How Many Points Should Be Awarded for Interactive Textbook Reading Assignments?

Alex Edgcomb
Dept. of Computer Science and Engineering
University of California, Riverside
Riverside, CA, USA
Also with zyBooks.com.

Frank Vahid
Dept. of Computer Science and Engineering
University of California, Riverside
Riverside, CA, USA
Also with zyBooks.com.

***Abstract*—New college engineering textbooks and other online learning materials use activities like interactive questions to engage students and improve learning. Some such materials use a "safe" learning approach where activity solutions are readily available to students, as opposed to being graded like a homework assignment. Instructors have inquired how few course points are sufficient to ensure students complete such assigned activities. Furthermore, some wonder if assigning course points might lead students to "cheat the system" by revealing solutions to quickly earn points, rather than earnestly attempting to answer the questions. We analyzed behavior data of 1,394 students in 8 engineering classes at different colleges. We found that surprisingly few course points—just 5 or 10 points, and as few as 2 points—were sufficient to achieve over 90% average completion of activities by students. For comparison, assigning no points yielded only about 50% completion. Furthermore, we found that assigning points had only a minor impact on students earnestly attempting to answer questions, versus showing themselves the answer first, with earnestness changing only modestly from 92% to 86% when points were assigned.**

Keywords—reading assignment; reading earnestness; interactive textbook; course points; homework; cheating the system, online learning.

I. Introduction

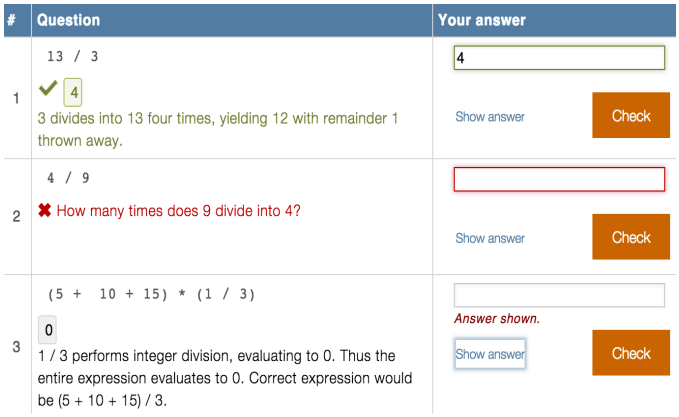
Engineering and other subjects increasingly use interactive textbooks and other online learning material from academic groups [12][14][15] and companies [5][9][19][20]. Interactive textbooks contain activities such as embedded questions that teach and reinforce the subject matter. Instructors commonly require such activities by assigning some homework points for completing the "reading". Reading completion is sometimes required before lectures, leading to more engaged students, and optionally supporting a "flipped" classroom.

We have developed such online learning material for several computer science/engineering subjects, presently used at over 250 colleges. The material emphasizes a "safe" learning environment where question solutions are available to students via a simple button click, where students can attempt questions as many times as desired without penalty, and where showing an answer incurs no penalty.

Given that courses have numerous items for which course points are awarded (exams, labs, projects, quizzes, written homeworks, etc.), a common question from instructors is how few points are sufficient to cause students to complete the assigned readings. Furthermore, another question is whether assigning points might cause students to just show themselves the answers to quickly earn those points, i.e., to "cheat the system".

Our material includes multiple questions types, including true/false, multiple choice, short answer, and definition matching. Figure 1 shows three short-answer questions, which provide a hint if an incorrect answer is entered, or an explanation if a correct answer is entered. The user can reveal the answer by clicking the "Show answer" button.

Fig. 1. Three short-answer learning questions on integer arithmetic with the question and feedback on the left-hand side, and input field on right-hand side. User entered the correct answer for question 1, an incorrect answer for question 2, and showed the answer for question 3.



Short-answer questions can be used to measure reading earnestness because if a student just shows the answer without first attempting an answer, then the student is clearly not trying. Reading earnestness could also be defined for true-false and multiple-choice questions by comparing the student's correct answer rate to the expected correct answer rate if guessing. However, that approach is prone to more data noise due to some earnest student activity appearing as guessing, whereas short-answer questions have an explicit button. Thus, this study focuses on short-answer questions.

II. Background

Reading assignments improve students learning [1][11][16]. For example, in an engineering design course, students who were assigned textbook reading were more sophisticated in their problem solving strategies for a given problem than students not assigned the textbook reading [1]. Though students believe the course textbook is important for learning [4], researchers have found that many students tend to complete assigned readings only while preparing for an exam, whereas completing the reading as scheduled [2][6][7][8]. Such postponement may hamper a student's ability to understand lecture material as presented, and other assignments during the course's progress. The effectiveness and usage of textbooks have been published more for psychology education than engineering education; hence, the reference to some psychology education works. However, textbooks are commonly used and assigned for reading in engineering classes.

