On-line Support of Precalculus Learning: Who May and Who Does Benefit from the Use of Technology?

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Abstract:
This paper describes the authors' experiences of implementation of the on-line support component, MyMathLaboratory, in teaching the Precalculus course at Memorial University. The process consisted of three stages expanded over two years: planning, pilot test period and a variation. Along with theoretical ideas related to the use of this type of technology, we present and interpret our results, and draw upon the participants' responses to this project.

Introduction

Technology has changed the face of the educational system. The evidence of technological expansion is reflected in the increasing number of mathematics textbooks including CDs or offering on-line support. These technological advances contain practice problems, tutorials, animated examples, interactive dynamical software, reviews, randomly generated quizzes, access to e-books and video lectures. University instructors and researchers implementing these innovations aim to facilitate and further students' mathematical progress (Gadanidis 2006, Borba 2007, Scucuglia & Borba 2007). Different types and categories of technological tools are available for instructional support. They include tutorials, simulations, drill and practice, educational games, exploratory environments, and are used at different stages of instructional process. Our project focuses on the on-line support component, MyMathLab, used in teaching and learning Precalculus.

The Precalculus course at Memorial University intends to prepare first year university students for Calculus studies. Precalculus is offered to those students who are not qualified to enroll in Calculus due to insufficient scores on the Mathematics Placement Test. Although Precalculus provides an overview of the high school material, the failure rate in the course is about 30 percent. Common grounds of students' underachievement may include students' weak algebraic and arithmetic skills, low reasoning ability with formal concepts, failure to check answers and validate solution processes, negative attitudes, low motivation, or poor time management skills. At this stage, additional activities concerned with factual memorization and skill fluency may not only improve students' fundamental knowledge but also build up their confidence based on successful performance in small and elementary steps. Many pedagogical practices confirm that students enjoy doing mathematical problems if they know how to approach them.

An additional challenge is related to the transition from high school to university, process undertaken by most students enrolled in Precalculus. University mathematics differs from grade school mathematics in two major aspects: it offers increasingly complex procedural techniques as well as more systematic and formal approaches (Tall 1997). In view of the above, an educational dilemma stands out. On the one hand, without employing correct mathematical procedures, routine computations and symbolic manipulations, students cannot achieve proficiency neither in doing mathematics nor in thinking mathematically. On the other hand, procedural learning can offer no more than limited success in performance, and lacks assistance in meaningful mathematical interpretation. As the number of mathematical procedures and level of sophistication grow, students can easily become overwhelmed by the amount of apparently non-structured information, particularly if they are unable to link different mathematics concepts and ideas. Therefore, university instructors must provide both a large variety of mathematics examples and a strong conceptual basis that allow students to meaningfully make sense of, process, classify and connect mathematical information.

By providing unlimited additional mathematics problems, the on-line course component can become an invaluable mathematics resource. The use of interactive computer-based technology may assist students in improving their basic skills of doing routine mathematics accurately and efficiently along with shifting their thinking from concrete to abstract. Repeated experimentation and instant on-line feedback allow the learner re-conceptualization of fundamental mathematics notions and action self-validation.

Implementation of MyMathLab in different sections of Precalculus during 2007-2009 was a response to changing instructional settings and a call for improvement in students' mathematics understanding. By solving on-line exercises and quizzes and by sharing ideas and experiences, students can build the necessary mathematics knowledge and confidence. Students' progress using MyMathLab quizzes and paper-and-pencil tests was monitored. We analyzed and interpreted students' attitudes toward computer-assisted learning, the role of balance between computer-based and traditional paper-and-pencil assessments, and level of merger of in-class and homework practices. Moreover, this research explored differences in instructors' opinions about the on-line course component.

