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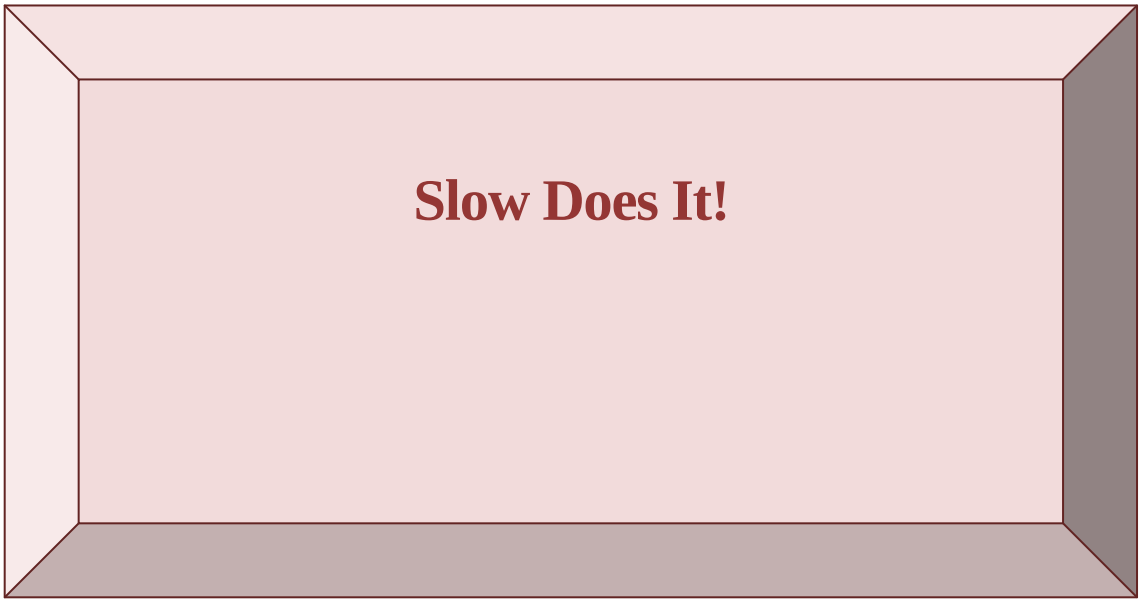

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An Introduction to ATINER's Conference Paper Series

ATINER started to publish this conference papers series in 2012. It includes only the papers submitted for publication after they were presented at one of the conferences organized by our Institute every year. The papers published in the series have not been refereed and are published as they were submitted by the author. The series serves two purposes. First, we want to disseminate the information as fast as possible. Second, by doing so, the authors can receive comments useful to revise their papers before they are considered for publication in one of ATINER's books, following our standard procedures of a blind review.

Dr. Gregory T. Papanikos
President
Athens Institute for Education and Research

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Slow Does It!

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Abstract

What will it take for a student who is a *math-phobic* to be successful in a first year calculus course? This is the question that many mathematicians are trying to find the answer to, especially if they are teaching a calculus requirement in a program (such as life sciences or management) that attracts a wide spectrum of students - a large group of which is not prepared for the first year university calculus course.

At the CMS department of UTSC such students caused a large attrition rate for MATA30F (Calculus I for Biological and Physical Sciences) and MATA32F (Calculus for Management I) for many years. Numerous attempts to alleviate this problem with extra resources had failed with the theory emerging that more than just resources are needed. The students most probably needed more time.

Consequently, new sections were created, MATA30Y and MATA32Y, one for each of MATA30F and MATA32F. These ran at half the pace and took twice as long, but with the same content and difficulty, however, with more resources than their respectively *regularly* paced sections offered. This paper will give a background of these courses and provide a statistical analysis to determine if the result is indeed the desired one.

Keywords:

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Two large calculus courses at University of Toronto Scarborough (UTSC) have challenged their instructors for many years. The reason is actually quite common to most first year calculus courses that are considered s*ervice courses* to programs such as life sciences and management. Most of the students in these programs are attracted to them for the careers they lead to (medicine, pharmacy or management in the corporate world), but do not consider themselves math-friendly. This causes a large number of these students to be unsuccessful in the course. Thus, the first year calculus course that they must pass in order to continue working on their dreams is often viewed as an obstacle and not as a tool that they will actually use. In that light, their dislike of mathematics is intensified making studying in this course even more undesirable. Previous attempts to help these students using extra help and resources had repeatedly failed, which brings the question: would slowing down the course help them? If so, would it also help average students as well? This paper will provide the background of the structure of these course as well as statistical result to help answer the mentioned questions. It will also give a brief historic background of the courses, how the *slow paced courses* were created and how students entered them.

