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Continuous Evaluation of Student Class Performance Using Group-based, In-class Quizzes

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Introduction

Traditional methods of evaluating student performance in the classroom involve assigning weekly homework assignments, semester long projects, conducting examinations (e.g., mid-terms/finals), and holding arbitrary pop quizzes. Amongst these methods homework assignments are a traditional indicator of a student's continuous learning of the subject matter. Traditionally, performance on homework assignments reflects the level of understanding that the student has of the material that is covered in the classroom on a weekly basis (assuming the homework assignments are handed out on a weekly basis). They help an instructor gauge the consistency of the student's effort. This is an essential aspect of classroom education because it instills a work ethic that is based upon the principles of daily effort, consistency and dedication from the student[1] as opposed to leaving large amounts of work to be completed just prior to a deadline. Projects, exams and quizzes are an end product of the accumulated effort by the student over the semester, but do not necessarily reflect the continuous acquisition of knowledge by the student during the semester.

Based upon personal experience and upon the experience of other instructors, we have observed that a certain percentage of students tend to copy from each other or from solution manuals on the internet while solving homework assignments[2]. Ubiquitous internet access makes it possible for students to discover information and problem solutions that in the past would have been difficult to find[3]. Regular homework assignments served as an excellent tool for the continuous evaluation of student performance before the internet was available to students. The onset of the internet has made it possible for students to gain access to some of the most obscure sources online, significantly enabling them to cheat on homework assignments and thereby making it extremely challenging for professors to ensure that they do their own work. One possible way to work around this problem is for each instructor to create their own unique assignment problems, whose solutions are not available online. This is an extremely time consuming and tedious process for instructors, which not only involves the rigor of creating problems that make sense, are reasonable and realistic, year after year, but also developing solutions to each of these problems. Consequently, to circumvent the problem of students cheating on homework assignments, we have developed a continuous classroom evaluation technique which involves giving quizzes in real-time during classroom hours which allow students to work in groups and to ask for hints from the instructor. This creates an environment where it is very challenging for students to plagiarize material and also provides the instructor with a tool to obtain a continuous and regular assessment of student performance and understanding of material covered in the class.

Purpose of the Study

The purpose of this study is to:

- Demonstrate that the proposed quiz technique results in improved student performance
- Present a technique that can be used for the continuous evaluation of the acquisition of knowledge by students in the classroom and reduce the occurrence of plagiarism that occurs in the traditional homework-based method of continuous evaluation.
- Create a more interactive classroom experience as compared to the traditional lecture. Awareness of the importance of the effect of an interactive classroom environment on student retention is already in existence. Thus far, it has been attempted to make the classroom environment more interactive in order to increase student retention in STEM programs. "The Association of American Universities, which represents 61 of the largest research institutions, announced a five-year initiative to encourage faculty members in the STEM fields to use more interactive teaching techniques."[4]

Significance of the Study

Based upon the discussion in the "background search" in the next section, it can be seen that including regular quizzes had a positive impact on students' performance. While they were generally very beneficial to students, we desired to investigate the continuous assessment of students' knowledge by using weekly group-based quizzes that were completed in the classroom that permitted open interaction with the instructor. The approach is unique in the following ways:

1) Interaction with the instructor is permitted: The instructor can give the concerned student/s hints/guidance if necessary, since all the material being tested is fresh and the students have not had time to prepare. This eliminates the need for plagiarism. One of the main goals of this pilot project was to develop a means of continuous evaluation of the student's acquisition of knowledge by eliminating the effect of plagiarism that occurs in the traditional homework based approach. Another benefit of communication with the instructor is that it helps build a rapport between the students and the instructor and creates an interactive classroom experience.

2) Distribution of homework assignments that are not graded: Weekly homework assignments are still distributed, but they are not graded. The exams are closely based on the homework, thereby giving the students an incentive to work on the homework assignments independently, even though the homework is not graded. It has been observed that students who did not work on the homework problems prior to the first exam, changed their attitude and worked on the homework problems after the first exam since they found that the exam was closely linked to the homework. Once again, this eliminates any component of their grade being dependent upon work that has the possibility of being plagiarized. Also, indirectly requiring the students to work on the homework by basing the exams on the homework results in the student's performance on the exams (which reflects "accumulated" work over the semester) not being adversely affected. The goal of this evaluation is to improve upon the approach used to evaluate the "continuous" acquisition of knowledge.