The Project

How It Started

In the Fall 2006 one of us (O. R.) was teaching a 300-students section of Precalculus (Math 1090). At the initiative of Dr. Phil Davis, then special advisor to the Associate Vice-President (Academic) on student success, O. R. was working on implementing a new math teaching strategy in close collaboration with another course instructor, Edmund Loveless. This process resulted in developing weekly problem-based instruction sessions for the course. Numerous hours were put aside to develop representative problems for these sessions that would match the math topics covered each week, to coordinate the logistics of the whole process, to meet with the graduate students who taught these sessions, and to discuss the strengths and weaknesses of the process with the University's administration. While a lot of publicity was made around these weekly problem-based sessions, most Math 1090 students choose not to take advantage of them. Some voiced their unhappiness with the problem-based sessions since they felt that they could not take the time to attend them, while others did not seem to enjoy the fact that active participation in the sessions was not included in the course's final mark, and ultimately, most of them did not attend the sessions. At the end of the semester, students' success in this course continued to remained a concern for both administration and the instructors of this course. Looking for a way to address this problem, O. R. reflected on using technology to improve students' learning and to advance the teaching methodology of this course. After carefully examining the software market, the Pearson software, MyMathLab appeared to be most suited. This software presented the possibility of creating a graded weekly on-line laboratory, of offering students unlimited on-line access to practice and homework problems, of adding the instructors' own set of problems to the on-line data base, of using the on-line marking system, and of quickly evaluating students' progress.

This innovative idea on the use of technology developed into a March 2007 full-fledged proposal to the Memorial's Vice-President (Academic) office and to the Instructional Development Office. The proposal focused on implementing a new program designed to improve teaching and learning, and that would be of assistance to a large number of students and faculty. From the teaching perspective, the benefit of this project was related to a wider knowledge-based construction. This alternative-learning medium aimed to facilitate students' understanding and processing of certain fundamental mathematical concepts. By using the computer interface, students had the opportunity to work at their own pace, to review course material via interactive video tutorials, to practice on a large number of problems they have difficulty with, to obtain instant feedback to each problem, and to access the on-line version of the textbook. From the research perspective, the benefit consisted of having access to design, implement and analyze the use of technology in partnership with the traditional teaching methods.

In April 2007 the authors of this paper were notified that the Instructional Development Grant for the project "Development of new instructional media for introductory mathematics courses at Memorial University" was funded. After a successful first try, new research hypotheses were put forth and a second Instructional

Development Grant for the follow-up project "Implementation of mixed learning environment for Mathematics 1090" was funded in December 2008. Throughout the Spring and Fall 2007, as well as the Winter and Spring 2009 semesters, we have been involved in the organizing, supervising, monitoring and facilitating the development of the on-line component of the Precalculus course.

Background

The Precalculus course is open for students with a Mathematics Placement Tests (MPT) score more than 55 percent and is a prerequisite for the Calculus course for those students who score less than 80 percent on the MPT. In the late 1980s, a Mathematics Skill Inventory (MSI) was introduced in order to give the Department of Mathematics and Statistics a way to measure the mathematical skills of the incoming students. Shortly, it become possible to detect with accurate precision which students are able to cope with first year calculus. Consequently, the MSI was transformed into MPT. Each year, the MPT is a requirement for approximately a thousand students.

Traditionally, the course format was four hours per week in groups under 60 students. About five years ago, the class size increased to 300 students, while the course continued to be delivered in a lecture format with no tutorials. The textbook used for the Precalculus course is Algebra and Trigonometry, Custom Edition by R. Blitzer. The course structure normally consisted of ten written assignments (10 percent), three written midterm tests (30 percent) and a written final exam (60 percent). On an annual basis, about 1000 students are enrolled in this course. Lecturers and graduate students of the Department of Mathematics and Statistics usually taught the several sections of the course. The pool of instructors teaching the course is changing on the semester basis with the exception of one or two. Thus we could not count on having instructors who are technologically flexible and quick in learning new software. Throughout the project, we secured one laboratory instructor who provided technical assistance for both teachers and students.

During the first implementation of the on-line component, the course structure was slightly modified as follows: ten on-line quizzes (5 percent), ten weekly written assignments (5 percent), three written midterms (30 percent) and a written final exam (60 percent). During the second implementation of the on-line component, the following modifications tended to increase the weight of the on-line assignment (up to 20 percent in the latest delivery) on the expense of written assignments and midterm tests, while the format of the final exam remained the same. The long-term goals of the project were to diminish the high failure rate and to help the Precalculus students in achieving the best possible mathematics results. We also wanted to see how friendly, cooperative and useful the on-line tool is from the instructional point of view. Our project was designed in three stages: planning and theoretical considerations, test implementation and variations aiming at further extension.

Stage One: Theoretical Considerations, Planning and Goals

The first stage revolved around designing a new instructional media with the built in possibility of combining the traditional and the new technology based approach. Theoretically, a computer assisted learning environment can:

- provide the field of experience and support meaningful interpretations within the field,
- support the development of mathematical ideas and of the mathematical language,
- facilitate the communication between students and teachers,
- facilitate the review, comparison and rethinking processes for students via monitoring and recording written work,
- help students in gradually taking responsibilities for learning and problem solving activities,
- allow the teacher to configure teaching and learning environments which best fits his/her educational goals as well as the students' needs.

