Assessment of Student Learning in Undergraduate Engineering Courses Using Quizzes In Lieu of Homework

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Assessment of Student Learning in Classes Utilizing Regular Quiz Schedules in Lieu of Regularly Collected Homework Assignments

Abstract

The paper is an Evidence-Based Practice Paper that presents the justification and challenges of a group of instructors in a mechanical and civil engineering program at the University of Evansville, located in Evansville, IN. During a multi-year study in undergraduate engineering courses, the effectiveness of daily homework assignments is investigated and a comparison of an alternative "quiz only" approach is made for undergraduate basic mechanics and pre-engineering classes including statics and dynamics. Results of a course offering a hybrid quiz and homework approach are then explored.

Effective teachers continue to search for evidence that the topics they teach are being easily received and clearly processed by their students. In recent years, as student behaviors have changed and access to information has become more mainstream, teachers are faced with new challenges to classical learning techniques. Educators at engineering universities across the United States have employed a variety of different ideas related to homework and quizzes in their attempts to improve student learning. A specific comparison of cohort groups that have progressed through basic engineering classes such as statics and dynamics into upper-level major specific classes such as soil mechanics are also presented. Several cohorts starting as freshmen in statics and progressing through upper-level design classes provide a broad overview of the impact of this teaching pedagogy.

Comparisons and correlations for each of these approaches are made to their corresponding in-class exams. Potential improvements as well as current limitations to this study are then revealed.

Introduction

The traditional method for most engineering course instructors is to assign a handful of problems based on the current topics for each class period and then collect the students' worked solutions at the beginning of the following class. This method then requires the grading of multiple problems, which can be a very time consuming process.

These days, electronic resources available on most campuses provide an easy means to deliver content to students outside of the classroom. Common educational software packages allow instructors to easily provide assignments, host discussion forums to answer questions, or even record grades in a manner that is readily accessible to students. With this technology, students are able to track their performance scores in real-time and obtain access to materials posted by

the instructors. However, the common availability of the internet has also provided opportunities for alternative resources to be supplied to students that can actually undermine a teacher's control of information and may encourage unscrupulous homework behavior. Of particular concern is the ease at which students are able to procure solution manuals to common textbooks and solution keys for assignments. While students often argue in favor of being able to use solutions to check their work as part of the learning process, the temptation to blindly copy homework without fully understanding all of the concepts may become too great for even the most noble of students to resist. This situation is further exacerbated when instructors choose to base a percentage of a student's overall grade on points awarded from homework assignments. This leaves instructors with only a limited number of options, among which include: continue collecting homework from preprinted sources as has been done historically, create custom homework assignments from scratch for each class, or eliminate mandatory homework altogether. Creating custom homework can definitely eliminate the problem with online solutions. However, this places an extra burden on the instructor who wishes to create meaningful assignments. Eliminating homework, or simply making it optional, can present its own set of difficulties. Without homework being assigned, students may tend to lose focus on their learning, whether through prioritization of assignments that are deemed more urgent or through simple procrastination in doing the requisite work on a regular basis.

At the University of Evansville, some engineering faculty members within the Department of Mechanical and Civil Engineering have opted to eliminate homework as a requirement for course grades. Instead, recommended problems are given for every class period, and solutions to all of these problems are made available immediately. By choosing this method, the faculty members have been able to increase the number of problems that students are expected to study and understand prior to the next class period by almost 40%. To keep students accountable and on track, weekly quizzes are then held over the same topics as these recommended homework assignments. For most classes, these quiz scores replace homework scores in computing a portion of a student's final grade. Typically, the scores of all quizzes combined have approximately the same weight as each of the semester exams.

Literature Review

Over the past several decades, methods of student learning have changed. Despite the long history of research on the use of homework, the role it plays in enhancing student achievement is, at best, only partly understood (Trautwein and Koller, 2003). Direct assessment of homework assignments is limited by a lack of knowledge of the conditions under which homework assignments are completed. This uncertainty can be due to a number of factors such as availability and utilization of assistance from peers, known problem solutions and answer keys, online help, and even help from the instructors themselves may lead to the student being able to submit correct solutions without understanding the material. In order to remove these uncertainty factors from measuring overall performance, the alternative use of a quiz only approach, whether

they be unannounced “pop” quizzes or even prescheduled, is an idea among educators that seems to be gaining traction in teaching and assessment pedagogy.

