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A quantitative analysis of the relationship between an online homework system and student achievement in pre-calculus

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Supporting student success in entry-level mathematics courses at the undergraduate level has and continues to be a challenge. Recently we have seen an increased reliance on technological supports including software to supplement more traditional in-class instruction. In this paper, we explore the effects on student performance of the use of a computer software program to supplement instruction in an entry-level mathematics course at the undergraduate level, specifically, a pre-calculus course. Relying on data from multiple sections of the course over various semesters, we compare student performance in those classes utilizing the software against those in which it was not used. Quantitative analysis of the data then leads us to conclusions about the effectiveness of the software as well as recommendations for future iterations of the course and others like it.

Keywords: pre-calculus; student achievement; online homework system; quantitative analysis; time spent on homework

1. Introduction

York College is a four-year degree granting institution located in Jamaica, Queens. It is one of 11 senior colleges within the City University of New York (CUNY) system of public colleges. The mathematics and computer science department offers four-year degrees in mathematics with a choice of four areas: actuarial mathematics and operations research, applied mathematics, mathematics/education (7–12) and general area, as well as a degree in computer science. The department offers an extensive list of courses in these areas. Among these is mathematics 120: pre-calculus. The research presented here focuses on this course. Specifically, we look at data collected in the form of final exam scores and item analysis of students' performance on this exam in addition to data about the use and efficiency of a computer software program introduced in the course. In doing so, we consider what these data say about student ability/performance/success in the course as well as examine how the technology introduced affects these aspects.

1.1. *An introduction to mathematics 120*

Math 120 is a typical pre-calculus course covering the following topics: linear, quadratic, polynomial, exponential and trigonometric functions as well as solving equations in these

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topics. It is a pre-requisite for calculus I and so taken by those students majoring in mathematics and science related fields who do not initially place into calculus I. These students include but are not limited to those majoring in mathematics (including mathematics education), physics and health related fields such as nursing, occupational therapy and physical therapy. Traditionally, because it is a pre-requisite to calculus I as well as to physics 101 and a number of other courses, many sections of the course are offered. Until the creation of a new course in College Algebra (taught for the first time in the fall of 2010), math 120 was the lowest-level credit-bearing course offered at the college in mathematics. As is the case with introductory-level mathematics courses at many institutions,[1,2] the course proves to be a challenge to many students and rather than a gateway to further mathematics or to science-based majors, it stands as a filter keeping many from moving forward in these areas. Specifically, the course has a pass rate (a grade of C or better which is required for students for whom the course is a requirement in their major) that hovers between 55% and 69%, given the data obtained for the past four years.

1.2. *Adoption of software package*

Given the consistent high rate of failure in the course, the attrition that such a pass rate adds to with respect to majors that require the course and the importance placed upon it as a gatekeeper to further coursework in many majors, the department decided to introduce technology into the course. This is in keeping with the recommendations of the American Mathematical Society (AMS) First-Year Task Force which urges colleges to, 'harness the power of technology to improve teaching and learning' including the use of technology that grades and presents feedback to students on homework assignments and tests.[2] At York College, all sections of the course (approximately 8–10 each semester) are taught using the text Pre-calculus [3] by Paul Sisson. The publisher provides a software package, Hawkes Learning Systems, that accompanies the text. The software is a mastery-based software program where students can do homework, or take tests on the computer. More information about the program can be found in the methodology section. The software was initially introduced on a voluntary basis with the decision about its use up to each individual instructor (fall 2009). It was later made a mandatory component of the course for selected sections in the spring 2010 semester. It should be noted that while the software was a mandatory part of the course for various sections, it was up to each individual instructor to determine how the software would be used. Thus software use varied from course to course, an aspect that we consider further in the methodology section of this paper. It was thought that the software would supplement instruction providing a necessary support allowing more students to successfully complete the course and move on in their respective programs of study. It was implemented with the hope that its use would lead to increased student achievement and success in the course as measured by pass rates in the course and scores on a uniform department-wise final examination that all pre-calculus students take.

