes in 4 mathematics courses for first-year engineering students and performed a linear regression analysis between the mean score of the quizzes and the final exam mark. The analysis displayed a positive linear correlation with correlation coefficients of 0.44 to 0.69 ($p < 0.001$).[4]

Research on the use of clickers in college chemistry showed either enhanced student learning or inconclusive results.[5] For instance, Gebru et al.[6] found students who used clickers or online homework scored 2% higher on a test of long-term content retention than those who did lecture only, but the difference was not statistically significant due to the small sample size.

Our Work

Our data were collected from five introductory chemistry (*CHEM 102/105*) classes taught by two instructors between 2005 and 2012. These classes consisted of 200-450 freshmen and sophomore students with diverse educational backgrounds (science, non-science, and engineering).

Instructor 1 conducted 3 in-class quizzes in Fall 2005 and 4 in-class quizzes in Winter 2005 (**class 1 and 2,** respectively). Two versions of the 10-15 minute in-class quizzes of 5-7 multiple choice (MC) questions were used. The lowest of the 3-4 quizzes was dropped in determining the overall quiz mark.



In 2012 Instructor 1 used online Moodle quizzes (**class 3**). Each of the 9 quizzes consisted of 4-6 MC questions randomly selected from a bank of 5 variants. Students could attempt each 30-60 minute quiz up to twice during a week (90.5% ± 5.1% participation rate, 1.39 ± 0.12 attempts per student). The student received the average mark for the attempts, and the best 7 of 9 quizzes determined the overall quiz mark.

In 2010, Instructor 2 incorporated online quizzes into Blackboard Vista to provide ongoing feedback to students (**class 4**). Each of the 5 quizzes consisted of 4-6 MC and/or numerical questions randomly selected from a bank of 3-100 variants. Students could attempt the 120 minute quiz up to twice during a week (85.1% ± 7.6% participation rate, 1.42 ± 0.04 attempts per student). The student received the highest mark achieved over all attempts.

In 2012 Instructor 2 implemented online Moodle homework and i>clickers. Each of the 5 **online homework** assignments consisted of 4-7 MC and/or numerical questions randomly selected from a bank of 3-100 variants. Students could attempt the 24-hour homework up to twice during homework availability (94.8% ± 3.1% participation rate, 1.67 ± 0.07 attempts per student). The student received the highest mark achieved over all attempts.

The **i>clicker** response system was used to generate a participation mark. Students were not graded on whether their answer was right or wrong. Students received full marks for answering ≥80% of the i>clicker questions down to 0 marks for answering <30% of the questions.

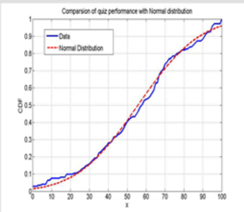
Therefore, there were variations in the question styles, time lengths, number of quizzes and weight of course credit available among these quizzes/homework.

Data Analysis

Pearson Product-Moment Correlation is a standard research method in information technology. It is frequently used to measure the correlation between two variables X and Y, which are measured at the **interval or ratio level** and are **approximately a normal distribution.** It is denoted by *r*, which has a value between +1 and -1. When *r* is close to +1 or -1, there is a significant correlation between variables X and Y.[7]

Table 1: Example of two variables	
Average quiz grades	Final exam grades
7.5	17.00
25.5	20.00
18	26.50
0	29.00
5	32.00
27.5	32.50
33	33.00
21.5	33.50
18	33.50
10	33.50
7.5	35.00
0	35.50
…	…

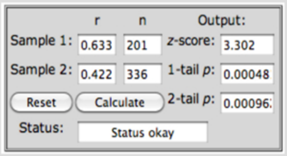
Variables in our study have a numerical value and zero of the measurement indicates that there is none of that variable. They are ratio variables.[7]



The variables in our study are normally distributed. CDF is the Cumulative Distribution Function. It is used to describe the probability of variables in statistics.

