

Will Students Earnestly Attempt Learning Questions if Answers are Viewable?

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Abstract

Modern online learning materials may include built-in learning questions that are used for some of a class' homework points. To encourage learning, question solutions may be easily available to students. We sought to determine to what extent students earnestly attempt to answer learning questions when solutions are available via a simple button click. An earnest attempt means to try answering a question at least once before viewing the solution. We analyzed data from 550 students in four classes, at a four-year public research university, a four-year public teaching college, and two community colleges. We found average earnestness was a rather high 84%. We also found that 89% of students earnestly attempted 60%-100% of questions, with 73% earnestly attempting 80%-100%. Only 1% of students blatantly "cheat the system" by earnestly attempting less than 20% of questions. Thus, the heartening conclusion is that students will take advantage of a well-designed learning opportunity rather than just quickly earning points.

We noted that earnestness decreased as a course progressed, with analyses indicating the decrease being mostly due to tiredness or some other student factor, rather than increasing difficulty. We also found that analyzing per-question earnestness can help question authors find questions that need improvement.

In addition to providing results of our earnestness analysis, this paper also describes the style by which the learning questions were made -- how they complement text, teach rather than test, take only a small amount of time each, always include explanations, strive to occasionally "trick" students to explicitly dispel common misconceptions, avoid drill/kill and instead each teach a unique concept, create questions where alternative right answers are less likely to be marked wrong, and more. Via such design, students seem to discover that the questions are worth their time and effort, and thus most students earnestly try. We also discuss processes that can hurt earnestness, such as assigning excessive work. We describe our philosophy of not limiting student attempts for such learning questions, to create a safe learning environment (whereas other activities may indeed benefit from limits).

I. Introduction

Modern interactive textbooks may include questions as part of the learning (formative assessment). Such learning questions are commonly assigned as homework. One type of learning question is the short-answer question, containing an input field for the student's answer, a "Check" button to submit the answer, and a "Show answer" button to reveal the correct answer. For students to receive credit, the student must submit a correct answer. There is no limit to the number of attempts a student can make. An incorrect answer yields a hint. A correct answer awards credit and also displays an explanation. A somewhat unique feature is that "Show answer" shows the answer and the explanation (without awarding credit), and no penalty exists for first showing the answer and copy-pasting to the input field.

Instructors commonly ask us: If students can show and copy-paste the answer to receive credit, won't most just do that to receive homework credit, without earnestly trying? This paper provides data from real usage to help answer that question.

Fig. 1. Three short-answer learning questions. Each question contains an input field, a "Check" button, and "Show answer" button. Instant feedback is given when a user presses the "Check" button, either correct plus an explanation (as in 1 below), or wrong with a hint (2). The student can press "Show answer" to see the answer and explanation.

#	Question	Your answer
1	Write an assignment statement to assign 99 to numCars. ✓ numCars = 99; The program will store the value 99 into the variable numCars.	numCars = 99; Show answer Check
2	Assign 2300 to houseSize. ✗ houseSize = ____ ; Don't forget the ;	houseSize = 2300 Show answer Check
3	Assign the current value of numApples to numFruit. numFruit = numApples; The program will read the value of numApples, then store a copy of that value into numFruit.	 Answer shown. Show answer Check

II. Background

Several academic groups ^{1,2,3} have conducted research on student cheating and concluded that students justify cheating by the benefits of the outcome. Students are tempted to cheat more if

they feel that their grade depends on how well they do. Students surveyed by Newstead ¹ suggest that students are motivated by whether they are studying to learn or studying for good grades.

The factors of cheating in an offline environment had been widely studied by different academic institutions ⁸⁻¹¹. The factors that were mentioned focused on examinations and homework assignments that did not have any reference to topics being asked. Students tended to cheat more on examinations and homework assignments where the questions or problems were not referenceable. Students that did not understand what the question was asking tended to cheat by copying from another student. Another factor that was discussed by ¹⁰ explained that students do not see certain acts as cheating. Students were unsure what constitutes as cheating as compared to an instructor's point of view of cheating. Students assume that certain tasks such as asking another student for the correct answer to help check their work is a socially accepted, whereas an instructor sees it as cheating because the student copied an answer from another.

