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Does Homework Matter? A University Case Study on the Effect of Doing Homework on Final Exam Scores

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***Abstract* – With the recent advent of sophisticated online and remotely accessible educational technology, prevalent even before its rapid acceleration due to the COVID-19 pandemic in 2020, the revolution in the contemporary university classroom is only getting started. The true transformation is most likely still ahead, and its eventual form is a source of spirited debate in administrative boardrooms across the nation. In light of all this, it is worthwhile to revisit the age-old question: *Does Homework Matter?* As a small step towards answering this large question, in this paper we report the results of a case study conducted at a large research-intensive university in the western United States on the effect of doing homework on final exam scores. The study was inspired by observing the high level of engagement and enthusiasm shown by students participating in adaptive team-based online in-classroom quizzes, a method of active learning. Our findings indicate that the statistical explanatory power of adaptive team-based quizzes is far greater than that of traditional homework problems, as measured by the classical coefficient of determination. We conclude with a comprehensive discussion of several explanatory factors of this compelling result and propose future directions for this exciting area of research.**

***Keywords* – Active Learning, Homework, Team-Based Learning, Adaptive Learning, Remote Teaching.**

I. INTRODUCTION

Homework has traditionally been considered as a widespread and common instructional strategy to improve daily educational activity. Harris Cooper, a well-known and prolific scholar on homework defined it as follows: "Homework can be defined as any task assigned by schoolteachers intended for students to carry out during non-school hours" [1]. Interestingly, the usefulness and effectiveness of homework, and how much to assign, has been a heated polarized debate for many decades [2].

In the mid 20th century, some critics were questioning the role of homework and its value in improving student learning. In his critique published in the Encyclopedia of Educational Research, H.J. Otto [3] stated that "compulsory homework does not result in sufficiently improved academic accomplishments to justify retention."

This sentiment quickly changed after the Soviet Union shocked the world by launching the world's first successful artificial satellite Sputnik in 1957 ahead of the United States of America, immediately calling into question the preparedness of young Americans to compete with Russians in new technological developments during the Cold War era [4]. This spurred a movement towards increased homework loads with the goal of strengthening education in the United States of America. Since then, the pendulum has swung back and forth in regard to the effectiveness of homework on student achievement.

There is extensive literature in the recent years endorsing homework for students, specifically in early education. Long-term meta-analyses conducted in [5] and [6] both demonstrated an overall positive relationship between homework and achievement. Additional studies support the positive relationship between homework

accuracy and exam performance [7], [8] and between homework performance and success on standardized exams [9]. Emerson [10] found that students who were assigned required homework had higher achievement, as measured by exam performance, in comparison to students who were not assigned required homework. Lastly, several studies revealed that performances on homework may be a strong predictor of students' success, specifically in mathematics [11], [12].

In contrast, many critique homework assignments claiming that research has not proven that homework is effective [13] and that too much time on homework may lead to increased stress, health problems, a lack of balance in life [14], and disruptions in family time [15]. Back in 1968, Wildman claimed: "whenever homework crowds out social experience, outdoor recreation, and creative activities, and whenever it usurps time devoted to sleep, it is not meeting the basic needs of children and adolescents" [16]. Kralovec & Buell [17] claim that homework creates overly competitive students, overburdening them with workloads that is detrimental to personal and social well-being. Other studies conclude that homework should not be completely abandoned but employed effectively by improving instructional quality [18].

Despite the disagreement between educators and researchers about the effectiveness of homework, active learning has recently emerged as a more potent solution associated with positive educational outcomes. Active learning is a teaching method whereby students are directly involved in the learning process and are engaged in the material to be studied through various meaningful methods [19]. Students are encouraged to collaborate and interact with each other, ask questions, solve problems together and work as teams. Specifically for STEMM (Science, Technology, Engineering, Mathematics and Medicine) specialties, it has been shown that active learning increases engagement and learning [20]-[22]. Team-based learning (TBL), a specific active learning method, incorporates small groups into a large group setting [23], [24] and welcomes participation and collaboration to solve problems. TBL is associated with positive educational outcomes with regards to knowledge acquisition, participation, engagement and team performance [25].