2. Literature review

The importance of infusing technology into K-16 education is evidenced by the position taken by the National Council of Teachers of Mathematics (NCTM) on the subject. In 2008, NCTM, arguably the most influential professional organization in the nation with respect to mathematics education, put forth a statement supporting the use of technology in the teaching of mathematics throughout the lifespan. Though it is impossible to capture all the nuances of NCTM's position in one quotation, the language of the position statement makes clear the value that NCTM places on the potential that technology has, when used appropriately, to spur student learning of mathematics. Specifically it states:

> Technology is an essential tool for learning mathematics in the 21st century, and all schools must ensure that all their students have access to technology. Effective teachers maximize the potential of technology to develop students' understanding, stimulate their interest and increase their proficiency in mathematics. When technology is used strategically, it can provide access to mathematics for all students.[4]

2.1. *Technology's effectiveness in college mathematics classrooms*

There is an overwhelming amount of technology available for use in classrooms. Technology varies widely and new instructional technologies are being created everyday. As our work focuses on a software package that provides the opportunity for students to engage in online homework, quiz and exam completion as well as practice problems, we focus our review of the literature mainly to such software packages. Though there has been much research in the area of technology with respect to the teaching and learning of mathematics, the results of such research are mixed. Exemplifying these mixed results are the findings of Pierce and Stacey.[5] These show positive results including an increase in confidence, motivation and fewer questions left blank on assessments in classes where a computer algebra system was used to aid learning,[5] but also note that the increased positive experiences for students did not result in increased levels of achievement. That is, while students embraced the use of technology, their knowledge of the content did not seem to be affected by its use. Similar results were found by Meletiou-Mavrotheris et al. [6] in a study undertaken with undergraduate students in statistics. Here, too, students spoke positively about the use of technology and the authors note an added benefit of the use of technology in that this allowed for the study of real-life data-sets as opposed to much cleaner data used in classes where technology was not introduced. However, here too, the positive student response did not come with an increase in content knowledge. The work of many researchers highlights the fact that more and more students welcome the use of technology of various types in their mathematics classes [5–8] and feel more positively towards these classes as compared to those where technology is not used at all.[5,6] Though increased positive experiences for students have been widely noted, the literature on student achievement and technology use does not present a clear, consistent and positive correlation between the two.

Studies including those of Dynarski et al. [9] and Meletiou-Mavrotheris et al. [6] show lack of effect with regard to student achievement as measured by standard variables such as test scores and course grades in well-designed studies. However, these studies are contradicted by the findings of others that support the conclusion that the use of technology improves student achievement in introductory-level college mathematics courses and that these increases in achievement are statistically significant.[8,10–12]

Zerr's [8] work in a calculus I course shows that students were not only comfortable with the software used but indicated in a survey that the time spent on the software was more useful than if they had used traditional paper and pencil homework because of the feedback they obtained. Zerr's work explores students' opinions about an online homework system implemented in a calculus I course as well as examines the online homework's effect on student achievement. With respect to this, Zerr notes that, 'quantitative evidence was found that supports the hypothesis that [the] online homework system improved student learning' (p. 72). Zerr attributes this increase in student achievement to time on task. Students using the software, he argues, spent more time on the material than those who were in a class that did not use this homework system although it should be noted that time spent on the software was not measured in that study. Our study includes data on time spent on the software by students and so may support the assertion by Zerr and others [7]. In a study of the implementation of technology in introductory-level engineering classes, researchers found that the technology improved student performance on in-class exams as well as helped to combat the high attrition rate in these classes that had existed prior.[10]

