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# Helping Students Develop Better Skills in Solving Word Problems

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# Helping Students Develop Better Skills in Solving Word Problems

## Introduction

Students often say they know how to solve the equations and it is just that they have trouble with "word problems." The problem is, of course, that in engineering, virtually all problems are word problems. Because of the advent of inexpensive, powerful computers to crunch numbers, it is now very important that people be able to correctly interpret and express technical information. However, empirical evidence shows that students' ability in this area has declined, rather than improved. This paper describes some specific issues in math literacy and the use of technology to address them. Examples are drawn from a junior-level data analysis course having a large fraction of international students. However, these issues are common in most engineering courses and occur among domestic as well as international, students. For a number of reasons, this report is anecdotal, though some indications of success are presented.

## Background

A major engineering function is to represent elements of the world with mathematical models, use those models to answer questions, and then interpret results in light of the real-world problem. For example, "Is this beam string enough?" requires modeling the beam itself, the probable stresses on it, and then using strength of materials to determine if anticipated stresses would exceed the beam's limitations. Because instructors, out of necessity, compel engineering students to carry out the mathematical calculations by hand, students tend to focus on those calculations. However, nowadays, computers do the actual calculations. Thus, the primary functions of the engineer are to select the proper model, input the proper data, check the output, correctly interpret it, and then properly implement the solution.

Math literacy plays an important role in helping students develop these skills. Engineering instructors employ various mathematical constructs, such as graphs, tables, equations, and charts, to describe situations and concepts. Exercises and exams employ similar constructs to present situations. There is the implied expectation that students comprehend these constructs. If students fail to answer a question correctly on a test, it is presumed they didn't know how to solve it. However, what if the students did not understand the mathematical constructs in the question? If math literacy is poor, how can students be effectively taught engineering concepts or be rationally evaluated?

Unfortunately, many engineering students are not highly-skilled in math literacy[1, 2]. Perhaps, this is because this skill is in the overlap between English and mathematics[3] and, as a result, is not addressed as fully as is could be. Whatever the reason, the weakness is evident in the results of the *Programme for International Student Assessment* (PISA) assessments. The tests, scored on a 1000-point scale, assess 15-year-old students' abilities. They have been held every three years since 2000, with the latest being in 2012. The 2012 test included over 500,000 students in 65 countries or economies[4]. As shown in Figure 1: US and OECD PISA Scores 2000-2012, US students have performed at about the average among the *Organisation for Economic Co-operation and Development* (OECD) countries. These reports are quite detailed and people can argue over rankings, but a lot can be inferred by looking at the individual problems.

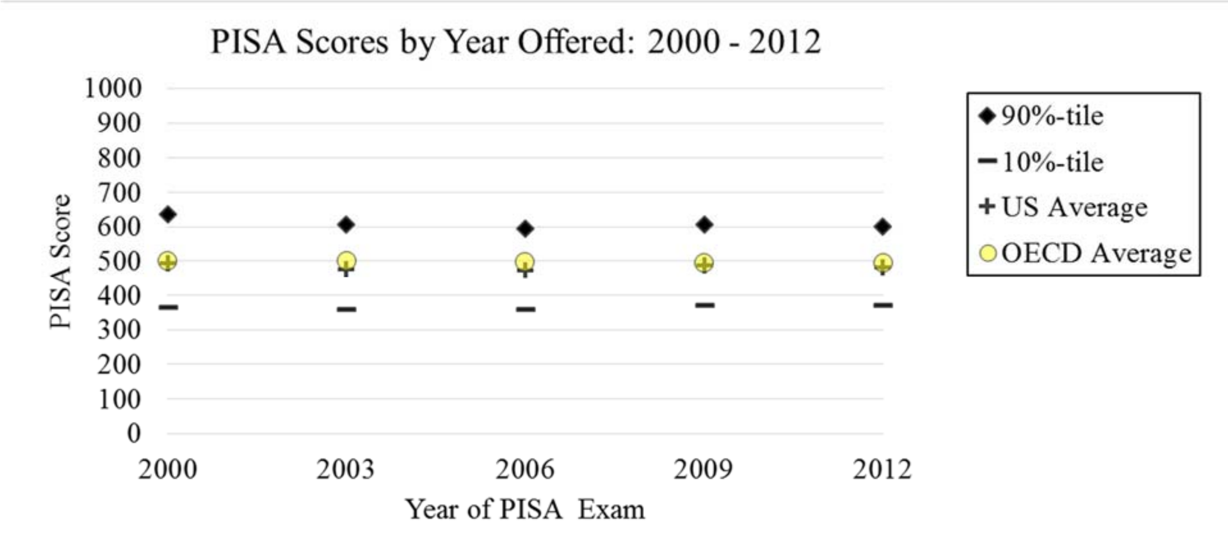



Figure 1: US and OECD PISA Scores 2000-2012[4-8]