In this paper, we perform a retrospective review of data comparing student test scores on homework and team-based quizzes to final examination scores, comprising a total of 135 students over 2 academic quarters. Based on our understanding of the literature on active learning, we examine the hypothesis that active learning performance in the form of adaptive team-based quiz scores may be a better predictor of final examination performance as compared to homework scores.

II. METHODOLOGY

Student performance data for the introductory math finance class at a large research-intensive university in the western United States was meticulously collected over the course of two distinct 10-week quarters during the Fall of 2019 and Winter of 2020. The course required the students to complete 8 homework assignments, 5 adaptive team-based online quizzes taken during class, a midterm exam and a final exam. The final exam material was cumulative, testing the students on the subject matter presented during the entire 10-week period.

The 8 homework assignments were all completed individually by each student, at home, each with a 1-week deadline for completion. The 5 adaptive team-based online quizzes were given approximately every other week during the 10-week quarter in class, with a 50-minute duration.

The quizzes were administered online, and auto-graded instantaneously once submitted. The quizzes were

adaptive in nature as the difficulty week-to-week was dynamically adjusted in accordance with students' quantitative and qualitative feedback. The quizzes were structured to test the students on material presented in the previous 4 lectures, shifting the composition of the time spent in class to 24 lectures, 5 online quizzes, 1 midterm exam and 1 final exam. The students were allowed to form their own quiz teams of 2 to 3 students per team to collaborate and take the quizzes together on the quiz days, fully open book, open notes, and free to use the internet. Over the first few weeks, teams learned to split up the questions between the team members and then share answers, checking each other's work. There may have been reduced anxiety in the team collaborative effort, compared to a solo quiz-taking effort, and this may have improved students' ability to calmly solve the mathematical problems. Over time, the teams were allowed the option to merge, and some did naturally and organically with various competitive strategies to improve performance.

A final score was computed for each student at the end of the quarter, as a percentage-weighted combination of their homework assignments, quizzes, and midterm/final exams. In this study, the percentage-weight for homework was 10%, the percentage-weight for team-based adaptive quizzes was 20%, and the percentage-weight for the midterm and final exams was 70%. In this case, for a student who averaged 90% on homework, 80% on quizzes, and 80% on both the midterm and final exam, the final score S would be computed as

$$S = 0.10 * 90 + 0.20 * 80 + 0.70 * 80 = 81 \quad (1)$$

The final letter grade is determined based on a curve considering this final score and the department's suggested grade distribution, from the instructor's manual, as follows: 20% A, 25% B, 30% C, 15% D and 10% F.

The data set included each of the 8 homework scores for each student, from which the average homework score could be easily computed. Similarly, the individual quiz score data was included, so the average quiz score could easily be computed for each student. These two metrics, along with each student's final exam score, complete the data set used in this study.

III. RESULTS

A summary of the results of a linear regression analysis using the least squares method on the data described in the previous section is summarized in Table 1 and depicted in Fig. 1 and Fig. 2.

Table 1. Summary of linear regression analysis.

Variable	0^{th}-Order Coeff.	1^{st}-Order Coeff.	R-square	F stat	Estimate for Error Variance
Team Quiz Average Score	4.15	0.82	0.2876	53.69	275.33
Homework Average Score	39.14	0.44	0.1413	21.89	331.85

In Fig. 1, we provide a scatterplot of the 135 data points corresponding to the homework average score and final exam score pairs, with each blue circle representing one student data point. In Fig. 2, we similarly provide a scatterplot for the adaptive team-based quiz average score and final exam score pairs for each of the 135 students.

Visual inspection of Fig. 1 and Fig. 2 shows that the linear model fits the data better for the team-based quizzes than for the homework. This is quantified by the estimates for error variance provided in the right-most column of Table 1. More specifically, the estimate for error variance for the team-based quizzes is 275.33, while

the estimate for error variance for the homework is 331.85. This corroborates with the idea that the linear model is a better fit for the team-based quizzes than for the homework.