Fisher r-to-z Transformation

Fisher r-to-z transformation calculator was applied to assess the significance of the difference between two independent correlation coefficients. The difference between the two correlation coefficients was statistically significant when the z-score (calculated below) has a value that falls outside the range -2 to +2.[9]



Results

The Pearson Product-Moment Correlation (*r*) between the quiz item and the final exam are summarized below. The number of degrees of freedom are shown in parentheses. (# of degrees of freedom = sample size – 2).[8]

Table 2. Correlation of online quizzes/homework and in-class quizzes

Quiz item	r (degrees of freedom)
In-class quizzes[a]	0.633 (199) ……class 1
	0.422 (334) ……class 2
Online quizzes	0.613 (368)……class 3
	0.715 (169)……class 4
Online Homework	0.553 (282)
i>clickers	0.283 (282)

a) Data for in-class quizzes used as an example in Fisher r-to-z transformation in Data Analysis section.

Since the sample size varies among the above correlation coefficients, z-scores were determined to test for statistically significant differences.

Table 3. Z-Scores for the above correlation coefficients [a]

	In-class C1	In-class C2	Online C3	Online C4	Online Homework
In-class C1	-	-	-	-	-
In-class C2	**3.287**	-	-	-	-
Online C3	0.369	**3.473**	-	-	-
Online C4	1.431	**4.702**	1.971	-	-
Online Homework	1.327	**2.123**	1.145	**2.802**	-
i>clicker	**4.887**	1.959	**5.316**	**6.186**	**3.918**

a) Data shown in bold have z-score[9] |z| > 2

As the CHEM 102/105 classes contain a diverse student population, correlation analysis was also performed based on student program.

Table 4: Correlation for students in different programs [a]

	Non-Science	Science	Engineering
In-class quizzes	0.675 (54)…c1	0.647 (103)…c1	0.507 (38)…c1
	-0.013 (34) …c2	0.490 (148)…c2	0.432 (152)…c2
Online quizzes	0.650 (57)…c3	0.598 (309)…c3	-
	0.711 (22)…c4	0.714 (145)…c4	-
Online Homework	0.650 (32)	0.497 (247)	-
i>clickers	0.153 (32)	0.305 (247)	-

a) Data shown in bold have z-score[9] |z| > 2.

Discussion

1. Correlations between all evaluative methods and final exam performance are comparable to previous research.[4]

2. Poorer correlation was observed for in-class quizzes class 2 relative to class 1 (*Table 2*).
   - More experienced student body in class 1 (off-sequence vs. traditional sequence)
   - Experienced students have learned that keeping up-to-date in class is important and every mark counts

3. Both online quiz scores significantly correlated with final exam performance (*Table 2 and 3*).
   - The flexibility of online quizzes enables students to engage more readily
   - This is consistent with previous findings[1] based on satisfaction surveys.

4. Online quiz (class 4) and online homework had essentially the same content. However, there is a statistically significant difference between student performance *(Table 3*).
   - Longer time scale for homework (24 hours vs. 1-2 hours)
   - Ability to share questions and to look up answers.

Online style	Average for Quiz or Homework	Average for Final Exam
Quiz	64.6%	62.4%
Homework	78.7%	64.7%

   - Reaffirms the importance of designing online evaluations to avoid plagiarism, as concluded previously.[2]

5. The rate of i>clicker participation correlates poorly with final exam performance (*Table 2 and 3*).
   - Attendance is encouraged but not deeper understanding
   - Greater engagement (and understanding) may be achieved via group learning strategies.[5] Requires rethinking of course content.

6. There are no statistically significant differences in the correlations for students with different educational backgrounds, except for in-class quiz class 2 (*Table 4*).
   - In-class quizzes require high levels of class participation and commitment.
   - May be challenging, especially for those outside their major study area. Online tools may alleviate this barrier.

Conclusions

- Students' attitude to the quizzes is a key element to make the quizzes become an effective teaching tool (e.g., in class quiz class 1 vs. class 2).
- Format of presentation can significantly affect the correlation with final exam performance (e.g., content of online quizzes for class 4 vs. online homework was nearly identical but time for completion was different).
- Online tools are an excellent format to facilitate student learning.

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Acknowledgments

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