For example, Figure 2 shows a sample mid-level (Level 3) question from the mathematics section of the 2012 test. To answer this question correctly, the student must interpret the table and rank four decimal fractions. US students correctly answered questions at this level 48% of the time. The OECD average is 55%. At level 4, 25% of the US students correctly answered the questions, compared to the OECD average of 31%. At level 5, 9% of US students were correct, while the OECD average was 13%[7]. Even though the OECD averages are slightly higher, The US and OECD 10$^{th}$ and 90$^{th}$ percentiles are virtually the same. As noted in Figure 1, the differences from year to year are small, compared to the overall distribution of scores.

Chris has just received her car driving license and wants to buy her first car. This table below shows the details of four cars she finds at a local car dealer.

| Model: | Alpha | Bolte | Castel | Dezal |
|---|---|---|---|---|
| Year | 2003 | 2000 | 2001 | 1999 |
| Advertised price (zeds) | 4800 | 4450 | 4250 | 3990 |
| Distance travelled (kilometres) | 105 000 | 115 000 | 128 000 | 109 000 |
| Engine capacity (litres) | 1.79 | 1.796 | 1.82 | 1.783 |

QUESTION: Which car's engine capacity is the smallest?

a) Alpha
b) Bolte
c) Castel
d) Dezal

Figure 2: Sample Mathematics Question[9]

Of course, these are 15-year-old students and those who go to college will probably be more proficient by the time they get there. However, the PISA results do indicate that the students in the USA are not doing as well as they could be. This is primarily an issue for k-12 educators and there are some efforts to rectify the situation[10]. However, because there is a great deal of controversy over this matter, it can be expected that some school districts will not address these issues. After all, this issue was addressed in the past[11-13] but action was not uniformly effective[14]. In short, it is reasonable to expect that some students in undergraduate engineering classes will have this sort of weakness[1, 2].

Beyond the ability to analyze and solve word problems, students also suffer a disadvantage in abstracting principles from solutions due to a weak ability to verbalize key concepts. When students are asked how they know an answer is correct, responses are often vague and sometimes reveal that the student has a completely incorrect perception of the problem. Even if a student knows precisely why the answer is correct, failure to verbalize the facts means the student will have difficulty remembering it later. This difficulty often leads to subsequent errors when students attempt to adapt a method to a slightly different problem.

This is further complicated by the fact that what might lead to understanding in one student might simply confuse another. Understanding is a very individual thing and a students' problem-solving is more reliable when he or she is able to draw on familiar analogs and ways of thinking. This idea is borne out by the fact that successful problem solvers use a variety of methods to analyze and solve problems, rather than relying on a single method[15, 16]. It would be difficult for an instructor to teach multiple methods of solving every problem, but it would be helpful to encourage students to explore different methods on their own[17].

Of course, a student lacking the skill to solve problems, such as that in Figure 2, would have difficulty solving engineering problems, but the impact is more basic than that. Engineering professors tend to use examples employing tables, charts, graphs, and other non-textual means of communication that may not be understood by a large fraction of the class. As a result, what appears to be students' misunderstanding of the course content may actually be students' misunderstanding of the communications[18]. This is exacerbated when a student is less familiar with the language[19]. Finally, this breakdown in communications introduces uncertainty in assessment. Engineering professors want students to know how to design bridges that do not fall down, but it is not possible to know whether students have that knowledge or not if students' ability to communicate their knowledge is uncertain[18]. This may also explain why an instructor may ask, "What is one plus one?" and the students reply, "Green!" Somewhere along the line, there is a failure to communicate.