Within our project, the instructor's objectives were to provide more examples and exercises for students, to organize mathematics resources, to use quick assessment tools, to monitor achievement, to collect information, to increase the effectiveness of teaching. The desired and potential benefits for the students who

took part in our project were: to improve the basic algebraic skills as a by product feature of solving problems, to allow self-diagnosing common mistakes, to enhance reasoning skills, to improve conceptual understanding, to develop positive attitudes toward mathematics and to increase the effectiveness of leaning. Our main objective was to develop the instructional media for teaching introductory courses in mathematics. This includes creating a mixed learning environment. Working in this environment, an instructor uses a combination of traditional teaching methods and the on-line Pearson software, as part of the classroom teaching. Consequently, the instructor has the opportunity to monitor, control, adjust and correlate the teaching process (with its use of on-line mathematics) with the on-line laboratory.

From a researcher's perspective, the goals consisted in creating, implementing and analyzing a new teaching medium that combines the traditional teaching methods with the on-line teaching strategies. We hoped that we will engage more students in their future study of mathematics, by instilling and developing their curiosity, fascination with mathematics as well as their self-confidence and trust in their abilities. During the project, our on-line mathematics laboratory was available to assist weekly in-class meetings of the students with their graduate student assistant. The on-line software was available for additional practice at all times during the experimental terms.

Stage Two: Test Implementation and First Results

The second stage of the project – the test implementation run over two semesters: Spring 2007 with a class of 26, and during the Fall 2007 with a class of 127. In both cases, the course followed a lecture format in the traditional face to face teaching structure of four times per week, and a computer laboratory once a week. A graduate student of the Department of Mathematics and Statistics ran the computer laboratory. The TA's assistance was restricted to one hour a week, but the students had unlimited access to the on-line software for the entire duration of each semester. The software was provided by Pearson Education Canada and its features included: instructors' announcements, homework, take a test, study plan, results, electronic version of the textbook, practice tutorial exercises, video lectures, multimedia library, discussion board and e-mail.

Based on the assessment made at the end of each semester, we have created comparison charts to test the effectiveness of the mixed environment. Table1 (last column) shows that the proportion of students receiving A's increased from 12.9 percent in Spring 2006 (taught without MyMathLab) to 15.4 percent in Spring 2007 (when MyMathLab was first incorporated into the course). Although the table indicates that the average scores of students receiving As were about the same in both years, comparison of the average MPT score, which is taken prior to enrollment shows that the group using MyMathLab made greater progress than the group not using MyMathLab did.

The last column of table 2 shows a more drastic improvement in the proportion of students receiving Bs that corresponds to a score of 65 to 79 percent. In this case, the percentage of students earning a B increased from 19.3 percent in Spring 2006 (without MyMathLab) to 26.9 percent in Spring 2007 (when MyMathLab was first incorporated). Worth mentioning is that the students using MyMathLab had lower MPT scores – more than 10 percent less than the previous semester's students – thus making an even more remarkable gain over the previous year's students (Kondratieva & Radu 2008a).

	MPT Average	Precalculus Average	Percentage of A Students
Spring 2006 (without MML)	76%	89%	12.9%
Spring 2007 (with MML)	70.5%	88%	15.4%

Table 1: Comparison of A-Student Results in Spring 2006 and Spring 2007

	MPT Average	Precalculus Average	Percentage of B Students
Spring 2006 (without MML)	68.7%	68.7%	19.3%
Spring 2007 (with MML)	81%	71.4%	26.9%

Table 2: Comparison of B-Student Results in Spring 2006 and Spring 2007

Figure 1 illustrates an increase in percentage of students earning an A, B, or C during Spring 2007. Similarly, the percentage of students earning a D or F decreased with the use of MyMathLab.