Educators have suggested a long list of both positive and negative consequences of homework through research (Warton, 2001). However, a definitive relationship between the amounts of time a student spends in completing required homework assignments and their overall academic achievement has never been fully clarified through research (Dettmers et al, 2009). In fact, as part of a study conducted at the U.S. Military Academy (Bronikowski et al, 2011), graded homework was eliminated and replaced with study problems and quizzes in three electrical engineering courses. After looking at the student performance, the authors suggest replacing homework altogether with in-class quizzes.

In a research study conducted by Friess and Davis (Friess and Davis, 2006), homework was assigned and solutions were posted for student access in three different engineering classes (Integrated Engineering, Strength of Materials, and Dynamics). By tracking user access statistics on these posted solutions, the authors discovered that students accessed the information infrequently. They cite that over the course of a full semester with 11 graded homework assignments, solutions were only downloaded a total of 13 times. Even in the few instances where the students actually downloaded the solutions, they found that it was often weeks after assignments had been returned and would have had little value in closing the loop on understanding and learning from their mistakes. The authors conclude that students do not value homework as an effective study tool. Upon introducing the quizzes, they noticed that access patterns to posted solutions changed drastically.

In a semester long study conducted at the Florida Atlantic University (Lura et al, 2015), rather than directly grading assigned problems, a random problem was selected from the assigned homework set and used for a quiz during the following class period in an engineering mechanics course. Motivation for this research was generated by negative feedback from students in respect to the difficulty and time spent on homework and a lack of correlation between homework, quizzes, and exams in the class. The research proved that the students’ performance via frequent quizzes had a greater correlation with exam performance than did graded homework assignments. In a subsequent study conducted at the same institution (O’Neill et al, 2016), online software that offered randomized homework values, automatic grading, and tutorials was used in the same course. Following this study, the authors concluded that there was actually a stronger positive correlation between quizzes and exams than between online homework and exams.

Another study conducted at the California State University Long Beach (Farraji, 2012), showed that switching from traditional homework assignments to weekly quizzes, increased grades, time spent on homework, and student perceptions of learning. Similarly a civil engineering multicourse study at the University of the Pacific (Fernandez et al, 2006) explored relationships between individual student grades in homework, quizzes, tests and final examinations in four different undergraduate civil engineering courses taught by three different, full-time faculty.

Their data indicates a very weak correlation between homework and test scores when compared to a much stronger correlation between quizzes and exams. In fact, the use of quizzes has been established as an effective tool for assessment and encouragement of self-directed learning (O'Neil et al, 2016).

In this paper, a team of faculty members in the Department of Mechanical and Civil Engineering at the University of Evansville have undertaken a similar, multi-year study, in an attempt to further quantify and support the findings of these studies.

Method and Study Parameters

Data from three different courses in the Mechanical and Civil Engineering curriculum were collected for this study. Table 1 contains information regarding the study parameters and the three instructors (listed as A, B, C) associated with each course included in this semester. For each of the courses in this study, there are typically 3-4 exams each semester, approximately 20-25 homework assignments and 8-10 quizzes. Average enrollment for ENGR prefix classes is approximately 20 students per section. For CE prefix classes, the average enrollment is approximately 16 students per section. For all classes, data from students that retake a course multiple times are included in the section in which they appear.

Table 1 – Study Parameters

Course Title	Students	Study Semesters	Instructors
ENGR212 – Statics	290	15	A, B
ENGR213 – Dynamics	42	3	B
CE338 – Soil Mechanics and Soil Behavior	81	6	C

Assessment Methods

For the courses included in this study, Instructor A has ten years of teaching experience, Instructor B has two years of experience, and Instructor C has ten years of experience.

Quiz-Only Methods

In this study, data was gathered that related performance on groups of quizzes that were immediately related to corresponding exam material. For example, in a typical ENGR212 quiz-only course, prior to a student taking Exam #1, three quizzes over similar content would have been taken. The average score of this group of quizzes is then divided by the average score of the corresponding exam to compute a single ratio value.