## Pólya's method

George Pólya first published How To Solve It in 1957, then updated it in 1973. The current edition was published post humorously in 1988[20]. This little book was aimed primarily at teachers and promoted the idea that students could learn problem-solving by developing their own proofs in geometry classes. Briefly, the problem-solving method consists of four steps:

1. Understanding the problem
2. Devising a plan
3. Carrying out the plan, and
4. Looking back.

In Pólya’s teaching method, the instructor facilitates the students’ attempts to solve problems by suggesting ideas that would eventually occur to the student. The book also contains a table of general hints which the student can refer to.

Although How to Solve It was set in the geometry classroom, both the problem-solving method and the teaching method have been adapted to solving problems in many science, engineering, and mathematical settings[21-24]. The author of this paper has been using Pólya’s method in problem-solving and developing students’ problem-solving skills since 1962. It can be effective, but should be reserved for non-trivial problems and does require monitoring and guiding students at the start.

Generally, students initially need a lot of help with Step 1. Step 2 is not difficult, but students need to be encouraged to not go with the first idea. This seems to be best developed in student teams. That is, it is easier for several students to come up with alternate plans than one student working on his or her own. Students generally have little trouble with Step 3, but often forget Step 4. In instructional settings, this step is important because each problem will contain at least one lesson. Doing the work, but not identifying the points to be learned is simply a waste of time. Another important aspect of Step 4 is checking the reasonableness of the answer. Finally, developing the habit of carrying out Step 4 is beneficial in an engineer’s career because it assists the engineer in developing greater knowledge and skill and helps avoid costly blunders[25, 26].

This paper proposes a use of Pólya’s method that has not been widely studied. In Step 1 of Pólya’s method, a student would abstract pertinent facts from the problem and put them into a form he or she can relate to better. Thereafter, the student can refer to the abstraction, rather than the original problem. This may be an additional benefit for students who have difficulty with language, whether due to a specific learning disability or due to English not being their primary language. Because this step isolates the process of abstracting information from the rest of the process, it could reduce the impact of limited math literacy on the rest of the student’s efforts to solve the problem. There is also an emphasis on Step 4 for similar reasons.

## Brief course history

Typically, about 80% of the students taking this course are transfers from other majors. Thus, students often have a wide range of knowledge and skills. For that reason, the author has always used a beginning-of-course survey to assess students’ prerequisite knowledge. However, since 1997, inspired by Paskusz[2], the author has also addressed some basic math literacy skills. For example, one survey question is:

> Which of the following expressions conveys the idea that there are twice as many red balls as yellow balls in a box? Use $R$ to represent the number of red balls and $Y$ to represent the number of yellow balls.
>
> a) $2R = Y$  b) $R = 2Y$  c) either a) or b)  d) neither a) nor b)

About half of the students answer “a” and half “b.” Statistically speaking, that means nobody knows. Certainly, students that are unable to parse this simple mathematical statement will have a great deal of difficulty dealing with typical situations in data analysis. For that reason, this and other basic problem-solving issues have been addressed in this course since 1997.

As shown in Figure *3*, there has been a recent sharp increase in the number of international students in the data analysis course. All have studied English to some extent, but some are not as comfortable with English as others are. This adds a further complication to the issue of problem interpretation, as well as one of assessment. Figure 4 shows a question from a test administered in 2014. As illustrated in Figure 5, 75% of the international students completely misinterpreted the instructions. Almost all of those students correctly looked up a normal probability (part d) of that question in another part of the test. Students staed that while they could have worked out the instructions, given enough time, they had run out of time, so they just gave a wild guess or did not answer the question. This sort of thing complicates assessment in that while the question was intended to measure students' ability to use statistical tables, for some students, it was a test of English proficiency.