An economics education institute ⁷ studied the effects of student effort and performance over the semester. They studied the relationship between student effort measured by the hours spent on various course activities, and their performance over the semester in an intermediate macroeconomics course. Their findings showed that students starting the course tended to put a large amount of effort into the course and once they received an examination score they realized how much effort was required to accomplish the grade of their liking. Students tended to put less hours into the course as the course went on because they discovered that they did not need to try as hard and grew tired of putting extra hours into the course with no noticeable benefit in their grade.

Automated homework systems are a growing trend in education as they free up instructor time to focus more on teaching rather than grading.¹⁸ Several companies have built homework systems, such as: CodeLab, WileyPlus, MasteringPhysics, MathXL, Connect, WebAssign, and zyBooks. ^{4, 12-17} This paper uses zyBooks to establish an earnestness metric.

zyBooks are a form of interactive learning material (intended to replace textbooks and homework systems) that have various interactive activities ranging from animations, interactive tools, and learning questions ⁴. The material records student activity and presents instructors with a dashboard summarizing student completion of activities, which instructors commonly use for some homework points. Activities in zyBooks focus mainly on content that is being taught, which allow students to readily reference the content as they answer learning questions. zyBooks records whether a student reveals an answer for a learning question. By analyzing this information, we can calculate how many learning questions a student did not attempt even once before revealing an answer.

III. Data / Participants

Data for this study was obtained after semester completion involving 553 students across four classes at four different colleges. All participants were enrolled in similar “Introductory to Programming in C++” courses offered in Fall 2014 using the same zyBook ⁴. Students were not aware of the conditions of the study. Specific student demographics are not available. The four colleges involved in this study were broken down into three classifications:

- Public research university: 4-year college that offers a full range of baccalaureate programs. Committed to graduate education through the doctorate and give high priority to research. As classified by ^{5,6}.
- Public teaching university: 4-year college that offers a wide range of baccalaureate programs. Typically a state college.
- Public community college: A nonresidential community college that offers courses to people living in particular areas. Offers 2-year associate degrees.

Students were then separated based on their college’s classification. Table I shows the number of students per classification.

TABLE I. Number of students for each college classification.

College type	Number of students
Public research university	379
Public teaching university	117
Public community college	57

IV. Methods

A. Student earnestness

We define an earnest answer as is an answer in which the student first makes an attempt, before revealing the answer. A student’s earnestness is calculated by the following:

$$Earnestness = \frac{Questions_{attempted}}{Questions_{total}}$$

Questions_{attempted} is the number of learning questions for which a student made at least one attempt before revealing the answer. Questions_{total} is the number of learning questions the student answered.

We defined five earnestness categories:

- Highly earnest: 80%-100%
- Moderately earnest: 60%-80%
- Moderately unearnest: 40%-60%
- Highly unearnest: 20%-40%
- Cheating the system: 0%-20%

B. Student earnestness through the course

The average earnestness was calculated for each individual learning question for each college classification. Questions were ordered in our analysis based on the order they were presented to the student. We plotted the averages, and noticed a decline in earnestness as students progressed through questions.

Two factors were considered that might have affected student earnestness:

- Tiredness factor: Easy learning questions at the end of the semester may have lower earnestness than easy learning questions early in the semester due to student tiredness (or busyness). To calculate a tiredness factor, we divided the questions into two equal halves: the first half of questions a student encountered, and the second half of questions encountered. We then picked 10 questions from each half with the highest earnestness. We averaged the earnestness for the 10 questions in each half and took the difference between the two percentages as the tiredness factor. Another contributing factor to tiredness is the student effort factor which was studied by ⁷. Student effort decreases throughout the course because students start to understand how much effort is required to receive the grade they desire.
- Difficulty factor: The intrinsic difficulty of the material presented to students tends to increase through the semester, which may lead to a general decrease in earnestness. To calculate the difficulty factor, we took the average earnestness of all the learning questions in each half, as with tiredness factor. Then we subtracted the tiredness factor from the difference between the two to obtain the difficulty factor.