Homework-Only Methods

Homework-only methods are similar to the quiz-only methods, with the exception that the homework averages prior to a corresponding exam were used to determine a single ratio value. In this assessment methodology, no quizzes were used.

Hybrid Methods

The hybrid-methods were used in all three classes included in this study for at least one semester. In these class-sections, both the quiz-only methods and the homework-only methods were used to compute ratio values. However, for hybrid methods, the quiz / exam ratio and the homework / exam ratio were computed separately. This allowed for comparison of results between the hybrid sections and non-hybrid sections directly, while also studying the effectiveness of these methods in comparison to each other within the same class.

Description of the Courses

- *ENGR212 (Statics)* is a semester long, three credit-hour course typically taken either in the spring semester of the freshman year, the summer semester between freshman and sophomore years, or the fall semester of the sophomore year by civil and mechanical engineering students, and by junior level electrical engineering / computer science students. The data contained in this study is gathered from two professors: one having taught the course for more than ten years and the other for the past two years. In total, 290 students have taken ENGR212 from these two professors since the Spring 2011 semester. In this study, nine semesters were quiz-only semesters, 5 semesters were homework-only, and a single hybrid semester was included in Fall 2016.

  In Fall 2015 and Fall 2016, both instructors A and B taught this in consecutive hours on the same days of the week. In Fall 2015, both instructors chose a quiz-only approach for assessment. However, in Fall 2016, Instructor A taught the course as a quiz-only approach and Instructor B taught the course as a hybrid quiz and homework approach. This was done intentionally to investigate any possible differences between the two approaches for this class. All quizzes and exams for these two semesters were designed by both instructors together and the homework problems were drawn from the same pool of textbook problems. Special attention was given to ensure that both sections proceeded at the same pace and covered the same material on any given day. Instructor B chose to select one of the problems from the common pool at random for grading during every class.

- *ENGR213 (Dynamics)* is a semester long, three credit-hour course typically taken immediately following ENGR212 (Statics) by sophomore level students by mechanical and civil engineering students. This course is offered in the fall and spring semesters,

with a summer session in this study offered during the summer of 2016. The data contained in this study is gathered from one professor over one spring, one fall, and one summer semester. In total, the performance of 42 students is included in this study. In this course, one semester was homework-only, one semester was quiz-only, and a single hybrid semester was offered during Summer 2016.

- *CE338 (Soil Mechanics and Soil Behavior)* is a semester long, three credit-hour course typically taken during the spring semester of the junior year by civil engineering majors. All students in this class would have already successfully completed ENGR212 (Statics) and ENGR 213 (Dynamics) prior to enrolling in this class. The data contained in this study is gathered from one professor over the course of the study (since 2011). In total, 81 civil engineering students are included in this study. In this course, all six semesters were hybrid semesters in which both homework and quizzes were utilized to assess student learning.

Results

This section contains the results of the study for all three courses. For each course, a simple ratio was determined using the assessment methods discussed earlier. The results of each of the courses in this study are contained in Tables 2, 3, and 4. In addition, quiz-only and homework-only data were plotted for comparison in Figures 1, 2, and 3. In the corresponding figures, a reference trend line is also placed from the points (0, 0) to (100,100), which corresponds to a single-value ratio of 1.0. Points that plot above and to the left of this trend line indicate a single ratio value that is less than 1.0 (exam average was higher than the corresponding data point) while points that plot below and to the right of this trend line indicate a single ratio value that is greater than 1.0 (exam average was lower than the corresponding data point). In addition, the overall exam averages are also compared for each of the study methods.

Course Data Comparison

ENGR212 (Statics): For this course, nine semesters of quiz-only courses, 5 semesters of homework-only courses, and one semester of the hybrid-method are included. A plot of both the quiz average vs. exam average values and the homework average vs. exam average are plotted in Figure 1. For the quiz-only method (29 data points), the average single ratio value for all quiz / exam ratios was 0.940. For the homework-only method (18 data points), the average single ratio value for all homework / exam ratios was 1.207. For the hybrid-method, the quiz / exam ratio was 0.906 and the homework / exam ratio was 1.140.