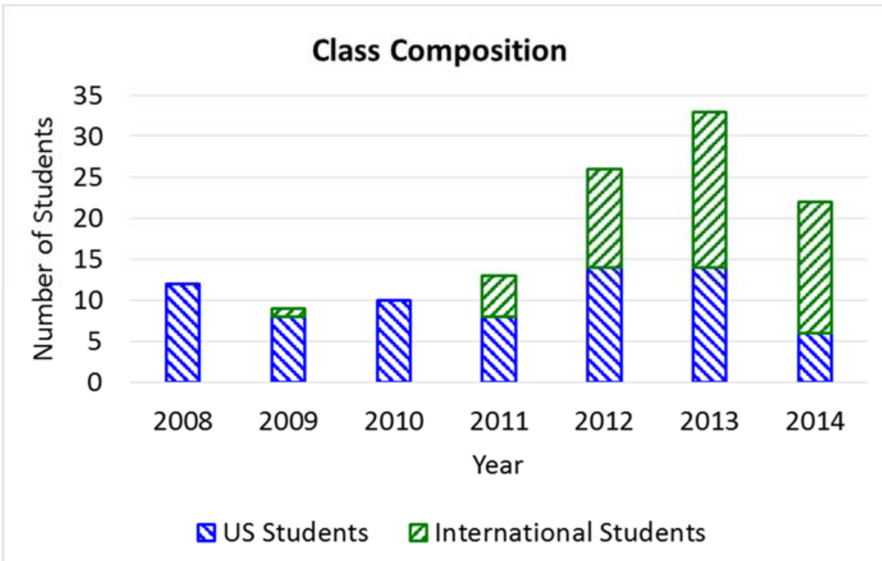



Figure 3: Class Composition 2008 – 2014

Determine the following probabilities. Each correct response is worth 3 points. **Hint**: most of these involve the statistical tables.

a. P(X ≤ 3) if X ~ binomial with n = 10 and p = 0.2.

b. P(X ≤ 10 hours) if X ~ exponential with E(X) = 5 hours.

c. Pr(X ≤ 4) if X ~ Poisson with E(X) = 5

d. Pr(X > 3.5) if X ~ Normal with μ = 5 and σ = 2.

Figure 4: Question from Test 3 in 2014

The rest of this paper focuses on efforts to deal with math literacy and related problem-solving issues in a junior-level first course in data analysis. The examples, of course, are from probability and statistics, but the focus is on dealing with the language barrier to improve instructional efficiency and develop students' problem solving skills. The techniques are mainly based on Pólya's Method[20], with adaptations to the engineering discipline similar to those described in several references[18, 21, 24, 27]. In addition, the focus is on the use of computer technology to facilitate this process. Because the class size is small and there are so many side issues, the paper is anecdotal in nature. Nevertheless, there are some indications of what seems to work and what does not. One result of note was that efforts to make the course more accessible to the international students also seemed to help the US students do better.

Determine the following probabilities. Each correct response is worth 3 points. **Hint:** most of these involve the statistical tables.

a. $P(X \leq 3)$ if $X \sim$ binomial with $n = 10$ and $p = 0.2$.

b. $P(X \leq 10 \text{ hours})$ if $X \sim$ exponential with $E(X) = 5$ hours.

c. $Pr(X \leq 4)$ if $X \sim$ Poisson with $E(X) = 5$

d. $Pr(X > 3.5)$ if $X \sim$ Normal with $\mu = 5$ and $\sigma = 2$.

Figure 5: Type of Response from 12 of the 16 Foreign National Students

Online quizzes

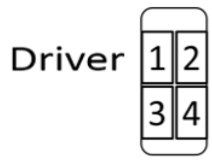
This course is primarily face-to-face and originally quizzes were given in class. In 2013, the in-class quizzes were moved to the Canvas Learning Management System (LMS)[28]. Moving the twelve weekly quizzes to online saved approximately four hours of class time. In addition, the online format presented options not practical in the classroom. One main change is that students may take each quiz up to three times over a two-day period.

- Because students get three attempts, the online quiz questions are more difficult than those on the prior in-class quizzes.
- Many questions focus on Step 1 or Step 4 of Pólya’s method, which are areas in which most students have the lowest skill levels.
- Some questions address math literacy issues.
- Because questions are changed on each attempt, students are encouraged to improve their skill, rather than simply finding correct answers by elimination.
- When students select incorrect answers, they get hints to help them find correct answers.
- As described below, some questions allowed the instructor to examine, in detail, the students’ problem-solving processes.
- Most quizzes provided an opportunity for students to express concerns about current topics
- Students who took the quiz prior to the start of the second class in the week got full credit. Attempts taken after that class were penalized 10%. This was done to encourage better preparation for class.

Although the questions were more difficult, students did better than with the prior in-class quizzes. Due to the uniqueness in open-ended responses, it appears the increase reflects improvements in understanding, rather than collusion. In addition, the quizzes provided an additional learning opportunity and a way for students to alert the instructor to topics they did not understand well.