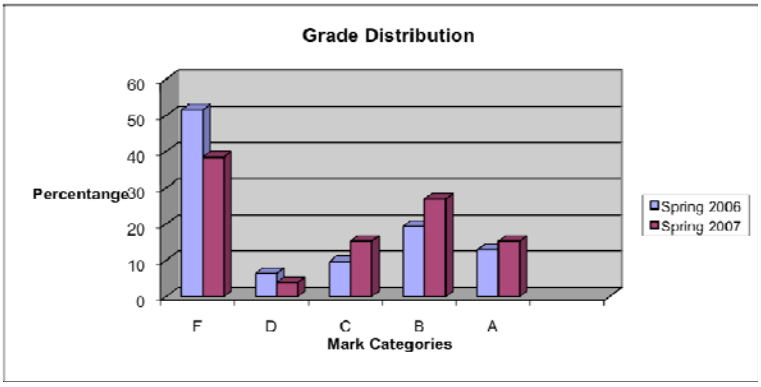

Figure 1: Grade Distribution, Spring 2006 and Spring 2007

Table 3 shows that the MPT average was the same for both semesters. Thos most clearly demonstrates the MyMathLab advantage, because not only did the percentage of students earning an A increased by about 50 percent, but those students' Precalculus average for the course is higher (Kondratieva & Radu 2008a).

	MPT Average	Precalculus Average	Percentage of A Students
Fall 2006 (without MML)	72%	85%	12.6%
Fall 2007 (with MML)	72%	88%	18.8%

Table 3: Comparison of A-Student Results in Fall 2006 and Fall 2007

It is hard to make comparisons because there are many factors involved in each class achievements. For our purposes we compared students' progress with and without MyMathLab, taking into account their initial MPT scores (Tab. 1, Tab. 2, Tab. 3).

Stage Three: Variation

We thought of two possible directions how the project might evolve in the future. Either the laboratory component is an integral part of the entire course in that it supports every topic in the course with high correlation between math laboratory exercises, in-class instructions, and assessment practice; or the laboratory component is a special part of the course in that it supports only assessment, improvement, and review of basic algebraic skills necessary for learning other topics in the course.

In Winter and Spring 2009 we gave preference to the first option, and at the same time a certain variation of the 2007 model took place. First of all, we wanted the on-line component to become an integral part of the lecture meetings. That is, the students would see the benefits of the on-line assistance during their classes. Second, all homework assignments were assessed automatically in MyMathLab, which freed the instructor's time from marking and helped to devote more time for students' consultations. Also, only an introductory laboratory required the students' presence for registration purposes. For the rest of the laboratories students could have chosen their own time and location and were assisted by the laboratory instructor via email, if necessary.

Students' Reactions on MyMathLab Use

To better understand the situation from the students' perspectives, we handed out a survey. Here we present some of the positive themes occurring in students' comments about MyMathLab: the on-line feature was helpful in understanding mathematical concepts, for achieving a higher grade in the course than they would have gotten without MML, for receiving instant feedback while solving on-line exercises, and for being user friendly. The on-line software was mainly used as practice for their weekly quizzes. We mention some examples of students' positive comments about MyMathLab (Kondratieva & Radu 2008b):

- I feel more confident
- I like math more because I understand it better
- I became more interested in math
- I see what the answers are more quickly than before
- I was able to see my mistakes
- I learned that there are more types of solutions for one problem
- I realized that practice makes perfect
- I realized my mistakes
- I realized that math is exciting
- I realized that math is not as hard as I thought
- I improved my math skills
- It showed me where I must work on to do well on the test.

At the same time, the students mentioned the most helpful features, such as extra practice, good for tests, rapid feedback, the fact that the computer assisted in doing "the whole process with you", the fact that results were generated instantly, the 'Help me solve this' feature, the step-by-step guidance and instruction, the flexibility, the user friendly and accessible software.

We also present some of the students' concerns with respect to the use of MyMathLab. One common theme was the students' inability to pinpoint where the mistake occurred throughout the solution coupled with the fear of loosing significant marks: "It worries me that I cannot get graded on my working so I am unable to recognize where I went wrong", "a missed negative sign could totally change your final answer even though you got the method correct". Another point of concern was an initial confusion on how to enter results into the on-line system and the new computer notation style. At times, installation aspects seemed to take a lot of students' attention "instead of being a one-step process, it is a multi-step process". Other points of concern were related to compatibility with Macs or with Firefox. More results will be presented in our upcoming paper.

Instructors' Views on the Course and the Use of Technology

During the Fall 2006 the 300-students section of Math 1090 was used by both authors of this paper to investigate students' background, in particular, their ability to make connections between different representations of the material presented in the course (Kondratieva & Radu 2009). Our research results pointed out the necessity of extra help required for the students' progress in this course, especially for a large section format. For a more thorough understanding of the situation, during this project we interviewed several instructors who teach this course with or without technology. Here we present some of their answers.