Background Search

Arteaga et al.[5] conducted a pilot study in which quizzes were introduced to mechanical engineering students. The purpose of the quizzes was to help the students understand the subject matter better by repeating important course material, giving instantaneous feedback and creating an environment where students can learn and exchange ideas from their peers. Students were given a half point bonus in addition to their exam score if they successfully completed 55% of all the quiz questions correctly. The pilot study was used to ascertain the effectiveness of this quiz-based approach, which was gauged by determining the number of students that passed the course on their first attempt, and also via student feedback obtained through a questionnaire. It was learned that the first time pass rate of students in the pilot study groups did, on average, increase significantly in comparison to groups in where the quizzes were not performed. Additionally, feedback obtained via the questionnaire demonstrated that students found this approach to be beneficial in identifying gaps in their knowledge. Hence, Arteaga et al. concluded that the pilot study was considered effective.

Balter et al.[6] conducted short online quizzes that incorporated standard questions having binary responses (right/wrong) during the initial period of a course. The purpose of doing so was to assist students in gauging their comprehension of fundamental ideas pertaining to the course and to encourage good study habits. A study was conducted in order to determine whether the quiz approach was beneficial to students' learning. Student feedback was obtained via surveys and interviews. Based upon feedback obtained from the surveys it was concluded that the study incorporating short quizzes using generic questions with limited correct/incorrect feedback on each question, had positive effects when administered early in courses.

Faraji[7] investigated the implementation of weekly quizzes in a chemical engineering program. The study replaced traditional weekly homework assignments with weekly paper quizzes. Achievement levels of students were compared with those students who learned through traditional homework assignments only. The comparisons showed that the quiz-based learning approach improved students' learning in both lower division and upper division classes. These results demonstrate the enhanced effectiveness of in-class quizzes in assessing the students' continuous acquisition of knowledge in comparison to traditional homework assignments.

Hannah et al.[8] used computer-aided assessment in two first year engineering mathematics courses with weekly quizzes to provide students with an opportunity to evaluate their performance. The majority of the students used the assessment until they achieved very high (>90%) quiz scores, but the quizzes did not improve the final exam performance.

Shafiq and Siddiquah[9] investigated the use of classroom quizzes to improve student learning outcomes. They compared the effect of quizzes on the results of the mid-term and final exams on an experimental and control group of students. The results revealed that the experimental group

outperformed significantly the control group on both the midterm and final exams thereby supporting the use of in-class quizzes to improve student learning outcomes.

Shorter et al.[10] designed a pilot study to determine whether a continuous assessment method (daily in-class quizzes), cumulative assessment (online homework) or project based learning best predicted student learning in an undergraduate mathematics course. Each of these methods was compared to post-test scores and it was found that continuous assessment (daily quizzes) best predicted students' post-test scores. The results of this investigation showed the benefit of conducting in-class quizzes.

Method

Participants

In order to explore the efficacy of the proposed "in-class quiz" approach of continuous student evaluation, a pilot study was conducted where students were evaluated using this method. The outcome of the study included: 1) an analysis of survey-based feedback from the students that participated in the study, and 2) an analysis of end of semester grades between classes that used the quiz approach and those that did not use it. The survey is presented in Appendix A, and the grade comparison results are in Appendix B.

The study consisted of applying the "in-class quiz" methodology at the undergraduate level over a period of three years. Students from the departments of civil engineering, electrical engineering, and mechanical engineering participated in the pilot study, the details of which are presented in Table 1.

Table 1: Pilot Study Course Description (Engineering)

Course	Session	Year/s	Department[1]	Major[2]	Number of Students	Average Age, Location
Statics	Fall	2013, 2014, 2015	CE[3], ME[4]	CE, ME, EE[5]	53	19, MW[6]
Mechanics of Materials	Fall	2013	ME	CE, ME	19	20-21, MW
Elementary Structural Analysis	Fall	2013, 2014, 2015	CE	CE	7	20-21, MW
Steel Design	Spring	2014, 2015	CE	CE	8	20-21, MW
Reinforced Concrete Design	Spring	2014, 2015	CE	CE	6	20-21, MW

Advanced Structural Analysis	Spring	2014, 2015	CE	CE	6	20-21, MW
Structural Dynamics 1	Fall	2014	CE	CE	3	22, MW
Structural Dynamics 2	Spring	2015	CE	CE	2	22, MW

1: This refers to the department within the school of engineering and technology that offered the concerned course
2: This refers to the major of the students that participated in the study by enrolling in the offered course
3: CE = Civil Engineering
4: ME = Mechanical Engineering
5: EE = Electrical Engineering
6: MW = Midwest

Procedure

This section focuses on the methodology employed in order to conduct the "in-class quizzes" discussed above. The intention of this section is to provide the reader with a step-by-step, detailed description of the process involved in the effective and efficient execution of this approach. The process involves the following steps:

1. Divide the class into groups of 2-3 students, depending on class-size. The group should be the same throughout the semester. The instructor can adjust the group based on attrition or group dynamics.