2.2. *Characteristics of effective technologies*

With respect to technology that supports online homework completion, two characteristics have been found to be most useful. The first of these are feedback mechanisms. Immediate feedback has been found to be an effective component of instructional technology (see [13] as cited in [14–16]). Additionally, a feedback loop can work in such a way as to provide detailed and specific feedback to a student when an incorrect answer is inputted in response to a question posed by the software. Similar to what an instructor might do, the software provides information as to why the inputted response is incorrect and may provide either a correct solution or some instruction as to what a correct solution might entail. A student then retries the question again receiving feedback if an incorrect solution is given. The process, called an attempt-feedback-reattempt sequence,[8] is useful to students in that it provides guidance towards mastery of the concept and provides such feedback even in cases when a teacher is not around to do so.[7] Given the length of typical mathematics classes at the college level and the inability of teachers to provide such feedback consistently to every student in the room, software that is able to do so provides a solid support to students and serves to support in-class instruction.

Another effective characteristic of technology is the ability of students to try a problem more than once or to try similar problems after incorrectly answering a question. The positive psychological effect of getting more than one try at a problem has noted in the research literature as well.[5,17,18]. This work shows that students were more motivated in situations where they could re-do problems, do similar problems or even re-do an entire homework assignment in order to receive a higher score. The ability to do so led the students to believe they could be successful in the course and increased their engagement with the material as evidenced in those same studies. In doing problems and assignments multiple times students were practising the material, refining their understandings and arguably improving their ability to master the content. Of course in such settings there is always a chance that students engage in surface learning. Time and time again we noticed students who have done their homework question correctly, but have not been able to answer the same question on the exam or they have not learned the topic (see Walker et al.[19]).

The technology used in our course incorporates both of these characteristics and so is a good candidate, given the literature, for improving student achievement.

3. Methodology

The research described herein, including the methods of data collection and analysis, was driven by the following research questions.

(1) What, if anything, does the data reveal about student performance in the pre-calculus course?

(2) What affect, if any, does the use of the online homework system (specifically the Hawkes Learning Systems) have upon student performance and success in the course?

3.1. *Description of homework software*

The software used for this course is the Hawkes Learning Systems accompanying the book Pre-calculus [18] by Paul Sisson. This software has a bank of questions in each section that range from easy to difficult, which can be assigned as homework. The main difference between this system of homework and the other existing software such as MyMathlab and WebAssign is its mastery-oriented aspect. Students are assigned a set of homework called certificates for each section, and they can only miss a fixed number of questions. Misses are referred to as strikes. The number of strikes allowed for each assignment is set by the instructor depending on the level of mastery required in the course and/or the level of students in a given class. For instance, on a certificate assignment with 15 questions, a mastery level of 80% means that students can miss up to 3 questions. Once a student misses the strikes allowed, he/she leads to practise the questions in the certificate. The student can then practise the material and, when he/she is ready, can go back to attempt to complete the assignment again, but with different numbers for each problem.

3.2. *Data collection*

Data was collected in the form of final exam grades for each student taking the course in spring 2010. There are generally about 200–250 students registered in the course. In spring 2010, there were 202 students registered in the course in eight sections. In addition to final exam score, data was collected for each question on the final exam for each student. For problem solving type questions, the exact number of points earned per question for each student was recorded. For example for the problem of solving a logarithmic equations if students found the solution and checked if the solution is in the domain of each logarithm, they got full credit otherwise they received partial credit for every step completed.

Data was organized both by student and by section. Thus, it is possible to determine what specific questions a single student answered correctly or the average number of questions answered correctly by any given class. In some cases (three sections), the number of hours each student in the class spent using the software package was also obtained.