C. Explain troughs in earnestness

Certain discovered learning questions had much lower earnestness than surrounding questions, defined as trough questions. A trough question may be caused by the question being challenging, having unclear instructions, or time consuming. We constructed a list of all trough questions.

We conducted a study with two instructors by presenting the trough questions and questions with high earnestness. Each instructor was given the task to rate each question with a difficulty of

easy or hard. This study was to check if these questions were potentially badly-formed questions or just difficult questions.

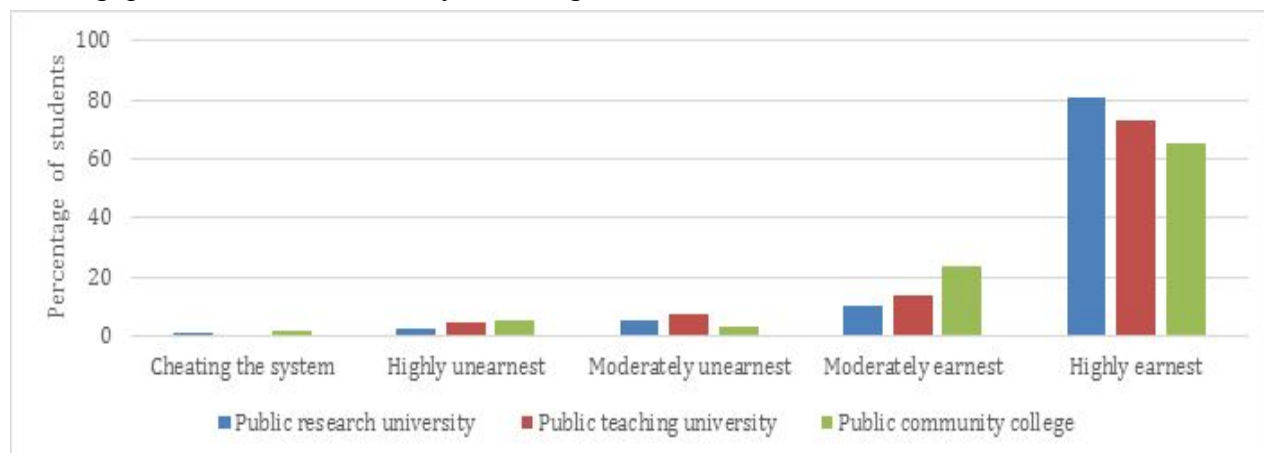
V. Results and Discussion

This section assesses student earnestness, as this paper is analyzing that metric. We categorized earnestness by the types of colleges to see whether any college was much different; later work may compare college types more completely.

A. Student earnestness

As shown in Figure 2, over 85% of students were in either the highly earnest or moderately earnest categories. Also, fewer than 2% of students were blatantly cheating the system. This indicates that in fact, most students diligently work through the assigned reading. Further, the level of earnestness was roughly consistent between college types.

Fig. 2. Percentage of students in each group of earnestness. Most students are highly earnest. Our results show that earnest students make up more than 85% of the class in all three college classifications. Less than 2% of students cheat the system by almost always not attempting learning questions and instead only revealing the answer.



The public research university had an 87% average earnestness, the public teaching university had an 85%, and the public community college had an 81%. We did not analyze the statistical significance due to a small sample of colleges ($n = 4$).

B. Student earnestness through the course

In Figure 3, we grouped learning questions ordered by appearance in the interactive material into 6 groups. Each group contained 40 activities, except the last group contained 38. Students across all three college classifications showed a declining trend in earnestness during a course. This

might be expected as student get tired through the term, and this might be expected due to student's other courses becoming more busy.

Each college type has a similar earnestness during the first 3 groups. During group 4, the public community college students seem to have a larger decline than the other two college types; this stronger decline should be investigated in later work. A possibility is the difference in student and instructor demographics.