In about half the quizzes, the students were asked to provide additional information on their thought processes. On each attempt, the instructor commented on the stated reasons and provided feedback to move the student in the right direction. For example Figure 6, shows a question from an early quiz that addresses Step 4 of Pólya’s method. The four versions of this question are identical, except for the listed responses. Each time a student attempts a quiz, he or she gets one of these four questions at random.

You (A) and three of your friends (B, C, and D) are going to Carlsbad Caverns in your car. You and friend B can drive, but the others cannot. Below is a diagram of your car. Position 1 is the driver's position.




Below are some vectors that indicate seating arrangements. For example, (A,B,C,D) indicates that A is driving, B is in seat 2, C is in seat 3 and D is in Seat 4. Indicate all seating arrangements that are valid, given the information above.

- ☐ (B,C,A,D)
- ☐ (C,B,A,D)
- ☐ (A,B,C,C)
- ☐ (A,B,D,C)

Figure 6: Example Quiz Question

Why do you feel your answer to Question 1 is correct?

**Notes:**

1. If you retake the quiz, question 1 may change, so a correct answer here may change, too.
2. Wait for me to grade this question prior to attempting the quiz again.

Figure 7: Follow-up Question

The follow-up question in Figure 7 is always the same. Possible outcomes are:

1. The answers to the first question are correct and the reasoning in the follow-up is sound.
2. The answers to the first question are correct, but the reasoning in the follow-up is either incomplete or incorrect.
3. The answers to the first question are not all correct, but the reasoning in the follow-up is consistent with the incorrect answers.
4. The answers to the first question are not all correct and the reasoning in the follow-up is inconsistent or incomplete.

The instructor grades the first question on the basis of correctness, but the second question in terms of its correctness, completeness, clarity, and relation to the answer in the first. So, in cases 1 and 3, students get full credit for the answer in the follow-up question. However, in case 3, the instructor explains that while the reasoning is consistent with the first answer, the first answer is not correct. In cases 2 and 4, the instructor gives feedback on why the answer to the follow-up is not consistent. Here are some examples:

- Q1's answers are correct,
  - but the answer to the follow-up is, "Only A or B can drive.
  - Instructor's response: Why didn't you select the third option, (A, B, C, C)?
- Selected (B, C, A, D), but not (A, B, D, C).
  - Follow-up answer was, "Because all the other answers except the answer I choose they put B in the back and B is the driver who should be in the front (sic)."
  - Instructor's response was, "You explained correctly what you did, but you got part of Q1 wrong. Please read the question more carefully next time.
- Q1's answer is correct
  - Follow-up answer is, "I think my answer to question is correct, since only two people can drive A (me) and my friend B. The only possible people to be located on the first integer in the vector is A and B, that is why I chose this answer."
  - Instructor's comment, "The third choice has A in the first position. Why did you not choose that one?
- Same student, after a later correct answer to first question
  - Since only A and B can drive the only seating arrangement that can be done is my answer. The other vectors shown included some seating arrangement where people had more than one seat. Or people who cannot drive in position 1 (drivers seat).
  - Instructor's comment, "I can figure out what you mean, but your answer is not clearly stated." (Worth more credit than the first answer, but not full credit).

Students sometimes demonstrated different, but correct thinking. For example, for the third choice, most students stated something like, "A person can't be in two seats at the same time." However, one said, "Everybody is supposed to be on the trip and only three people are in the car." The instructor confirmed correct answers, even if they were not the expected answers. Generally, students who engaged in this activity converged on correct answers to both questions.

International students seem more willing to converse via computer mediation than face-to-face. In face-to-face conversations, issues of vocabulary and pronunciation, add to the technical issue the student is concerned about. When using computer mediation, have more time to deal with the language issue and can focus more on the technical one. In addition, many of these students seem to have better reading and writing skills than listening and speaking skills.

A second type of question is less labor-intensive. This type asks the students to select correct responses from a list. If a student selects an incorrect response, he or she will see a comment, usually in the form of a question. For example, the following question addresses a chronic failure of students to identify random variables as part of Pólya first step.

> **Question:** An experiment consists of repeating independent trials until you get three successes. The random variable is the number of failures that occur prior to the third success. The probability of success on each trial is p. What kind of random variable is this?