ENGR213 (Dynamics): For this course, one semester each of quiz-only, homework-only, and hybrid-method are included. A plot of both the quiz average vs. exam average values and the homework average vs. exam average for all methods are plotted in Figure 2. Likewise, a linear trend line for the overall average ratio of all homework / exam pairs is also included. Numerical

results of these trend line values are contained in Table 4. For the quiz-only method (4 data points), the average single ratio value for all quiz / exam ratio was 0.905. For the homework-only method (4 data points), the average single ratio value for all homework / exam ratio was 1.103. For the hybrid-method, the quiz / exam ratio was 1.011 and the homework / exam ratio was 1.049.

CE338 (Soil Mechanics and Soil Behavior): For this course, six semesters of hybrid-method courses are included. A plot of both the quiz average vs. exam average values and the homework average vs. exam average are plotted in Figure 3. Likewise, a linear trend line for the overall average ratio of all homework / exam pairs is also included. Numerical results of these trend line values are contained in Table 4. For the hybrid quiz / exam ratio (18 data points), the average single ratio was 0.887. For the hybrid homework / exam ratio (18 data points), the average single ratio value for all homework / exam ratios was 1.009.

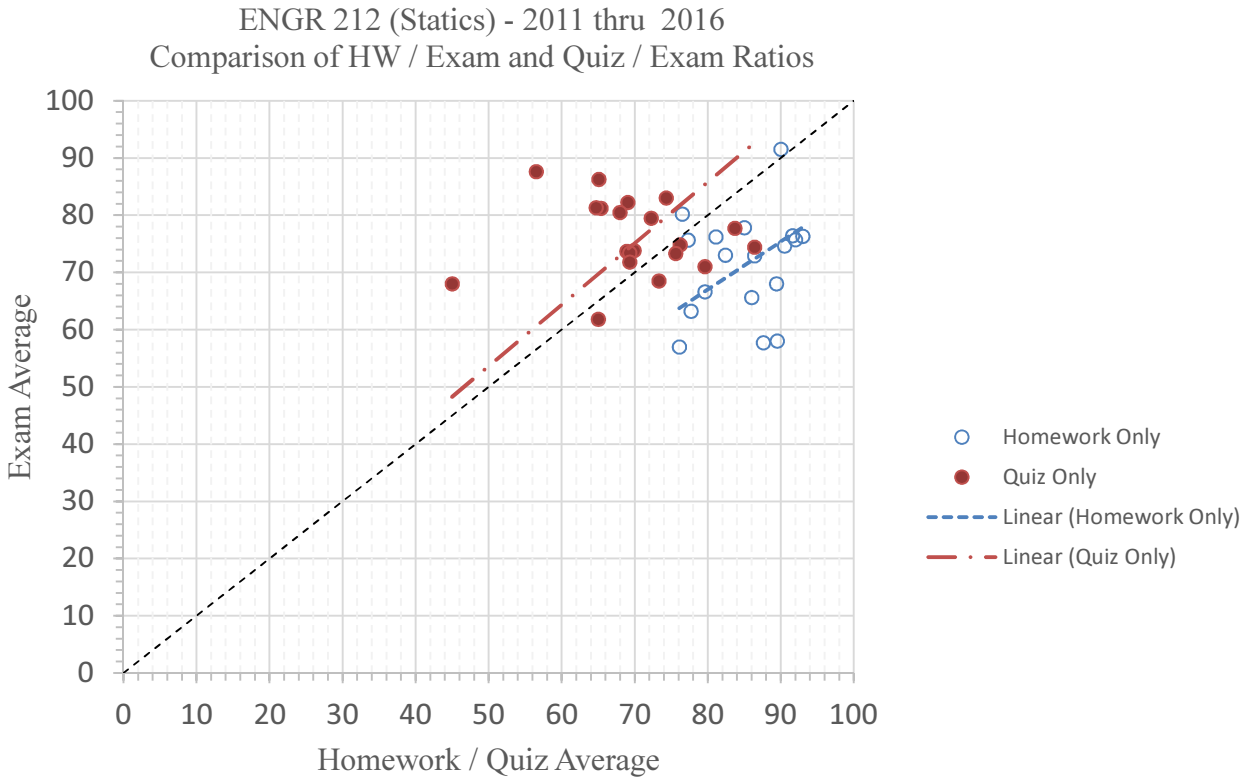

Figure 1: Plot of HW / Exam and Quiz / Exam Ratios for ENGR212 (Statics)