For each of the sections of the course, the course syllabus, final exam review sheets and homework problems, as well as the final exams, were the same. The course instructors have some flexibility with respect to grading but must follow some guidelines. Final grades rely on homework and attendance (10%–25%), midterm exams (30%–50%) and the final exam (30%–40%). While midterm exams are not identical across sections, they cover the same content and are of the same format. Multi-section mathematics courses at York College are coordinated (that is, there is a course coordinator, and midterm–final exams are uniform) but still run somewhat independently. Individual instructors have the freedom to not adopt online homework software and/or to curve their final grades. Yet all sections of the course take the same department-wise final exam. That is why our analysis will rely on final exam data as opposed to course grades. Topics tested on the final exam include the study of linear and quadratic functions, circles, properties of functions as well as polynomial, exponential and trigonometric functions. Generally no scaling is necessary since the grades have been staying within the same range each semester. For the two semesters on which we report, the final exams were graded with a grading rubric. Instructors got together to grade the assigned specific exams as a group.

As noted prior, data was obtained for spring 2010 during which the course was offered. Data for the spring 2010 semester includes a total of eight sections of the course. It is known from the previous semesters' data that the final exam score data (and not the cumulative grade) have a very similar average and a high standard deviation of about 22%–26%. Multiple instructors of the course indicate that there are many students who do not seem to benefit from the class, a reaction that is supported by the data. This we believe is due to the gap between students' prior knowledge in mathematics, prior college experiences with respect to mathematics and the level expected of students when they enter the course at our college. The course, taking into account the fact that students struggle with it, begins with a review of algebra. However, the historic data of final exam scores seem to indicate that some 20% to 30% of students still struggled at the end of the course with questions addressing these areas. This is evidenced by the fact that 23% incorrectly answered a question about lines and 30% incorrectly answered a question on solving a linear or quadratic equation. Again, we attribute this to the lack of preparedness in mathematics with which many students enter the college. This is consistent with the experience of other CUNY colleges as well as other colleges in general when it comes to introductory-level work in mathematics. This reality has, in many cases (ours included) resulted in the creation of a course in college algebra to be taken by those students who may need additional preparation in order to be successful in pre-calculus. In our case such a course was created and offered in the fall 2010 semester for the first time. One might expect that the creation of this new course and the placement of students with weaker backgrounds in mathematics into such a course prior to pre-calculus would have some effect on student performance in pre-calculus. Additional work is needed to 'test' this claim, though such work is not our focus here.

4. Results

For data obtained with respect to the spring 2010 semester, we divided the course sections into two groups with four sections in each group. Instructors are randomly assigned to sections and a pretest is given to students at the beginning of the semester to assure that the two groups are equivalent. The test consists of questions in college algebra, lines, circles and basic facts about functions. The results of the pretest had an average grade ranged from 45% to 53% with a standard deviation ranging from 20% to 25.0%.

The control group consisted of those four sections in which the software was not used and the treatment group consisted of four sections in which the software was used. There were 122 students enrolled in the control group who completed the course. These sections completed the semester with the traditional syllabus, paper and pencil homework and in-class exams.

The treatment group implemented the Hawkes Learning Systems for homework assignments. This group also consisted of four sections with 123 students enrolled and 99 students completing the course. The homework (certificates) had a weight of 20%–25% depending on the section and was in all other ways very similar to the control group.

In the treatment group, there were 30–39 certificate assignments throughout the semester, with a 60%–80% mastery level set, depending on the assignment. Setting the appropriate mastery level is important. Since students had much difficulty in completing the assignments during the first half of the semester, a lower mastery level was set. However, as time progressed, students completed more assignments leading us to increase the mastery level. Even though there was a penalty for late assignments, it was not meant to discourage students from completing the assignments. Students had the option to complete all the assignments until the end of the semester.

One difference that should be noted between the control and treatment groups is the amount of homework assigned. The treatment group had to complete more homework assignments than the control group. With the software it is much more feasible to assign homework that is graded (in this case by the software itself) and for which feedback is given to the student about their performance on a particular question. Grading the same number of assignments and providing comparable feedback in a more traditional class is impossible especially if one is teaching multiple sections. Hence, the control group was not assigned as much homework and was given less feedback on these assignments as well. The fact that those students using the software did more homework and got more feedback on their work is a positive result of the adoption of the software and one that we feel was directly related to the success of these students as will later be noted.