2. Conduct a weekly quiz in the classroom. The in-class quizzes contribute to approximately 15-20% of the final grade. Typically, the quiz should contain anywhere between one to three fairly straightforward questions that cover the fundamental concepts discussed in class during that week. The problems should be judiciously selected so that they are layered (i.e., a single problem covers more than one concept, starting from the more basic ones to the more advanced ones). By doing this, a large number of questions are not needed and yet, most of the week's concepts are covered. By grading the in-class quizzes in class or on the same day, the instructor has a good idea of the depth of each student's understanding of the subject matter taught during the week. Consequently, the instructor can spend a short time in the next class repeating any material that the students did not properly understand in the in-class quiz. Also, if only one or two students are weak in a certain area, the instructor would be able to see this very clearly, and instead of spending time in the next class on this material for just one or two students, the instructor can organize a meeting with them to personally teach them the material, thus saving class time. This is an excellent way to obtain a real-time understanding, for both the instructor as well as the student, of each student's progress and grasp of the study material, and also to obtain real-time feedback on the efficacy of the

instructor's teaching performance. An additional benefit is that this is a personalized process, as opposed to simply handing in homework assignments which is a more impersonal approach for performance evaluation.

3. Generally, the quiz is administered during the last 20-30 minutes of the last class of the week. The time to take the quiz is flexible. If the students are unable to finish the quiz in class, then they can complete it shortly after class and submit it to the instructor. The goal of this process is not to put them under the pressure of a deadline or to produce results in a short time. The goal of this approach is to test whether they have a basic understanding of new concepts discussed in class during the week. The time taken to solve the problems may differ for different students, depending upon their abilities.

4. Students are freely permitted to ask the instructor for guidance if they encounter an obstacle in solving the problem(s). The instructor can provide them with an overview or hint to prevent the student from getting stuck.

5. The students are free to communicate with each other within the group. This increases the exchange of ideas between students and improves their collaborative skills. Students that have questions will benefit from the fact that they are being taught the correct approach to solve the problem. There is also the added benefit that the students are learning from a peer, which may encourage the students to question each other more freely. Fellow students that are currently in the process of undergoing the same learning curve might be able to understand each other's perspective and questions better. Additionally, teaching a fellow student within the group helps to crystallize the understanding of the subject matter for the student that is teaching the material because the act of teaching is considered to be an excellent way to master subject matter. Thus, everyone in the group serves to benefit by this approach.

6. The quizzes must be done in class or shortly thereafter, but cannot be done at home. This ensures regular attendance. Additionally, it puts the students under pressure to be mentally present and focused during the lecture, since they know that they will be tested on this material during the week.

7. The mid-term and final exams are directly based on the homework assignments and students are explicitly told that. This encourages them and gives them an incentive to complete the homework assignments which may not be graded. By regularly doing the homework assignments, the students are preparing themselves for the mid-term and final exams. If a student chooses not to do the weekly homework, then their performance on the mid-term and final exams will reflect their effort.

Measures

A total of 72 students participated in the study. The students in elementary and advanced structural analysis, reinforced concrete design, steel design, structural dynamics 1 and 2 were all previously in statics and mechanics of materials. Hence, they were not surveyed a second time in order to prevent repetition. Out of these, 52 students provided feedback about the implemented approach via responses to an anonymous hard-copy survey that was distributed to the entire group after the course was completed. These surveys were both distributed and collected by another professor, who did not teach the course in question. Table 2 presents the participant responses to each question in the survey. It quantifies the survey results by displaying both the absolute number of students that provided a positive, negative or neutral response to each question in the survey, as well as the percentage of the total number of participating students that responded in each of the aforementioned ways. The neutral responses that appeared despite the survey offering only "yes" or "no" options were explicitly written by the respondents as either "neutral", or "neither agree nor disagree", or "neither yes nor no".