Question 1: How would you characterize in few words your good (ok) students (top 60 percent), the borderline students (mid 20 percent) and the weak students (low 20 percent) taking Precalculus? What are their goals and problems (in your opinion)?

"By the top 60 percent will take it to mean the people who passed. The borderline will be the students with final grades between 40-49 percent and the weak between 0-39 percent."

"I think that there are at most 10 percent of students that are good at math in Math 1090. These are students that could pass Math 1000 [Calculus] but would probably get C's. After Math 1090, they would probably get B's or A's in Math 1000. The reason they are in Math 1090 is generally because they do not believe they are good enough for Math 1000. Their goal is to do well in their courses."

"These top 60 percent are students who because of their background knowledge from high school math courses, work ethic, commitment to attending classes and doing assigned work, will do well in math 1090 with 4 lectures and a comprehensive weekly assignment. The goal of the top 60 percent is to be successful in the course. For some success means achieving and an A. They want to be able to move to the next course level in the next semester and fulfill their program requirements in a timely fashion. Some will be happy with a B standing."

"The remaining ok students (the ones that pass) generally know how to reproduce the work they saw their high school teachers do. Most of them will get through Math 1000 with C's if they pass. Their goal is to get their Math credits and move on."

"The okay students (next 50 percent) tend to be reasonably well-prepared for the course, but typically demonstrate deep difficulties with at least one topic (often trigonometry). They often underestimate their own mathematical deficiencies, and leave high school with an inflated impression of their skills. They generally wish to grasp the material well enough to succeed in Math 1000, but often are not willing to put in the extra effort required to master more difficult topics. These students have decent work habits, but are largely unengaged in mathematics, in many cases having been turned off the subject while still in high school."

"The borderline students do not have the basic math skills. For example, multiplying binomials in a different order than FOIL (first outside inside last) will confuse them. Their goal is to get through the course."

"These students (mid 20 percent) struggle with mathematics. This may be due to the fact that this has been their experience throughout high school. Those who demonstrate a determination to be successful in the course (work compensating for their weakness in math) will do what is required such as attend classes regularly, do assigned work (with assistance) and get a C or D or worse an F. These students find it difficult to communicate mathematical ideas both in explaining, justifying what they have done or in being able to express what their difficulty is. They don't readily make connections between topics completed and new topics until it is brought to their attention. They have to be lead to see things. There is a great deal of insecurity and lack of self-confidence regarding mathematics which undoubtedly contributes to their inability to communicate mathematical ideas or make connections. They do not use much of the mathematical terminology, which impedes their success because if one can't refer to a piece of mathematics as something e.g. 'difference of squares' or 'quadratic equation', then how does one know what to do with it? The goal of the borderline students (mid 20 percent) is to be successful in the course. For some this is a realistic goal, for others it isn't. Success for these is to get a C or D. The likelihood of getting a higher grade is slim to none because of the nature of the student. The students in this group who pass Math 1090 with a C or D are likely to take two semesters to complete math 1000."

"I do not know how some of the weak students got out of high school. Some of these students come to class over half the time and still can not get through Precalculus. The other group doesn't show up to class or midterms. There is always roughly 10 percent of students that do not show up to the final exam."

"The weak students (low 20 percent) have very poor preparation, often evincing deep misunderstandings of basic mathematics, which tends to be more of a factor in their course performance than a

lack of effort (although this is often an issue as well). Like the borderline students, these students generally wish only to pass the course."

"These students (lower 20 percent) seem to be in this category for several reasons. I will list 5 reasons but there certainly could be more.

- They seem to lack the ability to do well in math.
- They have an extremely weak math background.
    - They are lacking numeracy and algebra skills
    - Automaticity of responses to simple number computation or simple application of rules of algebra is practically nil.
    - They lack self-confidence and so don't risk making an effort to learn new concepts or practice examples as evidenced by not handing in their weekly assignment
- They come with a negative mindset. This is likely a consequence of the lack of any real success in high school math courses.
- They lack the commitment to attend classes regularly, get help early, do regular assigned work and they miss quizzes. The latter two are part of their term evaluation.
- There is often a misplaced priority in that socializing in its various forms and often work commitments take priority to studies and class attendance.
- Some deceive themselves into thinking that they can pull it together at the last minute and be successful – it doesn't happen.