The final exam had been administered to all sections (both the control and treatment groups) and graded using similar rubrics and procedure described above. After compiling the data, we noted that students in the experiment sections had more success on the final examination. This is, in part, because these students were motivated to spend more time on the course as a result of the homework assignments that were completed using the software. Not only were they benefiting as a result of the feedback that the software was providing, but on a more basic level they were benefiting as a result of having more assignments to complete which, therefore, led them to spend more time on the mathematics itself. Increasing their practice time, in essence, led to an increase in their performance.

The fact that the treatment group had more success on the final examination is evident from the grade distribution on the final examination for both the treatment and control groups. The distributions show that the treatment group had fewer students scoring at very low levels and more students scoring in the upper half of possible grades. The distribution of the final exam grades (not the cumulative grade for the course) for the two groups is shown in Figures 1 and 2, respectively.

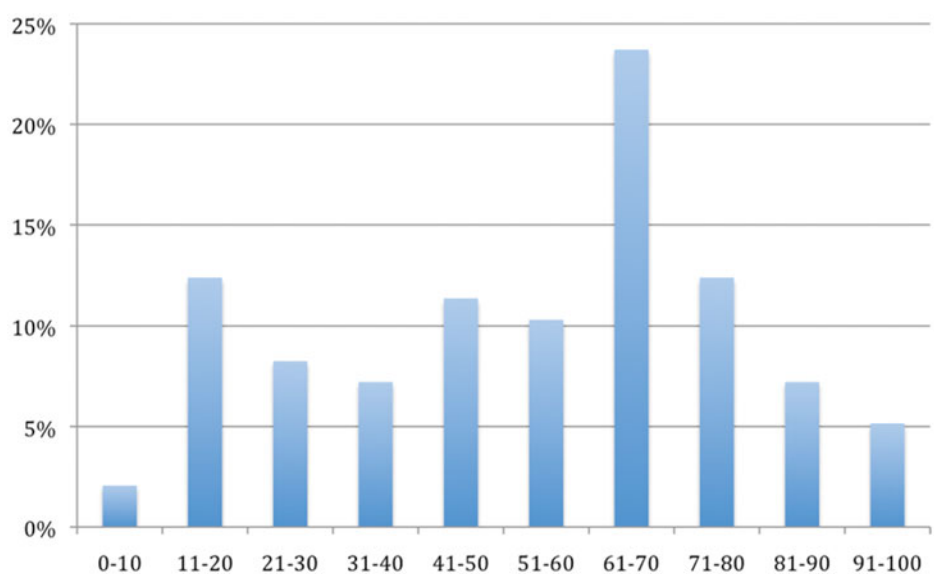

Figure 1. The distribution of the final scores in spring 2010 for control group.