Additionally, a grade analysis was performed that compared student final grades in the same courses prior to when the quiz technique was implemented to grades after the technique was implemented.

Table 2: Survey Results (Total Number of Respondents N = 52)

Q[1]	positive[2]	negative[3]	neutral[4]	% (+)[5]	% (-)[6]	% (neutral)[7]
1	47	5	0	90.4	9.6	0.0
2	42	8	2	80.8	15.4	3.8
3	44	6	2	84.6	11.5	3.8
4	45	4	3	86.5	7.7	5.8
5	45	6	1	86.5	11.5	1.9
6	47	5	0	90.4	9.6	0.0
7	49	3	0	94.2	5.8	0.0
8	50	1	1	96.2	1.9	1.9
9	39	13	0	75.0	25.0	0.0
10	28	18	6	53.8	34.6	11.5
11	38	13	1	73.1	25.0	1.9
12	38	8	6	73.1	15.4	11.5
13	44	3	5	84.6	5.8	9.6
14	40	8	4	76.9	15.4	7.7
15	40	7	5	76.9	13.5	9.6
Avg[8]	42.4	7.2	2.4	81.53	13.84	4.6

1: Q: Question from survey (see Appendix A)
2: positive: Total number of students that provided positive feedback
3: negative: Total number of students that provided negative feedback
4: neutral: Total number of students that provided neutral feedback
5: % (+): Positive feedback expressed as a percentage of the total number of students that responded to the survey

6: % (-): Negative feedback expressed as a percentage of the total number of students that responded to the survey
7: % (neutral): Neutral feedback expressed as a percentage of the total number of students that responded to the survey
8: Avg: Average of all 15 questions

Survey Analysis

The survey feedback showed the efficacy of the "in-class quiz" approach of continuous student assessment from the student's perspective. Generally speaking, over 75% of the total students surveyed responded favorably to 12 of the 15 questions (see column 5 in Table 2). In other words, it can be concluded that a significant majority of the total students responded positively to 80% of the questions. Additionally, over 90% of the total students surveyed responded positively to 4 of the 15 questions (see column 5 in Table 2), which showed that nearly all the students had a positive impression of 26.7% of the questions asked. Finally, in the two categories mentioned above (i.e., above 75% positive and above 90% positive), not all the responses that were "not positive" were necessarily negative; they were a combination of negative and neutral responses.

Based upon the above discussion, it can be concluded that a significant majority of the students responded positively to the in-class quiz approach of continuous student evaluation. In particular, an overwhelming majority of the students that participated (96.2%; see column 5 corresponding to question 8 in Table 2) responded positively to question 8, thereby demonstrating that the fundamental purpose of this approach was satisfied:

"Were the quizzes successful in providing you with a continuous evaluation of your progress, thereby helping you to understand which concepts you needed to work on at the end of every week (Y / N)?"

However, one data point is worthy of attention. This is the response to question 10 of the survey:

"Did you find there was a mismatch (an unequal contribution between members) in the amount of effort contributed by each group member to solving the quiz problems? In other words, did you find the group relied on one member to get the job done? (Y / N)?"

It can be seen from the tabulated survey results that only 53.8% of the total number of students surveyed (see column 5 corresponding to question 10 in Table 2) responded positively to this question. Based upon this information, it can be concluded that a reasonably large percentage of students (34.6%; see column 6 corresponding to question 10 in Table 2) felt that there existed an imbalanced contribution among group members toward solving the quiz problems. This situation was anticipated prior to the pilot study being implemented. Despite the fact that 34.6% of the students felt that there was an unequal contribution between group members toward solving the quiz problems, it can be seen that 84.6% (see column 5 corresponding to question 3 in Table 2) of the participants responded positively to question 3 of the survey:

"Did working in peer groups help you understand the material better (Y / N)?

Was it due to either of these reasons?:

a) It might have been easier for you to relate to a peer instead of trying to relate to the instructor.

b) It can be less intimidating to interact with a peer instead of feeling pressured to ask the instructor seemingly small questions.

c) Explaining material to your peer might have improved your own understanding of the subject matter."