History of MATA30F (Calculus I)

This course was created in 2007. Its duration was 12 weeks (one term) with 3 hours of lectures and 2 hours of tutorials per week. It was designed to be the first calculus course for all students in a Computer, Mathematical, Life or Physical sciences programs and this was the only course common to all of these disciplines. For this reason it attracted students from a wide spectrum of interest as well as knowledge and capabilities in mathematics. This created the biggest challenge in teaching the course. Trying to balance the needs of the various groups of students in the course, as well as teach the material set in the syllabus at the level required by all the programs of these students, was a difficult task. Similarly, the weaker students in the course found it very difficult to cope with the demands as well as the pace with which the material was taught. This had caused a large attrition rate in the course. On the other hand, students in the computer and mathematical sciences found the course easy and inefficient in preparing them for the second term calculus course in their program.

History of MATA32F "Calculus for Management I"

This course was created in 2007 and its duration was 12 weeks (one term) with 3 hours of lectures and 1 hour of tutorial per week, and was a requirement for management programs. The students in these programs also came from various backgrounds and were from a wide spectrum of interest as well as

knowledge and capabilities. This caused the same problems in attrition as in MATA30F.

Each of the courses MATA30F and MATA32F had large enrollments ranging from 500 to 1200. However, the number of students unsuccessful in them was high enough to cause concern. For this reason a proposal from the instructors (Sophie Chrysostomou for MATA30F and Raymond Grinnell for MATA32F) of the course came forward. As part of the first year programming initiative launched by the UTSC Academic Dean, with the purpose to enhance the experience of the first year students, a new section for each of the courses MATA30F and MATA32F was proposed to be created. These courses would cover the same material as their counterpart courses, but at half the pace and therefore with double duration (24 weeks or two terms). Further more extra lecture time and tutorial time would be allotted to them in order to aid with the special needs of the students. The proposal was granted and MATA30Y started in September 2011 and MATA32Y started in September 2012.

Simultaneously, and to alleviate another problem, in 2011-2012 a new course was created, MATA31F "Calculus I for Mathematical Sciences". This course was designed for all students in the computer and mathematical sciences. This dealt with the students on the higher end of the spectrum in MATA30F who found the course unchallenging and who would be placed in a more suitable course for their studies.

Through the years, various other attempts were made to eradicate the problem of the large attrition rate. We had started a "Diagnostic Test" to help identify students with inadequate preparation for the course and we offered various aids to help them. These included: "math modules" (short classes to go over pre-calculus material), "Math Aid Room" (a drop in center for math help), "virtual tutor" (a tutor online in the evenings), "Facilitated Study Groups" (groups formed to study with a former student as a facilitator), seminars, workshops, "WebAssignments", web option lectures, mentors, etc. Regardless, the attrition rate remained the same among this group of students.

In this paper we evaluate the effectiveness of the Y courses. In all fairness it is not acceptable to compare the attrition rate of the Y courses with the attrition rate of their corresponding F courses, as the students in the Y courses would be chosen to be "high risk" students. It is also not acceptable to compare the percentage of successful students in both MATA30F and MATA30Y in one year with the percentage of successful students in MATA30F from previous years since the high achieving students from MATA30F had been removed from the class and placed in MATA31F. For this reason the study compares groups of students with "similar strengths", the similarity being based on their performance in the Diagnostic Test.

Before describing the method with which students entered the Y courses, let me briefly describe the Diagnostic Test. This test contains 18 multiple-choice questions that help to evaluate the students in various foundational areas such as: Algebraic Manipulation and Equations, Numbers and Inequalities, Graphs and Analytic Geometry, Functions, Exponents and Logarithms and Trigonometry. There were three different versions of the test available online

so that students could try the test more than once (maximum of three tries). Through the years we identified the students with high risk to fail or drop the course to be the students with a mark of 12/18 or lower. For this reason a mark of 12/18 or less was considered as a "fail".