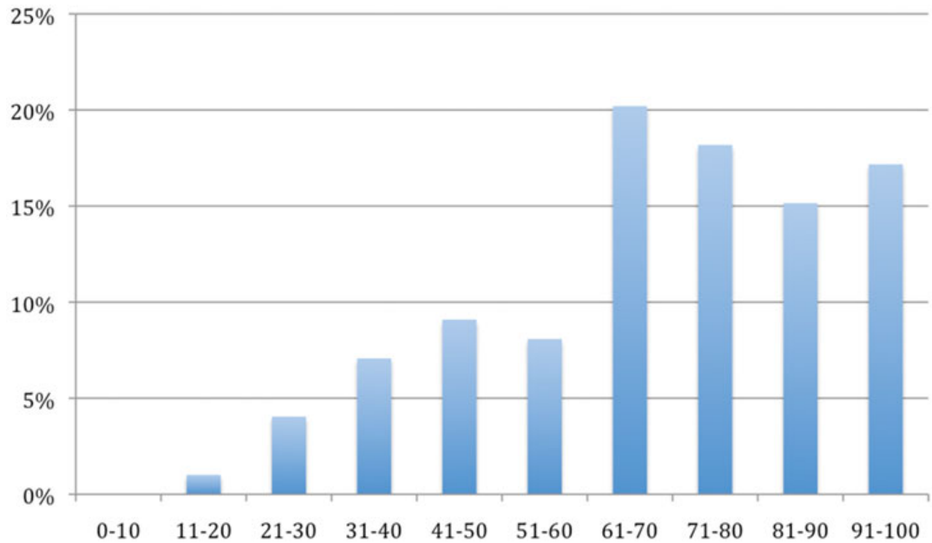

Figure 2. The distribution of the final scores in spring 2010 for treatment group.

Next, we compare the two groups (those that did and did not use the software) with respect to average grade on the final exam. The average grade on the exam for the experiment group is approximately 15 points higher on the same final examination than those in the control group, those sections that did not use the software. This, in and of itself, is a powerful example of the effect of the software on student performance as measured by grades on the final examination and leads us to the conclusion that such software is a way of supporting student success in introductory-level courses such as this one. Table 1 summarizes these data.

As it can be seen from the table the average grade in the treatment group is significantly higher than in the control group with a p-value of 0.00003, using a 95% T-test with unequal variance. The standard deviation seems to be smaller for the treatment group. Using an F-test with the null hypothesis $\sigma = \sigma'$, versus the alternative $\sigma < \sigma'$, we reject the null hypothesis with a p-value of 0.089. Even though we fail to reject the null hypothesis at 95%, we do reject it at 90% level.

It also seems that the control group has a skewness of about -0.25, versus the treatment group with skewness of -0.64, which indicates that the distribution has a left tale, indicating that there are a number of students with very low grades.

4.1. *Time spent on the software versus final exam grade*

In addition to collecting final exam grades data, we were able to collect data about the time individual students spent on the software for the three sections of the course. The software

Table 1. Summary of spring 2010 course data.

	Total	Drop rate	Average grade	Standard deviation	Skewness	First quartile	Median	Third quartile
Treatment group	123	19.5%	68.63	20.9	−0.64	56	71	86
Control group	122	20.5%	53.70	24.0	−0.25	34	60	70

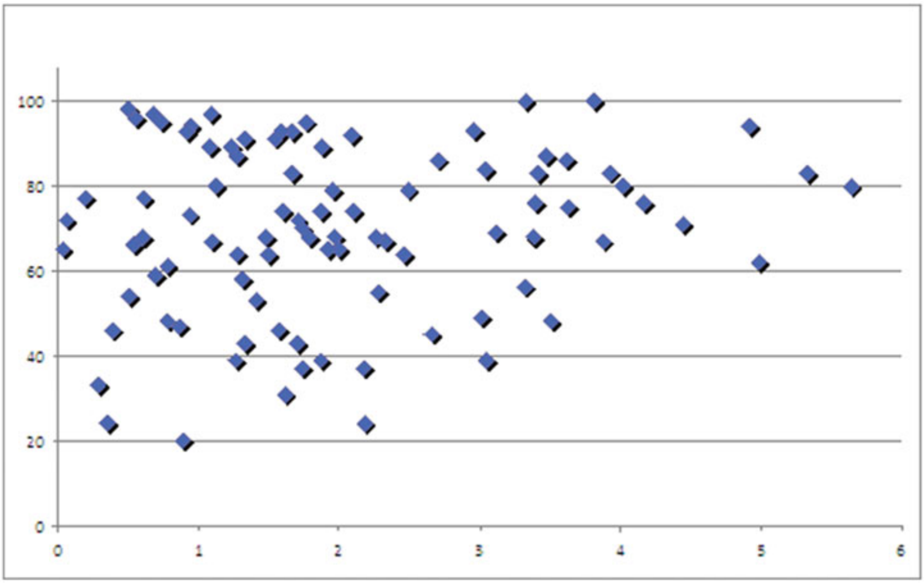

Figure 3. Scatterplot of the average weekly hours spent on software versus the final exam score.