Hence, it can be seen that most of the student participants felt that working in peer groups helped them understand the subject material better, due to the combination of the aforementioned factors. Specifically, interacting with a peer can be easier than interacting with an authority figure, and working on solving a problem within a team of peers can improve the understanding of the subject material for both the weaker and stronger participants within the group. Both the questioner as well as the questionee serve to benefit from this interaction. This is because the questioner's understanding improves due to the explanation provided by the questionee, and the questionee's understanding improves by engaging in the act of teaching the fundamental concepts to the questioner.

Additionally, 86.5% of the participants responded favorably to question 4 (see column 5 corresponding to question 4 in Table 2) of the survey:

"Did working in groups help you establish a sense of camaraderie with your group (Y / N)?"

Again, most of the student participants felt that the implemented approach assisted them with working in teams, which is very important in the professional world. Despite the fact that this skill is not directly linked to assessing the continuous progress of the students, it is a fringe benefit of the implemented approach. Working in groups is an aspect of this quiz-based approach, as opposed to working on quizzes in isolation.

One of the driving factors for this pilot study involved developing an approach to reduce plagiarism of homework. Question 15 of the survey addressed this issue:

"Plagiarism is a fairly common drawback of the traditional homework-based evaluation process. Did being evaluated in class via group-based quizzes that permitted free and open interaction with both your peers and your instructor eliminate the need for you to plagiarize solutions (Y / N)?"

Based upon the survey results, it can be seen that 76.9% (see column 5 corresponding to question 15 in Table 2) of the participants stated that the implemented approach eliminated the need for students to plagiarize assignments. This is an excellent development, since the "in-class quiz" approach not only results in students doing their own work and making a contribution leading to them learning the subject material, but also enhances the positivity of the academic environment for both students as well as instructors.

A unique feature of the described approach involves free and open interaction with the instructor in order to obtain guidance, if necessary. Since the quizzes are completed by the students directly after learning a new concept, the quizzes are intended to test the ability of the students to apply fresh material that they haven't had the time to study in isolation. Under such circumstances, it is reasonable to expect the need for students to ask for small hints or guidance from the instructor. This option to ask for the instructor's assistance was received very positively by the participants, based upon the fact that 94.2% (see column 5 corresponding to question 7 in Table 2) of them felt that this contributed toward them building a sense of rapport and trust with the instructor. This is evident from their reply to question 7 in the survey:

"Did you feel that having the freedom to ask the instructor for guidance within this process contributed toward building rapport, trust and interaction between you and the instructor (Y / N)?"

Grade Analysis

The percentage scores that each student secured in statics (2013 and 2015), and mechanics of materials (2013) are presented in tables 3, 4, and 5 in Appendix B. The scores for statics (2014) are unavailable and hence not added to this analysis. The civil engineering department was introduced at the university in fall 2013. Since it is a new department, the number of students in the core civil engineering courses (Elementary and advanced structural analysis, reinforced concrete design, steel design, and structural dynamics 1 and 2) was small, due to which these courses had only one section. Additionally, these courses were not offered prior to the addition of the civil engineering department. Hence, despite the fact that the proposed technique was implemented in these courses, it was not possible to compare the percentage scores with and without the proposed technique implemented. However, these students did complete statics and mechanics of materials and their survey feedback they contributed was analyzed.

In tables 3, 4, and 5, the score of each individual student is listed and the average score for the entire class is also computed. The scores are compared for two different sections of each course, the sections being conducted in parallel in the same year and same semester, one incorporating the technique proposed in this study and the other not incorporating the technique. The course section in which the technique was not incorporated was taught by another faculty member in the same university, who was not involved in this study. The material taught was nearly identical, and the level of difficulty of exams was similar. It was desired to demonstrate that this technique

resulted in better student performance and can be universally implemented, independent of the instructor teaching the course.

It can be seen that the average total percentage score in statics (2013) was 82.1% with the proposed technique incorporated, versus 80.82%. Thus there was a 1.28% improvement in the average percentage of the class on incorporating the proposed technique. Similarly, the average class percentage in statics (2015) increased by 5.65% from 77.11% to 82.76% on incorporating the proposed technique. Finally, there was an improvement in the average percentage scores in mechanics of materials (2013): the scores improved by 11.46% in the section that incorporated the proposed technique. A comparison has also been made in the Introduction to C++ programming course. This course was not a part of the pilot study but has been included here as additional supporting data. In 2015, there were a total of 34 students enrolled in this course. This course is currently in progress and the first mid-term exam scores are available. In 2015, the proposed technique in this study was not implemented in this course; in 2016, however, it is currently being implemented. A comparison between the first mid-term exam grades in 2015 and 2016 are presented in table 6. The same professor that is currently teaching the course also taught it in 2015. The content and level of difficulty of the course and its exams are nearly identical. It can be seen from table 6 that the incorporation of the technique proposed by this study resulted in an increase of 7.71% in the overall score for this course. Hence, based upon this initial pilot study, it can be observed the group-based, interactive, in-class quizzes resulted in better overall performance in the courses investigated.