I don't think they have any educational goals. So I don't think they realistically set a goal to be successful in the course. Most of them know that they have a slight or no chance of being successful in the course on the first attempt, at least."

Question 2. How much (you think) each of the groups would benefit from using the on-line tutorial?

"The good students benefitted the most. The top 10 percent could practice as much as they wanted to get the grade they needed. The remaining students in this group could practice their skills as needed and see as many examples as needed. The borderline students usually only used the software to get marks. They usually did not use the practice exercises to improve their skills. Those who in this group who did use the practice exercise usually had passing grades on the homework but didn't do as great on the written tests. Their math skills with resources available improved. Most of the weak students might have handed in homework half the time or less. Those who handed it in usually didn't spend much time on the homework.

Note: Few instructors had accents that might be hard for first year students to understand. The software was a fantastic way for students to get help in more understandable English. Also, a lot of the instructors teaching Math 1090 do not have a lot of experience teaching students with such weak math skills. The software is designed for such students."

"Many students voiced their unhappiness with the laboratory as being unnecessary since they were doing well in the written assignments and in the course generally. Some felt that they couldn't afford the time. The laboratory was adding to their already heavy workload and consequently taking time from other courses. Some students didn't like the composition of the laboratory questions. Some students didn't attend any laboratories. I wrote letters to those students but they still didn't attend."

Question 3. Describe your successful teaching strategies working with each of the groups. Is it possible to address the needs of each group within current format of the course?

"I created two sets of exercises for every homework. One set was the actual homework and the other was practice exercises on the same topics. The last two times we used the software I matched each question in the homework with a similar question in the practice exercise. The idea was that if a student had a hard time with question 4 in homework 7 they could practice using question 4 in the practice exercise 7 where the help features were available. The good students used the software as it was intended. Some of the borderline students used the software as it was intended but a lot of them did not use the practice exercise. I do not think the software made a difference with the weak students."

"For the good students it is possible. For the borderline students, a format we tried with laboratories in the math computer laboratory seemed more helpful. Some of the borderline students came to the laboratory and would use the software for help but also asked me for help as well."

"I do not think that there is anything that can be done for the weak students. For most of them it is a maturity issue. The rest of them should be in a program to build their basic math skills such as dealing with fractions."

"The top students are generally insensitive to teaching strategy: they will succeed regardless of the approach taken by the instructor. The okay students enjoy learning from examples, but are receptive to a more formal presentation of the material if broken down into sufficiently simple steps and ideas. The mediocre students are much more difficult to reach, and do not seem to thrive in the standard lecture environment. These students need to be made to do more work in the course, but the normal assignment style of course delivery seems to fail in this regard, because the relatively insignificant weight of individual assignments is often insufficient to encourage them to regularly complete and submit the work."

Question 3a. Do you think that there is another format of the course delivery, which would be more beneficial for the students? (with or without technology)

"The ideal format for the course would be to have an instructor that is familiar with the software and could create a final exam with questions in the same wording as the questions in the software. The way multi-section math courses are organized at MUN, this is impossible for an instructor teaching a daytime lecture since all of the daytime lectures have a common exam. Unless the instructor is teaching the night section, the realistic ideal situation would be to have a laboratory instructor who could work with Pearson to reword the questions and still have the help features. The wording of the final exam questions would have to be determined at the start of the semester."

"Given the present math curriculum (K-12) and the fact that many of our students having done this program demonstrate a pronounced weakness in numeracy skills, and algebra skills (one indicator is the MPT) and since this is a first semester course for most of the students who have always had a person teach them, help them when in difficulty, someone who can state or restate a question to help the student or who can correct misunderstanding immediately, etc. I believe that for most students Math 1090 is a necessary preparation for Calculus and the best way to do it is with a person (math instructor) rather than with technology."

"Because the needs of each student will vary considerably from topic to topic, a self-driven system like that used by the MLC for the Foundation courses and the Math 1090 sections offered thereby would seem to be the most appropriate format overall. This is especially true of those students who fall into the "weak" and "borderline" cohorts, as well as the lower segment of the "okay" cohort. The downside of this approach is that it will leave students ill prepared for the teaching style of Math 1000. An alternative would be a two-semester hybrid approach, in which lecture-style delivery alternates with (compulsory) self-driven sessions."