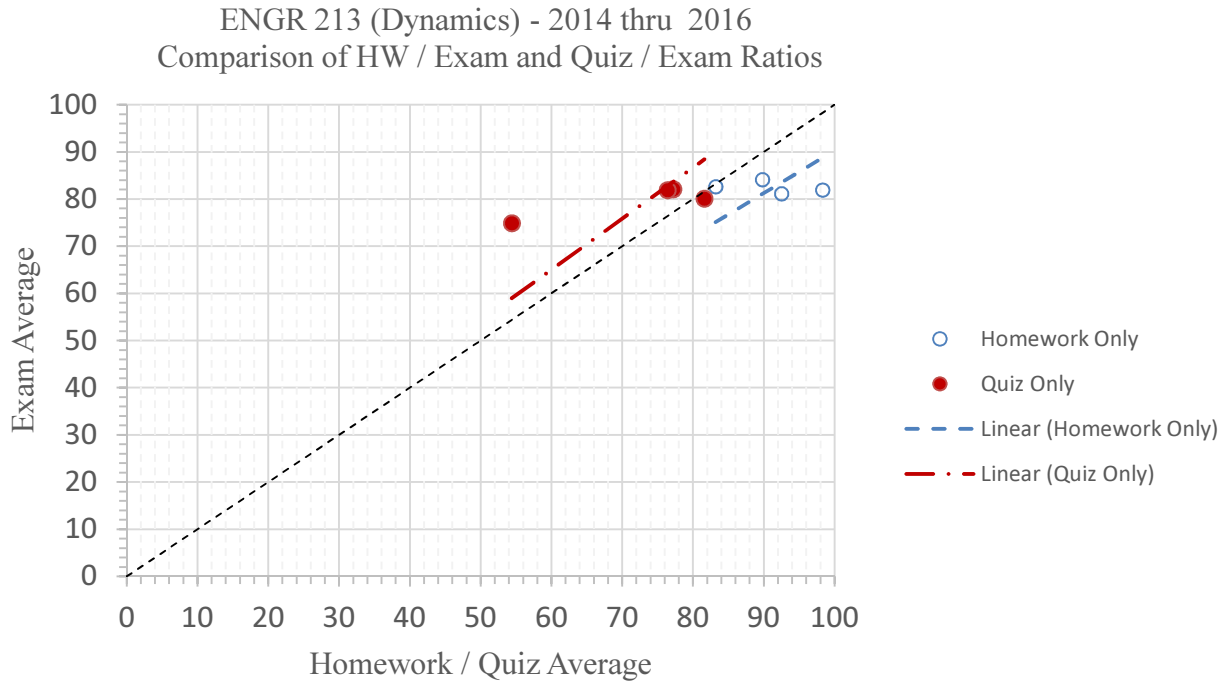

Figure 2: Plot of HW / Exam and Quiz / Exam Ratios for ENGR213 (Dynamics)