Results

Based upon the aforementioned discussion, it can be concluded that:

- The incorporation of the proposed technique resulted in improved student performance as demonstrated by the increased average class final scores expressed as percentages. Improvement in scores ranged from approximately 2 – 11%.
- The proposed method reduced plagiarism. The continuous evaluation of student performance was done in the classroom in the instructor's presence. Interaction with the instructor was permitted instead of the traditional homework based approach, thereby removing the need to plagiarize material. Based upon student survey feedback, approximately 77% of the students felt that this approach reduced plagiarism.
- Based upon student feedback, 94.2% of the students felt that the proposed quiz technique helped them build rapport with the instructor. Additionally, 86.5% of the students felt that the proposed technique helped develop a sense of camaraderie in the classroom. Hence, the proposed technique succeeded in making the learning process an interactive one.

Conclusions

Traditional methods of evaluating student performance in the classroom include examinations which test a student's accumulated effort and knowledge over a period of time, and homework assignments which attempt to assess the regular weekly effort and knowledge gained by students. We have learned that a fair percentage of students tend to plagiarize homework assignments, either from each other, or from online solution manuals. Internet access has made it possible for students to access online solution manuals. Prior to the internet, the traditional approach of homework assignments served as a reasonable indicator of a student's grasp of classroom material on a weekly basis and was more effective than it is today. To circumvent the problem of plagiarism, we have recommended a novel approach of conducting weekly interactive in-class, group quizzes which provide the instructor and students with a personalized, real-time assessment of the student's understanding of the subject matter taught in the classroom during a particular week.

Based upon the tabulated survey results and grade analysis in the previous section, some of the pros and cons of the proposed quiz technique are summarized below:

Pros:

- Prevents cheating.
- Improves regular attendance.
- Improves class participation and focus.
- Improves understanding of the subject matter due to students working in groups.
- Improves teamwork and ability to collaborate in future projects.
- Improves student learning by peer-to-peer interaction.
- Provides a balanced pressure between performance on a quiz and the flexibility of support within a group. In comparison, a homework assignment little pressure because it is not done in real-time and is done within the comfort and familiar environment of one's home.
- Trains students to absorb and freshly apply material learned without having to allocate structured segments of time to learn the material independently.
- Contributes toward building rapport, trust and interaction between the class and instructor, since the student can ask the instructor for guidance.
- Prevents students' final grade from being disproportionately affected by a single bad day [such as on a mid-term or final exam]
- Provides a continuous evaluation that allows the instructor to make adjustments to his/her teaching style and helps the instructor to emphasize certain topics that the students are weak on.
- Provides a continuous evaluation to the student so student knows which concepts they need to work on.
- Reduces the grading load on the instructor by dividing the class into groups.
- Increases interaction between students and the instructor.

Cons:

- Students may lose some points if they miss class thereby adversely affecting their grade.
- Intentionally insincere students may contribute less within a group.

It can be seen that the pros of the proposed approach significantly outnumber the cons. It was seen that student performance improved by implementing this quiz technique as shown in the grade analysis section. Additionally, the process was more interactive and helped reduce plagiarism.

Recommendations for Future Research

We intend to conduct a follow-up investigation to increase the sample size with more courses in engineering and information technology programming courses.

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Appendix A

Survey

In-Class Weekly Quiz Approach Feedback

1) Did the prospect of taking an in-class quiz that contributed to your final grade motivate you to try to attend class more regularly (Y /N)?

2) Did the prospect of taking a quiz at the end of class that contributed to your final grade motivate you to try to pay more attention to the lecture (Y / N)?

3) Did working in peer groups help you understand the material better (Y / N)?

Was it due to either of these reasons?:

a) It might have been easier for you to relate to a peer instead of trying to relate to the instructor.

b) It can be less intimidating to interact with a peer instead of feeling pressured to ask the instructor seemingly small questions.

c) Explaining material to your peer might have improved your own understanding of the subject matter.