- a) binomial
- b) hypergeometric
- c) negative binomial
- d) Poisson

For each of the incorrect answers, the student will see an appropriate comment.

- **Binomial:** Don't you need to know the number of trials in advance for the binomial?
- **Hypergeometric:** Are trials independent in the hypergeometric distribution?
- **Poisson:** What does the random variable in this problem represent?

In different versions of this question, students will see different situations. In addition, the hints for the same wrong answer may differ. For example, in the case of the Poisson, another hint could be, "How is the Poisson different from all other discrete random variables we study?"

Because this type of question is graded automatically, students do not have to wait for the instructor's comments. As in the case of the first type, students get different questions from a bank of related questions, so they usually do not see the same question again. However, the hints remind the students of specific facts which may still be helpful in a different question. This type of question frequently addresses aspects of math literacy and involves some form of abstraction, rather than simple factual recall.

Classroom attendance issues

Some of the international students arrive on campus after the start of classes and miss the first one or two classes. There are a variety of reasons this might happen, but the main issue is that they missed the initial activities. This is a big problem because aspects of math literacy are addressed in those two classes. Also, a moderate fraction of the international students have a lackadaisical attitude towards attendance.

The Canvas LMS has an interesting way of computing grades. The instructor sets up categories and indicates the weighting of the category. After that, the instructor can add quizzes, assignments, and graded activities to the category. So, if a category is worth 10%, has a total of 200 points, and a student has a score of 180 points, that student gets $0.10 \times 180/200 = 9$ points for that category. The instructor in the analysis course establishes at the start of the semester that class participation is worth 10% of the grade without having to specify individual items. Thereafter, the instructor can add class participation assignments to this category without having to worry about revising grade calculations.

Attendance is taken every day and the class participation scores for attendance are reported every two weeks. To deal with students arriving to campus late and students skipping key classes, the instructor created online activities that present material and activates consistent with the missed classes and then quiz students' understanding of the material. Students who attended class get full credit on the activities, but can do them if they want to. Students who have excused absences can earn up to full credit, depending on their performance, for the missed days. Students who had an unexcused absence can only get 70% of their score.

## In-class computer equipment

In 2013, the class was moved from its original room to a larger one. The new room has a computer workstation, including a document camera and projector. This opened up new possibilities. In quiz feedback, some students complained that they were unable to follow some of the instructor's examples. The TA, who is an international graduate student, felt it was because these students had more difficulty hearing English than reading English. The computer workstation allowed the instructor to introduce more redundancy into the presentation by writing on the image, using a digitizer pad and pen or typing on the image using the keyboard. This was especially useful when explaining how graphical items, such as histograms and boxplots, worked and explaining how to use statistical tables.

One issue prior to 2013 was that there were indications that some students were cheating on tests. In a few cases, the instructor and TA were able to make a clear case, but in other cases, results were simply suspicious. In an attempt to deal with this, each in-class exam was produced in four versions that appeared the same from a distance and the versions were handed out at random. Even so, the cheating seemed to continue. The instructor and TA were unable to determine the exact method, but surmised that the students were using their cell phones. The students argued that they needed them to do calculations, but even though the instructor and TA watched students closely during exams and saw no overt action, cheating still appeared to be happening. In 2013, it was announced at the start of the semester that students would not be permitted to use cell phones. As an alternative, the syllabus listed some low-cost calculators that would be adequate for tests. For example, the Casio fx300ES is capable of performing all necessary calculations and costs around $12. The indications of cheating ceased. Additionally, the students grew to prefer the calculators, which were easier to use than the cell phones.

On the other hand, students were still permitted to use cell phones during regular classes. It turned out that the more capable English speakers were texting clarifications to less capable students to improve comprehension.

## Results

Because of the small class size and the high variation in capabilities and backgrounds of the students, it would not be possible present any significant quantitative results. In addition, there is the issue of variable student participation in both optional and required activities. For example, it is important that the instructor evaluate answers to the question in Figure *7* and provide feedback between attempts. However, some students did not follow the guidelines. Instead of waiting for feedback, they just took the quiz three times in quick succession and repeated their initial errors.