The R-square, or the statistical coefficient of determination, is provided in Table 1 for both the team-based quizzes and for the homework independent variables with the final exam score as a dependent variable. The R-square metric is simply the sample correlation coefficient squared. R-square varies between zero and one. To be clear, a homework R-square value of 0 indicates that the student performance on homework has no effect on the final exam scores. A homework R-square value of 1 indicates that the student performance on homework completely determines the final exam scores. A homework R-square of 1 allows us to perfectly model the final exam score based on the homework performance.

In our data set, a homework R-square value of 0.14 implies that only 14% of the variability of the final exam scores has been accounted for by the performance on homework, and the remaining 86% of the variability is still unaccounted for. On the other hand, the team-based quizzes R-square value of 0.28 implies that 28% of the variability of the final exam scores in our data set has been accounted for by the performance on team-based quizzes, and the remaining 72% of the variability is still unaccounted for. The strength of the statistical correlation of the team-based quiz performance with the final exam scores is double that of the homework performance. This is the major contribution of this paper.

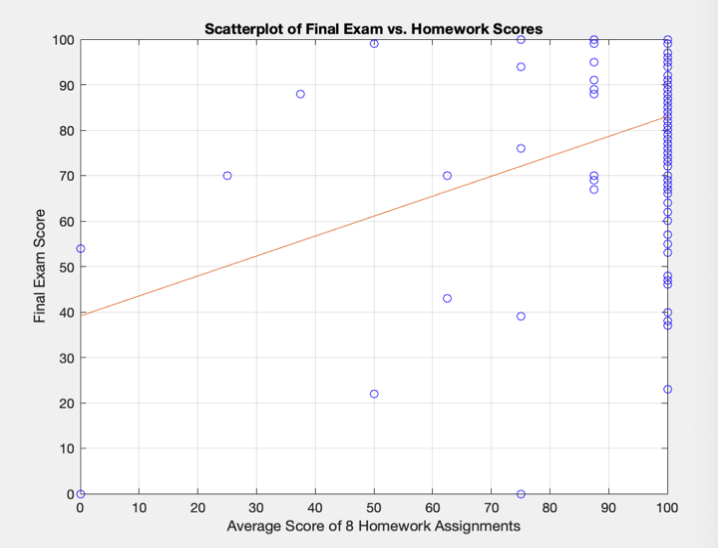

Fig. 1. Scatterplot of final exam vs. homework average scores.

IV. DISCUSSION

Upon visual inspection of Figure 1, we see that most of the students (112 out of 135, or 83%) received a perfect 100 on the homework. This is compelling and cause for alarm. Students may have the ability to find other students' homework solutions that were posted online, or alternatively from basic internet searches. For these reasons it seems impossible in modern times to prevent flawless solutions from being submitted, even when learning and knowledge accumulation has clearly not occurred.

To emphasize this point, within the group of 112 students who earned a perfect 100 homework score average, the range of final exam scores was 23 to 100. The average final exam score for this group with perfect homework was 83, only 3 points higher than the overall average final exam score including all 135 students.

One might expect that the perfect homework group would have a significantly higher average final exam score than the overall average, but this was not the case. In sum, perfection on homework in this study was not meaningfully indicative of higher final examination scores.

Given that grading homework is a time-consuming endeavor for teaching assistants and lecturers alike with ambiguous benefit to educational outcomes, we may ask the question: In the modern university setting, has homework become worse than worthless?

Only 30% of the students in the study (40 out of 135) averaged a perfect 100 on their team-based quizzes. Within this group, the range of final exam scores was 23 to 100 and the average final exam score was 87, compared to 80 which was the overall average. The perfect quiz group distinguished itself as strong performers on the final examination. Note the perfect quiz group outperformed the perfect homework group by 4 points on the final examination.

The study shows that the inclusion of more team-based quizzes and fewer homework assignments may enhance educational outcomes. College students are busy and face an avalanche of distractions; time efficiency is essential to success. Homework may not be the most time-efficient form of learning. This should be taken into consideration in curriculum development.