In July - August a message was sent to all students entering MATA30F/32F to take the Diagnostic Test. If the mark they received was 12/18 or less, then a pop-up message recommended to the student to enroll in MATA30Y/32Y with an explanation that these courses were designed to provide extra help for them. The students who did not take (or "failed") the test in the summer had two more opportunities (during pre-assigned time periods) to do so during the first two weeks of classes in September. In addition to the pop up message to all students who failed, the instructors of the courses strongly recommended to them a switch to the Y courses. After the first two weeks of classes students could no longer make a switch from F to Y. During this time, no student was forced to move into the Y courses and no student who wished to enter the courses was prevented from doing so.

Regardless of the warnings quite a few students who should have moved to the Y courses did not do so. The reasons were that many students felt that the test did not accurately portrayed their strengths, while others wished to finish the course at a short period of time and took their chances with the F course. For this reason, in October after the first test in the F courses, students who performed poorly were allowed to move to the Y courses with the instructors' approval. No student who performed well on the term test was at that time allowed to make the switch. After that, no student could enter a Y course.

The above method of allowing students to enter the Y courses resulted with a large number of students in these courses being the weaker students as expected, but the small window in September allowed a number of good students to enter the course.

The students in the Y courses had 2 hours of lectures and 1.5 hours of tutorials per week. In the 24 weeks this gave them a total of 48 hours of lectures and 36 hours of tutorials. In MATA30Y this was an increase of 33% of lecture time and an increase of 50% of tutorial time. In MATA32Y this was an increase of 33% of lecture time and of 200% increase in tutorial time. Further to these extra hours of instruction, the students had help from the Math Aid Center, the "online tutor", etc.

Dr. Mahinda Samarakoon, a Lecturer in Statistics at University of Toronto Scarborough, conducted the statistical study. The study determined if the slow pace helped the weaker students and compared the performance of the weak students in the slow pace (Y) and the normal pace (F) groups. The comparisons were carried out separately in MATA30F/Y and MATA32F/Y. The weaker students were defined to be those who had a Diagnostic Test (DT) test score below a critical value x. Analysis was repeated with $x = 13$ and $x = 14$. Comparisons of the proportions of weaker students passed in the two groups (Y and F) were carried out using chi-squared (approximate Z test for proportions) and Fisher's exact tests. Comparisons of the average scores of weaker students in the two groups (Y and F) were carried out using t tests.

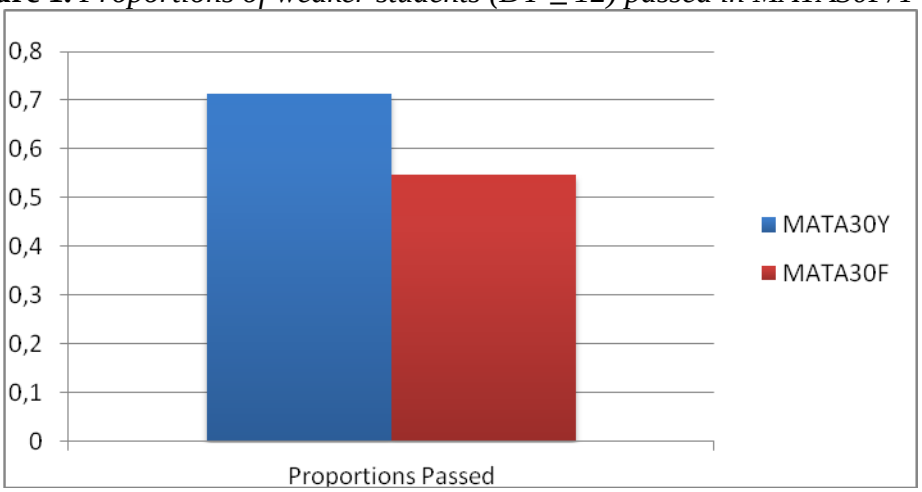
For MATA30 the results are as follows:

a) With x = 13 (i.e. for students with a DT score 12 or below) the data indicate that a higher proportion passed in the Y section, statistically significant at the 5 percent level (p-value = 0.02237). (see Table 1 and Figure 1). It is very interesting to note that with x = 14, the difference between the proportions of weaker students passed in the two groups (Y and F) is not statistically significant at the 5 percent level of significance.