4) Did working in groups help you establish a sense of camaraderie with your group (Y / N)?

5) Did you get the impression that the in-class quizzes provided a balance between performing during a quiz while having the flexibility of support within a group (Y / N)?

6) Did the quizzes assist in your ability to absorb and apply fresh material learned without having structured segments of time to learn the material independently (Y / N)?

7) Did you feel that having the freedom to ask the instructor for guidance within this process contributed toward building rapport, trust and interaction between you and the instructor (Y / N)?

8) Were the quizzes successful in providing you with a continuous evaluation of your progress, thereby helping you to understand which concepts you needed to work on at the end of every week (Y / N)?

9) Since these quizzes are done in class, if you missed a quiz or quizzes for a sincere reason, you might have lost some points which in turn adversely affected your grade. Did you experience this problem (Y / N)?

10) Did you find there was a mismatch (an unequal contribution between members) in the amount of effort contributed by each group member to solving the quiz problems? In other words, did you find the group relied on one member to get the job done? (Y / N)?

11) Would you have rather worked independently instead of within a group (Y / N)?

12) Did you find that being graded via this weekly in-class quiz technique was a more interactive and personalized approach to evaluate your weekly understanding of knowledge, as opposed to the traditional weekly homework assignment approach in which you solve homework problems independently (Y / N)?

13) Do you feel that these quizzes were an energizing diversion from continuously and passively listening to a lecture (Y / N)?

14) Did you feel that the quizzes forced you to not put off learning the weekly material (i.e. did not allow you to leave unfinished work to a later date), thereby encouraging personal responsibility and discipline (Y / N)?

15) Plagiarism is a fairly common drawback of the traditional homework-based evaluation process. Did being evaluated in class via group-based quizzes that permitted free and open interaction with both your peers and your instructor eliminate the need for you to plagiarize solutions (Y / N)?

Appendix B

Table 3: Statics 2013

Student	Course	
	with proposed quiz technique	without proposed quiz technique
	Total Score (%)	Total Score (%)
1	75.77	87.93
2	78.87	79.20
3	85.99	77.26
4	77.69	79.96
5	73.19	76.94
6	98.98	90.73
7	67.82	93.10
8	68.91	74.03
9	91.82	63.90
10	94.49	66.59
11	89.50	89.76
12	NA[1]	75.11
13	NA	96.12
14	NA	87.93
Average	82.1	80.82

1: NA = Not applicable, since these students withdrew from the course

Table 4; Statics 2015

Student	Course	
	with proposed quiz technique	without proposed quiz technique
	Total Score (%)	Total Score (%)
1	89.17	60.4
2	82.73	82.4
3	92.53	80.4
4	86.99	91.1
5	74.53	85
6	68.65	66.8
7	79.89	78.3
8	79.67	76
9	75.17	69.5
10	90.06	73.8
11	88.92	82.7
12	72.95	81.9
13	90.23	88.5

14	81.48	74.4
15	95.14	76.5
16	72.99	66.1
17	90.01	NA
18	78.54	NA
Average	82.76	77.11

Table 5: Mechanics of Materials 2013

Student	Course	
	with proposed quiz technique	without proposed quiz technique
	Total Score (%)	Total Score (%)
1	89.95	80
2	98.34	85
3	93.47	80
4	80.31	60
5	85.94	64
6	76.48	82
7	95.19	79
8	93.51	95
9	100.26	78
10	83.92	76
11	100.70	75
12	83.12	78
13	101.93	78
14	96.06	76
15	91.49	78
16	76.51	80
17	89.85	65
18	85.69	81
19	62.32	NA
Average	88.68	77.22

Table 6: Introduction to Programming in C++

Student	Course	
	with proposed quiz technique (2016)	without proposed quiz technique (2015)
	Total Score (%)	Total Score (%)
1	79	28
2	99	82
3	85	97
4	64	69
5	92	95

6	94	87
7	100	77
8	98	58
9	95	92
10	98	78
11	65	82
12	80	98
13	93	88
14	87	87
15	93	70
16	95	92
17	85	70
18	98	90
19	100	95
20	92	100
21	86	98
22	78	74
23	92	100
24	93	100
25	96	97
26	87	78
27	91	61
28	99	77
29	73	70
30	100	98
31	No student	73
32	No student	100
33	No Student	81
34	No student	41
Average	89.57	81.85