Fig. 3. Average earnestness per learning question group following the ordering presented to the student. Each group contains 40 activities, except Group 6 contains 38.

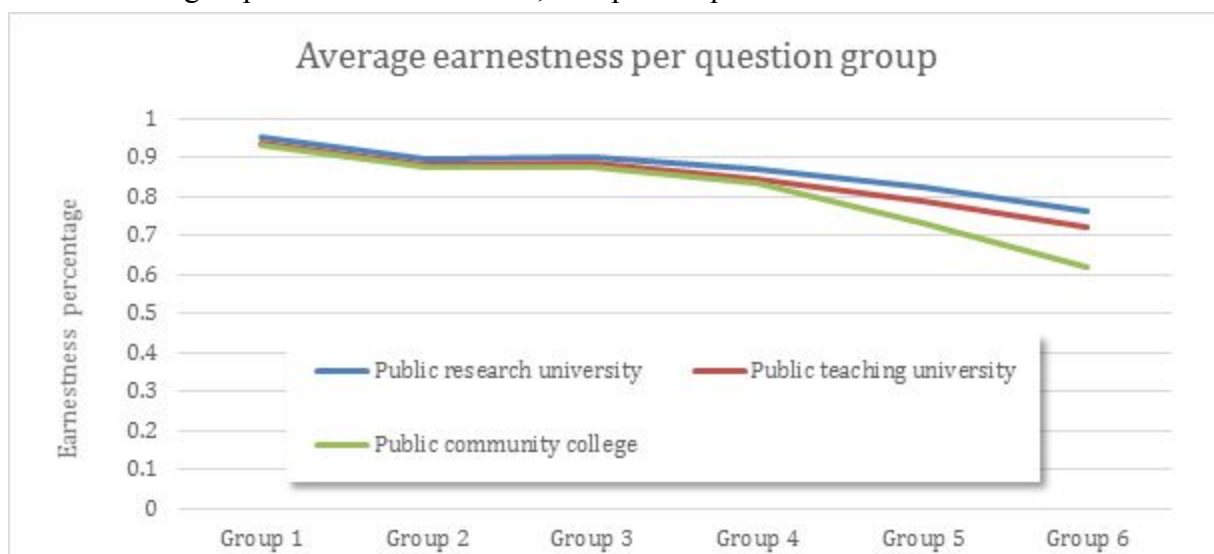


Table II shows the calculated tiredness and difficulty factor for each of the three college classifications and an overall tiredness, and difficulty factor. The tiredness factor was larger than the difficulty factor across all 3 college types. The larger tiredness factor indicates that students were getting tired or busy through the term rather than the content becoming more difficult.

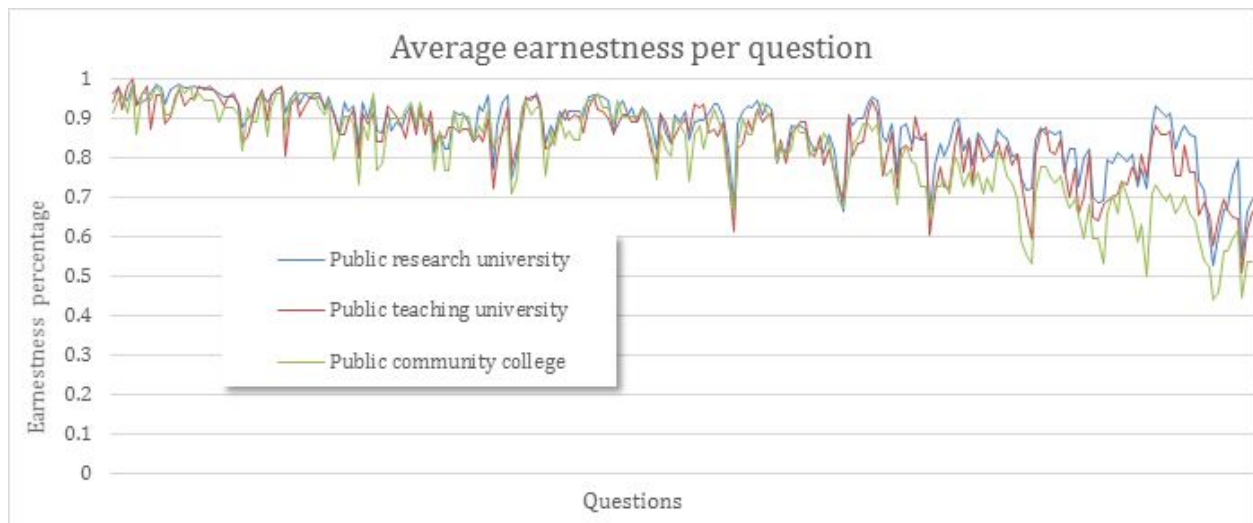
TABLE II. Percentage of earnestness decrease due to tiredness vs. difficulty.