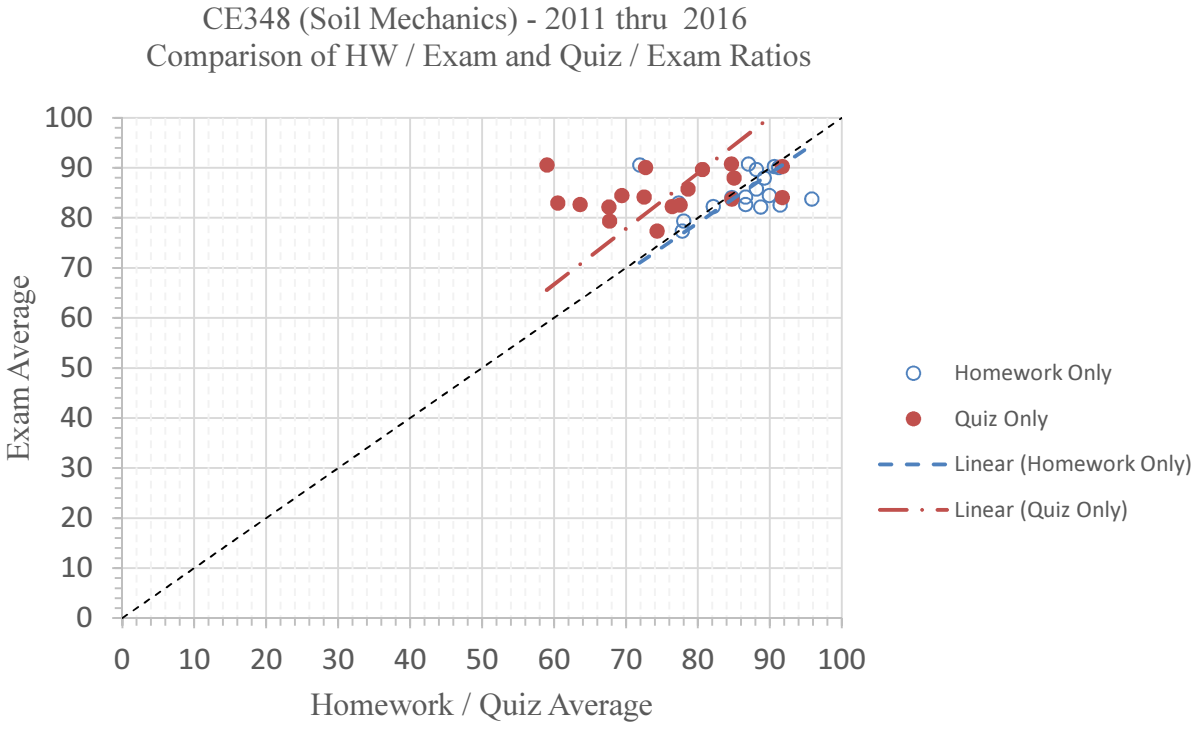

Figure 3: Plot of HW / Exam and Quiz / Exam Ratios for CE348 (Soil Mechanics)

Methodology Comparison Within Courses

Table 2 contains the data for the courses that utilized the homework-only method of assessment. In this table, the HW / exam ratios (1.207 and 1.103) for all courses (ENGR212 and ENGR213) were greater than 1.0, indicating that homework averages were higher than the corresponding exam average.

Table 2 –HW Only Method Semester Results

Course Title	HW Only Semesters	HW / Exam Ratio	Exam Average
ENGR212 – Statics	5	1.207	71.5
ENGR213 – Dynamics	1	1.103	82.5

Table 3 contains the data for the courses that utilized the quiz-only method of assessment. In this table, the Quiz / Exam ratios (0.940 and 0.905) for all courses (ENGR212 and ENGR213) were less than 1.0, indicating that quiz averages were consistently lower than the corresponding exam average.

Table 3 – Quiz Only Method Semester Results

Course Title	Quiz Only Semesters	Quiz / Exam Ratio	Exam Average
ENGR212 – Statics	9	0.940	77.3
ENGR213 – Dynamics	1	0.905	79.8

Table 4 contains the data for the courses that utilized the hybrid method utilizing both quizzes and homework for assessment. In this table, the HW / Exam ratios (1.140, 1.049, and 1.009) are consistently higher than 1.0, as was seen in the HW-only data of Table 2. Likewise, the Quiz / Exam ratio (0.906 and 0.887) for ENGR212 and CE338 are consistently less than 1.0 as seen in the Quiz-only data of Table 3. However, in the case of ENGR213, the ratio was 1.011, which was only 1.1% higher than the 1.0, but it was consistently less than the HW-only approach.