Researchers have developed subjective metrics to measure student perspectives of textbooks [3][10][11]. For example, Gurung [11] developed the Textbook Assessment and Usage Scale (TAUS) to measure students' textbook evaluations. TAUS includes over 20 questions that a student answers after having used a textbook. The questions ask about the quality of specific elements (e.g., Figures and Tables) and whether the placement of the specific elements was appropriate and visually appealing. In contrast to the subjective metrics previously developed, this paper introduces an objective metric that measures a student's reading diligence.

Numerous academic groups [12][14][15] and companies [5][9][19][20] are developing interactive textbooks for engineering. Open Learning Initiative offers free courses that come with an interactive textbook that includes multiple choice questions and interactive activities that are recorded [15]. Learning with Python [12] includes a programming environment, practice questions, a code visualization tool, and videos. For Dummies eLearning includes multiple choice quizzes at the end of sections [9]. Zyante's zyBooks include animations, interactive tools, and practice question sets [20]. zyBooks record student activity, and contain a student and instructor dashboard for monitoring activity. Many instructors assign homework points for completing readings according to a particular schedule, to keep the students up to date in the course and have them come to lecture better prepared.

Numerous online homework systems have evolved in recent years, such as MyMathLab (Pearson) [13], WebAssign [17], WebWork [18], etc. Those systems are mainly intended for homework submissions. Solutions are typically not available, or a solution may be viewed but then a new problem is generated. Such systems differ from the online "reading" activities that are growing in popularity and are studied in this paper.

III. Proposed metric: Earnestly-completed reading

Instructors commonly assign reading assignments with the intention that students will diligently read the assignment. We introduce the metric *earnestly-completed reading* to quantify a student's reading diligence, which is how much of the assigned reading a student spent time working through, as opposed to skimming through. Earnestly-completed reading is a combination of two metrics:

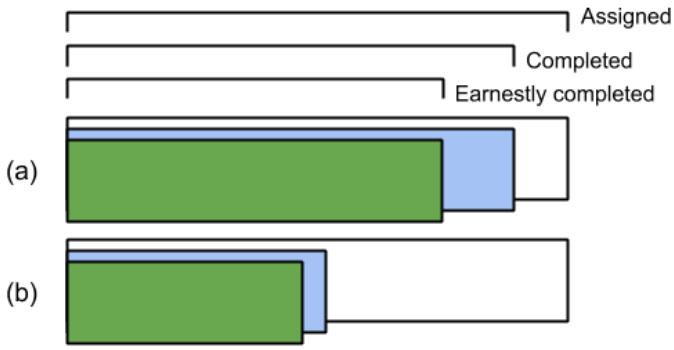
- *Reading completion* – The percentage of assigned activities that the student completed. For a short-answer question, the question is completed if a correct answer was eventually submitted for that question.
- *Reading earnestness* – Of the completed assigned activities, the percentage of activities that the student earnestly completed. For a short-answer question, the question is earnestly completed if the student attempts the question before eventually possibly showing themselves the answer. An attempt is a submission with more than whitespace. An unearnest completion is when the student shows the answer before attempting.

Earnestly-completed reading is then defined as:

earnestlyCompleted = completion * earnestness

Figure 2 shows the relationship between the amount of reading assigned, completed, and earnestly-completed. Figure 2(a) is for an assignment worth some points; Figure 2(b) is for an assignment worth no points. Ideally, a student would earnestly complete the entire assigned reading.

Fig. 2. Relationship between the amount of reading assigned, completed, and earnestly-completed for an assignment (a) worth points and (b) not worth points.



IV. Participants

We initially considered 26 classes across 23 universities for potential inclusion into our analysis. We tried to find a group of classes with similar reading assignment structure. We used the following inclusion criteria to mitigate potential confounding factors:

- Used an interactive textbook by zyBooks [20] and required the textbook for the class.
- Used the textbook for reading assignments regularly throughout the term.
- Assigned points proportional to completion, such as completing 50% of the reading earned 50% of the

points, as opposed to a threshold beyond which students receive full credit.

- Used a scheme with a single deadline per assignment, as opposed to awarding more points before lecture than after lecture.
- Contained at least 30 students in the class.