College type	Tiredness	Difficulty
Public research university	5.8%	3.9%
Public teaching university	10.3%	1.1%
Public community college	12.7%	3.5%
Overall	9.6%	2.9%

C. Explaining troughs in earnestness

As shown in Figure 4, some learning questions have abnormally large declines in earnestness compared to that question's neighbors, such questions are called trough questions. Note that the different college types often correlated in the abnormally large declines, though exceptions exist. A trough question may be due to a tricky question, wherein the student is deliberately tricked, or a bad question that is confusing or incorrect.

Fig. 4. Average earnestness per learning question group ordered as presented to the student.



We examined the large decline learning questions carefully and noticed that these questions were all bad questions. For example, the first question in Figure 5 was presented as one of the large declines in earnestness. We identified the question that students did not know how to answer. Students first showed the answer and were then able to effectively answer the subsequent question(s) without showing the answer. Questions where all three college classifications showed large declines were easily identified as bad questions.

Fig. 5. Example: Learning question 1 had a low earnestness, whereas question 2 had a high earnestness. Likely, students were unsure how to answer the question, indicating question 1 was bad.

Determine the result. Type "Error" if the program would terminate due to division by 0. Only literals appear in these expressions to focus attention on the operators; most practical expressions include variables.

#	Question	Your answer
1	13 / 3	<div><input type="text"/></div> <div>Show answer Check</div>
2	4 / 9	<div><input type="text"/></div> <div>Show answer Check</div>

This work indicates that the earnestness metric may be used to automatically identify bad learning questions. Such automation may be valuable to question authors, who can improve empirically worse questions.

The earnestness metric indicates that most students diligently work through the assigned reading. Further, blatant cheaters of the system are automatically identified. Future work might investigate methods to discourage such behavior.

Student earnestness declined a bit through the term as might be expected. Perhaps the decline is due to increased levels of tiredness. Future work should investigate the impact of tiredness and difficult factors across the term. Also, the tiredness factor may be due to decreased levels of student motivation through the term, as described by Krohn and O'Connor ⁷.

VI. Conclusion

When presented with good quality learning questions, the vast majority students will earnestly try to answer those questions rather than just looking at the answer to more quickly gain credit. Student earnestness decreased during a course, mostly due to tiredness (or a similar factor) rather than due to question difficulty. Large dips in a question's earnestness average compared to surrounding questions usually indicates a poorly-formed question, or a student not knowing how to answer the question, both of which can be remedied through question improvement and an example question. Students at various kinds of universities displayed similar earnestness.

Future work includes analyzing the tiredness and difficulty factors over time, as students are likely less tired early in the course and course content is likely less intrinsically difficult early in the course. Future work might also compare easy vs. difficult courses, subject matter (e.g., engineering vs. math), and student demographics. Further, students may be surveyed on their

earnestness to validate the earnestness metric, though challenges exist due to self-reporting bias and small percentage of blatant cheaters. To increase earnestness, one possibility is using randomly-generated short answer questions, which would mitigate the sharing of answers.

Acknowledgements

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