Nevertheless, there were some indications of success. For example, Figure 8 shows a scatterplot of students' test average vs. class participation scores. Although $R = 0.343$ and $P = 0.06$, this could just indicate that contentious students tend to participate more in class and study harder. The situation with test scores vs. quiz grades is virtually identical: $R = 0.354$ and $P = 0.05$.

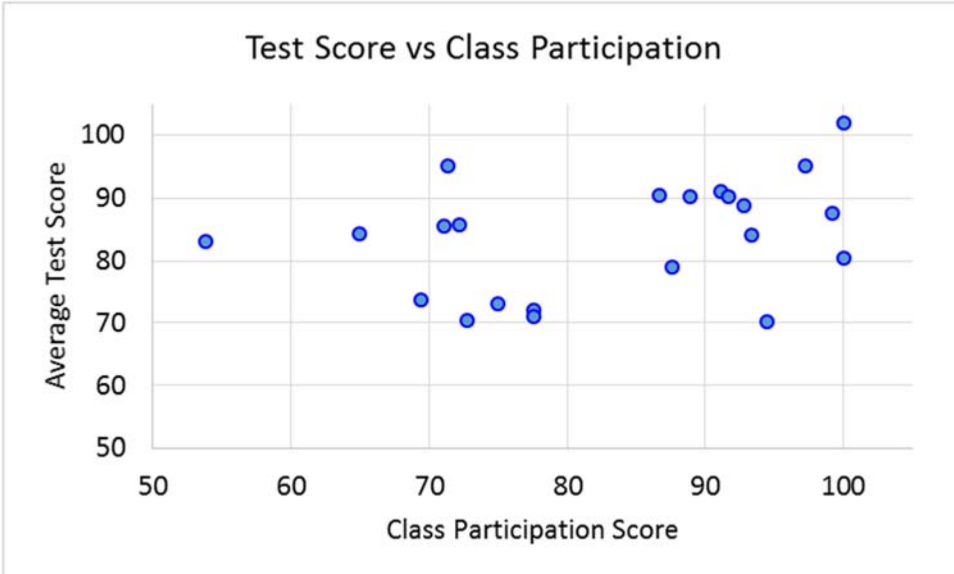


Figure 8: Scatterplot of Average Test Score vs. Class Participation Points

Figure 9 shows the average quiz score, compared to the total of all other points in the course. Both totals were adjusted to 100 points to simplify comparison. There is a surprisingly high correlation between the two scores ($R = 0.59$, $P = 0.002$). However, this probably reflects the fact that those students who skipped quizzes also tended to skip classes and skipped turning in some assignments. The fact that three students did very well in the quizzes, but got a “C” in the course indicates that there is no clear cause and effect.

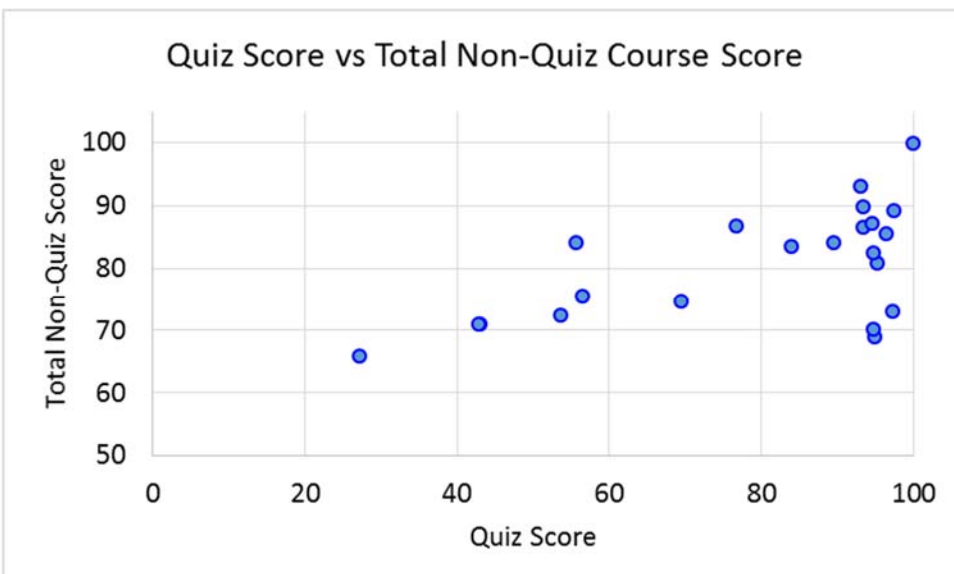


Figure 9: Quiz Score vs. Total Non-Quiz Course Score

Students who participated in the questions with instructor feedback between attempts did develop better responses and seemed to improve their grasp of those concepts, but this method involves a high level of instructor interaction. With 22 students in the class there could be a maximum of 66 attempts to evaluate per quiz. In addition, the instructor needs to check frequently since different students have different schedules. So, although this activity seems effective, the implementation method needs to be improved.