has a feature that logs the amount of time that a student spends on particular assignments as well as over specific time frames. An instructor is able to log onto the software and access these records for individual students as well as for the class as a whole. Using this feature we were able to determine the average time spent per student per week over the course of the semester. Figure 3 is a scatterplot where each point represents the average time spent on the software per week, versus the grade obtained on the final exam as a percentage. We need to clarify that this time is time logged in and not necessarily spent working. However, we have been told by the software representative, that after a few minutes of being inactive the timer stops and restarts again after students resume work.

Even though there is no strong linear correlation between the data ($\mathbf{r} = 0.18$). It seems that those students who did well on the course without spending much time on the software affect the correlation. This is not a surprise since there are a number of strong students in class for whom the class is not a challenge. However, a breakdown of the pass rate into intervals of average weekly time spent on the homework and the pass rate for the given interval shown in Table 2 can shed some light into the matter. This result shows that as the amount of time spent on the homework increases, the pass rate has a non-decreasing trend; here we assume that 69% and 70% are not statistically different. Note that the time intervals are the average weekly time spent on completing the certificates.

Data also indicates that about 75% of the students who spent more than 2 hours per week on average on the homework passed the exam, and of the students who failed the

Table 2. Breakdown of the pass rate, given average weekly time spent on software.

Average weekly time spent on the homework software (hours)	$0 < T \leq 1$	$1 < T \leq 2$	$2 < T \leq 3$	$3 < T$
Pass rate	56%	70%	69%	83%

exam, 72% spent less than 2 hours a week on the homework. Hence, we do suggest that students should spend at least 2 hours a week engaged in the material outside of class time. Of course, the amount of time spend outside classroom is dependent on students' background and other factors. Using homework software is one way to ensure that students devote significant time outside of class to study the material, minimizing plagiarism and has the benefit of providing feedback to all students.

5. Discussion and recommendation

As is evidenced by the data presented, those students in the treatment group during the spring 2010 semester had a higher average on the final exam than either those in the control group or those in the traditional courses in the past. Coupled with that is the fact that there was slightly less deviation amongst students in the sections that used the software. This might indicate that the software use is able to ameliorate the differences in incoming knowledge base among students in the course, to some degree.

In addition, the students in the sections utilizing the software completed more homework than those in other sections and as a result, we assume that they spent more time on the material in general. This would most likely influence their performance on assessments such as the final exam as well as positively impact their ability to understand the material. Furthermore, the software can be set up to provide students the opportunity to attempt challenging problems with assistance from the software as needed. Such problems might not be attempted by those in traditional sections because of a lack of support while completing paper and pencil assignments. Bonuses or extra credit assignments can also be easily incorporated into the course using the software as well.

Despite the fact that students in the treatment sections did significantly better on their final exams, there is still a group of students who received high score on homework, and scored incredibly low on their final exam. Two interpretations exist. First, these may be the students who are not positively supported by the use of homework technology but perhaps may be by other types of interventions. A second interpretation, and we think the more likely interpretation, is that these students are not appropriately placed in terms of their ability and the mathematics course sequence that exists. If this is the case, then interventions of any kind are not likely to mitigate the fact that these students are not yet ready for the material presented in this course. Of course, more data would be needed to support (or perhaps, refute) our inclination, right now supported by an anecdotal evidence that these students are indeed in the wrong course. It is suggested that these students be placed in a more elementary course or perhaps that they be placed in a section of the course that meets for an extended period of time allowing them to spend more time on task to develop the foundation needed to be successful in pre-calculus.