We found 8 classes meeting all the inclusion criteria. The 8 classes were offered in Fall 2014 and contained a total of 1,394 students. Table I shows the number of students per course points awarded. We determined the number of course points by a survey given to the instructors of the classes.

TABLE I. NUMBER OF CLASSES AND STUDENTS ACROSS THE COURSE POINTS AWARDED.

Points awarded	Number of classes	Number of students
0	2	250
2	1	54
2.3	1	437
5	1	380
10	1	69
17	1	90
20	1	114

V. RESULTS AND DISCUSSION

We classified each class by points awarded, such as 0, 2, 5, or 10, including merging 2 and 2.3 points awarded. Then, we compared the categories with respect to reading completion, reading earnestness, and earnestly-completed reading.

For each points awarded, we computed the average reading completion, average reading earnestness, and average reading earnestly-completed, which are defined as follows for each points awarded:

- Students are numbered 1… n
- C_i: Reading completion by student i
- E_i: Reading earnestness by student i
- Average completion: $\frac{\sum_{i=1}^{n} C_i}{n}$
- Average earnestness: $\frac{\sum_{i=1}^{n} E_i}{n}$
- Average earnestly-completed: $\frac{\sum_{i=1}^{n} (C_i \times E_i)}{n}$

The average earnestly-completed averages the earnestly-completed per student, as opposed to multiplying the average completion by the average earnestness, which would yield a different statistic.

Table II shows the average student reading completion and reading earnestness, and student earnestly-completed reading for a given points awarded.

TABLE II. AVERAGE STUDENT READING COMPLETION, EARNESTNESS, AND EARNESTLY-COMPLETED PER POINTS AWARDED. 5 TO 10 POINTS HAD THE HIGHEST READING EARNESTLY COMPLETED.

Points awarded	Average completion	Average earnestness	Average earnestly-completed
0	53%	92%	50%
2	90%	86%	77%
5	93%	89%	**83%**
10	94%	95%	**89%**
17	88%	72%	64%
20	94%	86%	80%

For reading completion, nearly any number of assigned points—as little as 2 course points—seemed sufficient to achieve completion of about 90%. Note that 100% completion is not expected due to some students skipping low-value items like readings, homeworks, or even quizzes, and due to some students who drop the class but remain subscribed to the material. As such, 90% completion is quite high. The conclusion here is that students merely need a small number of points to tip the scales in favor of students taking the time to do the reading activities.

With respect to earnestness, the student earnestness remained quite high, around 86% for classes that awarded some points for reading (versus 92% for classes that awarded no points). This value is also quite high, because not all "Show answer" clicks are due to not trying; some are due to legitimately not knowing how to answer a question. As such, one sees that awarding points seems to have little impact on earnestness.

Of course, such earnestness is dependent on the quality of the questions. We have observed in the past that questions that are confusing or unreasonably hard have low earnestness ratings. Likewise, questions that are viewed by the student as repetitive/drill have lower earnestness. Via earlier analyses, we have elimated most of both such kinds of questions from our material.

Based on these findings, we recommend assigning between 5 and 10 course points for reading completion. Although 2 points seems to be sufficient, we note that such a small number may be viewed as odd by students. More than 10 points is reasonable but may not be necessary, with such points being reserved perhaps for assessments (written homeworks, quizzes, exams, projects, etc.).

Many factors other than the number of points awarded can affect completion and earnestness. For example, a class that is on a topic for a particular major and taken mostly by students in that major is likely to have higher completion and earnestness; such was the case for the class awarding 10 points, for example. In contrast, a class that is taken mostly by students in a major differing from the class' topic are more likely to be less earnest due to not being as vested into learning the subject matter; such was the case for the class awarding 17

points (a class on programming for non-computing majors). Other factors may include: the instructor explaining the benefits of the reading assignments; the instructor painting the reading material in a positive light such as, "This is modern learning material that's been shown to really help students learn."; the amount of workload that the class gives; and the quality of the lectures.

Future work may seek to account for the instructor, such as including many different instructors in each point awarding category. Future work also includes continued data collection and analysis to determine other impacts on completion and earnestness. A similar analysis of student work completion and earnestness may be conducted with massive open online courses, commonly referred to as MOOCs.

VI. Conclusion

Interactive learning material is becoming more readily available to instructors as a replacement to a textbook. A common question is how many points should be awarded to insure the students complete the reading assignments. We found that very few points are sufficient to yield high completion rates of about 90%, while earnestness remained high. Based on the analyses, we recommend awarding between 5 and 10 points for reading completion. Awarding fewer points may be viewed as odd by students and awarding more points may not be necessary.

Acknowledgment

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