With lower emphasis on homework and greater emphasis on engaging students through active learning, educational efficiency may improve. Athletic coaches understand this well. Individual training and team workouts both have a place, but often teammates push each other to their full potential, breaking through perceived boundaries created by individuals themselves. Undoubtedly, the same thing happens in the classroom. In Table 1 we see that the strength of the relationship between final exam scores and adaptive team-based quizzes, as measured by the coefficient of determination (R-square), is more than double the strength of the relationship between final exam scores and homework. This is a compelling fact, and ultimately the essence of the contribution of this study to the literature on the value of homework in the classroom.

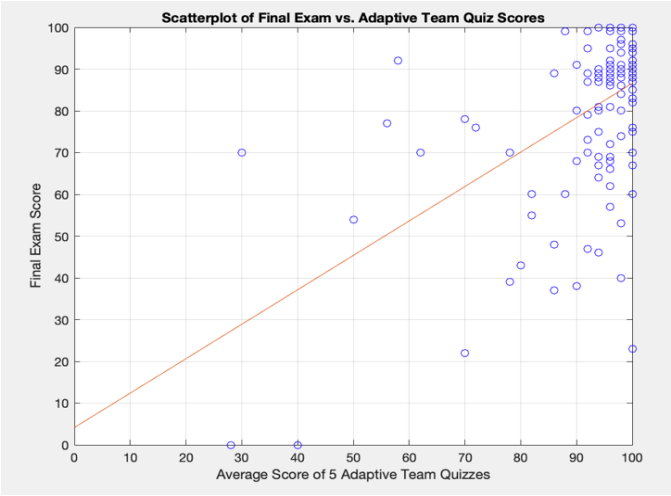

Fig. 2. Scatterplot of final exam vs. adaptive team quiz average scores.

V. LIMITATIONS

In this study we have noted that perfection on homework was not meaningfully indicative of higher final examination scores. One explanation for this would be that the homework was simply too easy. But in this case

the homework assignments were extraordinarily difficult, as compared to the adaptive team-based quizzes. Most likely the homework perfection was achieved through cheating.

Introspective educators may ask themselves: is it more productive to replace homework altogether with activities that involve active student engagement? This decision is particularly relevant for introductory classes in which student engagement may be more critical to success. For advanced undergraduate/graduate highly motivated and focused students, this decision may not be as important.

VI. CONCLUSIONS

The R-square statistic provides a useful and intuitive measure of how well the linear model fits a set of observations. In this case, the R-square value provides an estimate of the relative strength of the relationships (1) between the final exam scores and the homework, and (2) between the final exam scores and the adaptive team-based quizzes. While a sophisticated statistical analysis is beyond the scope of this paper, this study elucidates that the strength of the relationship between final exam scores and adaptive team-based quizzes is more than double the strength of the relationship between final exam scores and homework. We hope this result may inspire innovative educators seeking guidance on effective teaching methods to investigate and freely consider utilizing adaptive team-based quizzes and other active learning methodologies in their teaching practicum.

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Jeffrey Ludwig was born in Peoria, IL on November 23, 1968. He has a S.B. in aeronautics and astronautics (1991) and an S.M (1993) and a Ph.D. (1997) in electrical engineering and computer Science, all from the Massachusetts Institute of Technology, Cambridge, Massachusetts, U.S.A. He served as Director of Jump Labs, the research division of Jump Trading, a Chicago-based high frequency proprietary trading firm. Before that he was a portfolio manager at SAC Capital Management, New York where he managed quantitative futures strategies spanning equities, fixed income, commodities, and volatility, and also the Director of the Algorithmic Trading Group at Barclays Capital in New York and London. Prior to that, he was a Senior Vice President and Portfolio Manager for Pacific Investment Management Company (Pimc--o) for 5 years, where he served as Head of Equity Derivatives. Pimco recruited him from Credit Suisse First Boston in New York where he was a successful proprietary equity arbitrage trader. He has 20 years of investment experience. Professor Ludwig is an Assistant Professor of Teaching in the Department of Mathematics at University of California, Irvine, U.S.A. since 2018. He serves as the faculty advisor for the math finance concentration and specializes in innovative teaching and collaborative research with industry in mathematical finance and quantitative trading.