Given the results of this study, we support the inclusion of online homework software in introductory-level mathematics courses at the undergraduate level. The software utilized here seems to have increased students' time on task as well as performance in the course. We envision that this would be the same if the software be utilized in other, similar courses, as well. In doing so, this particular type of technology might help to support student learning and engagement with mathematical content. We attribute the differences in students' success to the support and feedback that the software provides coupled with an increase in the time spent doing homework. That is, an increase in the time spent on task, actively engaged with the mathematics itself. Finally, we find no significant difference in the drop rates for courses using the software as compared to those courses that do not. This indicates that the software itself is not a deterrent for students as they are just as likely to stay in a course that does not utilize the software as in one that does.

Our findings add to the somewhat mixed results that exist in the research literature on the use of technology in the classroom. These mixed results may be the result of several factors. As noted, there are many types of technology available and conflicting findings may be partly the result of comparing technologies that are not exactly the same in scope. Other differences can occur at the implementation stage. The use of technology in and of itself does not necessarily increase content knowledge of students. Factors such as the actual implementation of technology, the level of access to and comfort with said technology by the teacher and students, as well as the alignment that exists between technology's use and the assessments that are undertaken in the class are other factors that may affect the findings we are considering. Relying on and adding to the work of Leigh-Lancaster,[20] Stewart et al. [21] argue that the use effective of technology necessitates a 'congruency between curriculum, pedagogy and assessment' (p. 748). Pierce and Stacey [5] further argue that students value and focus on aspects of courses that they know will be assessed. As such merely incorporating technology is not sufficient as without valuing such technology in assessment, students may resist using it and thus not obtain the full benefits associated with its use. Despite these mixed results with respect to research findings in general, most research in the field supports the use of technology in the teaching of mathematics and note that it is the effective use of such that might make the ultimate difference.

6. Implications, limitations and questions for further study

This research has clear implications for the teaching and learning of mathematics in introductory-level mathematics courses. Findings with respect to student performance and success show that in many cases teachers cannot effectively teach to the entire class because the range of incoming abilities in mathematics is so varied. This disadvantages students on both ends of the spectrum. Well-prepared students are not challenged adequately and do not receive the enrichment they are ready for. Weaker students struggle to keep up with the course. A way of addressing such disparate abilities might be to introduce recitation sections where a small group of students works with an instructor. Weaker students can work on homework and also on solidifying prior knowledge that might be needed for successful completion of the course while groups of stronger students can work on enrichment activities that push their understanding. This differentiation is in-line with current research on best practices at the K-12 level and so applying it to college-level courses might also show promise. The technology itself could be used to support differentiation with challenge-assignments being set-up to support mathematically stronger students and review-assignments created for those students who are struggling in the course.

Another approach might be to provide a one-semester pre-calculus course for mathematically stronger students and a two-semester course for those needing more time and a review of prior work. Some colleges, ours included, are beginning to offer a college algebra course prior to pre-calculus to address the needs of mathematically unprepared students.

That the technology employed significantly and positively affected student achievement irrespective of the instructor is the reason enough to incorporate such technologies into these courses. That students spent an average of 2 hours per week utilizing the technology speaks to the fact that students are engaging with the material. Technology is one way to encourage increases in engagement of students and, as we see in this case, one effective way to do so.

The study has several limitations. Among these is the fact that only one homework technology was studied and so generalizing to such programs in general is slightly problematic, as results may not hold for these. There is also the possibility that there is some other factor at play to account for the increased performance in classes utilizing the software. A follow-up study where students are interviewed or submit surveys may help shed light as to what additional factors, if any, led to their successes or failures in the course. Having an instructor who taught both with and without the technology would also have strengthened the results.

Of course, the research has also left us with unanswered questions which need addressing in future work. These include but are not limited to the following.

(1) What software or technologies are most effective at improving student achievement in entry-level mathematics coursework?
(2) What methods of implementation and use of such technologies most effectively improve achievement in entry-level courses?
(3) How do we best prepare teachers to effectively use technology in their mathematics courses?
(4) How do we address issues of access, equity and student comfort with technologies that are adopted?

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