Table 4 – Hybrid Method Semester Results

Course Title	Hybrid Semesters	Quiz / Exam Ratio	HW / Exam Ratio	Exam Average
ENGR212 – Statics (Fall 2016)	1	0.906	1.140	80.1
ENGR213 – Dynamics (Summer 2016)	1	1.011	1.049	80.6
CE338 – Soil Mechanics and Soil Behavior	6	0.887	1.009	85.6

Potential Issues

Statistical Sensitivity: Perhaps one of the more significant issues with this study may be in the number of data points collected. At larger institutions, the pool of data can be significantly larger as multiple sections with many more students enrolled per section may be offered. At the University of Evansville, during each Fall semester, two sections of ENGR212 with approximately 25 students are offered, while in the spring and summer semesters, only one "trailer" section is offered, usually with smaller numbers of students enrolling. In each Spring semester, two sections of ENGR213 with approximately 25 students per section are offered. Additional trailer sections of ENGR213 are offered during the summer and fall semesters. Major specific courses such as CE338 are offered once per year, with only one section. Enrollment in these courses depends on the major cohort size at the time; varying from as low as 8 to as many as 18 in a given semester in the case of CE338.

Summer versus Non-Summer Semester Classes: At the University of Evansville, courses offered during the Fall and Spring semesters meet three days per week for 16 weeks, for 50 minutes each. Summer sessions meet five days per week for 5 weeks, for 75 minutes each. Total contact time for both semesters is the same for each term. However, it is possible that the expedited time frame of a summer class could have impacted the results of this study. Summer classes typically have fewer quizzes (5-6) and tests (2-3) in comparison to the same course offered during a normal fall or spring semester. It could also be argued that during a summer semester, a typical student takes fewer classes with less out-of class time between sessions and is more immersed in learning the course material. Additional data points for summer classes may help to further support the trends that are currently being observed.

Quiz and Exam Difficulty Comparison: Any time multiple professors are involved in student assessment of the same course, it may be possible for different standards to be applied. In this study, for ENGR212, both instructors A and B went to great lengths to minimize this variance. The instructors met on most days when classes were offered to discuss progress and topics that were going to be covered. They also met extensively while creating quizzes and exams to standardize a common assessment tool and meaningful evaluation rubrics that would be fair to both classes, regardless of instructor or methodology used.

Conclusions and Recommendations

In this study, three methods of student assessment are included for two freshman / sophomore level courses and one junior level course over the past six years. This section compares and contrasts the findings of this study and provides ideas for future research.

1. **Single-value Ratios Decrease with Quizzes:** Table 5 shows a summary of the single-value ratios for each of the methods used in each course of this study. Single-value ratios for quiz-only or hybrid quiz-only approaches were consistently 15-20% lower than their

homework counterpart scores. In all cases, homework-only average scores were consistently higher than their corresponding exam averages (greater than 1.0).

Table 5 – Overall Single-Value Ratios (Quiz / Exam or HW / Exam)

Course	Quiz-Only	Hybrid-Quiz Only	HW-Only	Hybrid-HW Only
ENGR212	0.940	0.906	1.207	1.140
ENGR213	0.905	1.011	1.103	1.049
CE338	N/A	0.887	N/A	1.009

2. **Segregated Data Groupings:** Figures 1, 2, and 3 show that the data points for quiz average versus exam average and homework average versus exam average are highly segregated with only minimal overlap of the data groups for all three courses.

3. **Significant Improvement on ENGR212 Exam Performance:** Tables 2, 3, and 4 show that overall exam average for ENGR212 was significantly improved by the quiz-only approach (77.3) when compared with the homework-only approach (71.5). The hybrid-approach produced an even higher exam average (80.1) than either of the quiz-only or home-work only methods. The authors concede that it is logical to argue that student performance should naturally improve when they are exposed to additional content. By collecting homework in addition to quizzes, students may experience an increased sense of urgency in staying up to date with their assignments. However, with only one set of data, the authors feel that it may be premature to ascertain if the improved exam average is due to the hybrid methodology only or if the class is a higher performing cohort of students than other sections included in the study.

4. **Format of Quizzes:** Table 5 shows that despite the type of quizzes given, the quiz / exam ratios are consistently less than 1.0, and are consistently less than the homework / exam ratios in the same classes.

The authors believe that this study provides a good basis of data that supports the quiz-only idea proposed by researchers at other universities. In the future, data from additional undergraduate basic engineering courses and major-related courses will be incorporated to help further validate this methodology. In addition, correlating this data to results observed on standardized tests such as the FE exam may shed additional light on the effectiveness of a quiz-only approach for student learning.

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