Question 4. Do you think that the course is overloaded with material? Do you feel the pace is the problem for many students? Could the on-line tutorial help with this issue?

"I think that the course is overloaded with material. The trigonometric section is full of material that will not help students be successful at Math 1000. There is more time spent on using double angle formulas than actually using trigonometric functions. The pace should not be a problem if we were going over material that the students see in high school. Do I think that the pace is a problem for many of the students, no? It is a problem for some of them but if they can't keep up with the pace than they wouldn't be able to keep up with the pace of Math 1000. The purpose of Math 1090 is to get students ready for Math 1000. The on-line tutorial could help students who have problems with the pace if they were able to read up on the material before class or go over material after class. This would require more time on their part."

"There are a few topics that we should be able to omit and not be detrimental to the successful completion of Calculus. It would also give more time to spend on the remaining topics needed as background for Calculus."

"The course is overloaded with material for those students identified above – the "weak" and "borderline" cohorts, as well as the lower segment of the "okay" cohort. The better students enter Math 1090 with sufficient mathematical skills to ably handle the amount of material. The on-line tutorial may help some of these poorer students by providing additional structure and feedback to their learning, but for many of these students, I don't believe that it would be sufficient to overcome their deep mathematical issues."

Question 5. If you use MyMathLab as an instructor, what kind of technical assistance you would need? What other conditions would be preferable for a successful application of this technology?

"Technically I would like to be able to rephrase the questions [from the pool]. The ideal condition would be to have students also hand in a written copy of their homework even though they wouldn't get any points for their written work. The point would be to get students used to written [solutions] as they would on a test even though they input the answer on the computer. When I taught Math 1090, my marker only had 30 minutes per student. If I were to use the software when teaching Math 1090, I would create the homework and practice exercise. The students would have to complete the homework on-line and pass in the homework with their calculations. If a student doesn't hand in the written homework, they don't get any marks. My marker/laboratory instructor's responsibilities would be to go over the answers on-line and to make quick comments on paper about the questions the student got wrong. The marker would not be assigning partial marks (not enough time) for the written homework, only comments."

"Even if I were given enough graduate students to supervise the laboratories, there's only so much they can do since they have their own studies to do. I would still feel the need to be checking the content of the laboratory, the attendance at the laboratory, the results of the laboratory, etc. I don't think a ready-made laboratory is likely to make for a successful experience as a laboratory that is geared to the topics in the curriculum. There are items we may not think important but the composer of the laboratory will still have questions on that material in a laboratory. The depth of treatment of topic in the curriculum differs from the way the topic is treated in the text and that will be reflected in the laboratory. Either the laboratory would have to be modified or else a laboratory compared similar to that of an assignment so that the lecture (notes) can be used as a resource for the laboratory. I can see that that might work but there is the time factor."

"As a general rule, though, I would be wary of any technology which would place additional burdens on the instructor: teaching Math 1090 is already a sufficiently time-consuming process, and so it would be important for any new technology to not place new demands on the instructor's preparation time."

Conclusions

Our project addressed the need to improve students' learning of mathematics and it was based on the idea that "Web-assisted courses give students resources not available in the traditional format… they can offer options and venues beyond the scope of classroom teaching" (Allen 2003 p. 276). And here are some of our current conclusions.

It is probably not a surprise that students who were determined to learn took full advantage from the on-line tutorial, and consequently improved their marks significantly. Among them we list not only A-students but also barely passing students who otherwise would not be able to collect even few marks in the final exam. Thus we indentify this determination as a principal component of the success, while MyMathLab is used as a tool helping those students to achieve their goal. We do not have evidence that MyMathLab helps to develop this determination in first place, but it certainly provided support and encouragement to those students who consistently did well on their on-line assignments. On the other hand, we observe that a certain group of students tend to attribute their unsatisfactory results to the novelty of the on-line component of the course. Complains range from "not being able to show their written work" to "too much time spend for learning the way to introduce the answers".

We suggest that it is essential for success to have a core group of instructors dedicated to working with the on-line component. This include their initial believe in the usefulness of technology as well as their ability to handle the software on a regular basis. It is known that teaching philosophy implicitly influence teaching approaches. If instructors feel that the problems which students experience lie in a different plane rather that the need of more practice with exercises, or if the instructors think that for some students the level of scaffolding provided by the on-line software is not adequate and lacks human factors, they will likely be less optimistic in using it.

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