Replacing cell phones with suitable low-cost calculators was very successful. The low-cost calculators were easier to use than cellphones or the more sophisticated ones. This advantage was enhanced further by the use of the overhead camera to more clearly illustrate specific key sequences. In exams, cases in which students set up problems correctly, but got incorrect numerical answers, dropped over 50%. In addition, the elimination of the cell phones during exams eliminated a probable means of cheating.

Future plans

This fall, there will be some major changes. Because there are a few distance students who will be taking the course, the classes will meet in a distance-education classroom. Aside from the cameras recording the instructor and class, the room has multiple video screens, a high-quality digitizer and whiteboard, an overhead camera, and computer presentation capabilities. Because the classes will be recorded and made available to all students on line, students who miss a class, for whatever reason, will be able to see what they missed. In addition, students who had difficulty understanding the instructor during class can view these recordings.

The new classroom also facilitates small group interaction. Instead of chairs bolted to the floor, there are small tables and movable chairs. The supporting technology also facilitates informal group presentations. The instructor plans to assign students to groups of four to five so that each group includes domestic, international students with high English skills, and international students with poor English skills. There will also be a mix of students with different math literacy levels within each group. These placements will be based on the results of a modified beginning-of-course survey. It is expected that having students work on problems in small groups will help with math literacy issues, as well as developing better problem-solving skills[29].This interaction will be further enhanced by setting up group areas in Canvas and assigning group work. This should reduce the need for direct instructor feedback in quizzes.

The author mainly teaches graduate-level online courses in which he employs self-checked exercises, most of which are implemented in SoftChalk[30]. These exercises involve moderately difficult problems, together with a number of hints[31]. The hints provide scaffolding[32-35] in a way that better-prepared students can ignore and students with specific weaknesses can target the hints they need. For the most part, these modules have been developed to address specific student difficulties. The author had previously made such modules available online, but most of the students who needed them did not use them. This fall, the plan is assign these problems to teams and, in some cases, have them done in class, rather than online.

In a somewhat different way, the author plans to reduce language effects in assignments and exams. Considering that the average undergraduate junior has at least ten years less formal education than the average professor, it is not unusual for a professor to use language at a higher level. For example, here is a question this author felt was quite clear.

> A family has three children. Assuming the probability of each child being male is exactly 0.5 and that genders of subsequent children are independent, in which case is it more likely that all three children are male?

However, according to RightWriter®[36], the passage is a bit too difficult to read. Among other things, its Fog[37] index is 12.76. The result of following specific recommendations from the program is:

> A family has three children. The probability of each child being male is exactly 0.5 and the sex's of the children are independent of each other. In which case below is it more likely that all three children are male?

This version has a Fog index of 9.3, which is about right for undergraduate juniors. In the past the author has recommended RightWriter® to students because it checks grammar, spelling, etc. However, because the program also evaluates readability, provides detailed feedback, and makes specific recommendations to improve readability, the author plans to use it on course materials, including quizzes and exams.

## Conclusions and recommendations

This paper presented a variety of ways in which technology can be used to enhance learning. This includes online quizzes, instructor interaction via quizzes, class management usage, recommending suitable calculators to students, banning cell phones, and using software to reduce math literacy issues. The online quiz examples focus on Steps 1 and 4 of Pólya's method because most students have poor skills in these areas. Future plans address math literacy further and seek more effective ways of implementing some techniques.

Because students' knowledge and skills will vary, it is prudent to check prerequisite knowledge, as well as basic problem-solving ability, at the start of the semester, and then address any necessary issues that arise before they interfere with achieving the course objectives. Technology can facilitate this process, if used judiciously with educational objectives in mind. However, because technology is evolving rapidly, periodic assessment is prudent.

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