Table 1. *Proportions of weaker students (DT ≤ 12) passed in MATA30F/Y*

Group	MATA30Y	MATA30F
Number of Students	52	239
Number of Students Passed	37	131
	0.712	0.548

Figure 1. *Proportions of weaker students (DT ≤ 12) passed in MATA30F/Y*



b) With x = 13 (i.e. for students with a diagnostic score 12 or below) the data indicate a higher average score in the low pace (i.e. Y) group compared to the normal pace (F group), statistically significant at the 5 percent level (p-value = 0.0005421). This means the mean score of weaker students in general is 3.9 to 13.5 points higher in the slow pace group compared to the normal pace with 95 percent confidence. (See Table 2, Table 3, Figure 2 and Figure 3).

Table 2. *Averages of weaker students (DT ≤ 12) in the two groups MATA30F/Y*

Group	MATA30Y	MATA30F
Number of Students	52	239
Mean	57.54	48.87
Median	57.00	50.00
Standard Deviation	15.40	17.50

Table 3. *Proportions of weaker students (DT ≤ 12) passed in MATA32F/Y*

Group	MATA32Y	MATA32F
Number of Students	63	306
Number of Students Passed	49	171
Proportion Passed	0.778	0.559

Figure 2. *Histogram of grades of weaker students in the MATA30Y group*

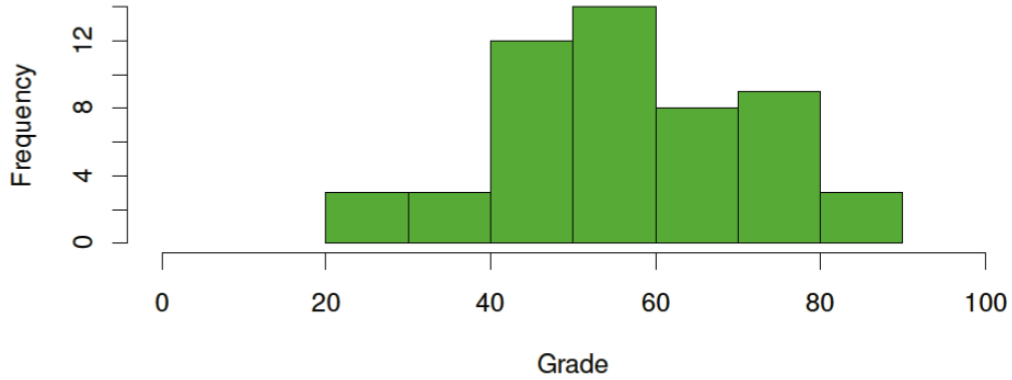
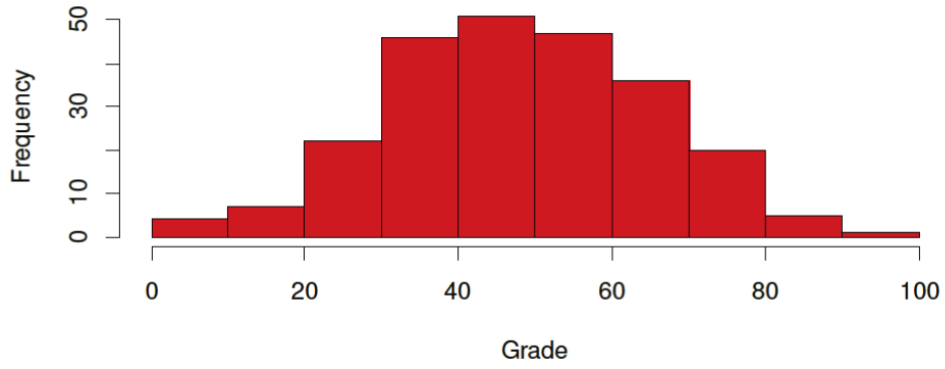


Figure 3. *Histogram of grades of weaker students in the MATA30F group*



Again it is[1] notable that with x = 14, the average scores of weaker students in the two groups (Y and F) is not statistically significant.

Similar results were seen in MATA32F/MATA32Y. That is, with x = 13 (for students with a diagnostic score 12 or below) the data indicate that a higher proportion passed in the low pace (i.e. Y), statistically significant at the 5 percent level (p-value = 0.00102) and the average score of weaker students is

[1] The authors thank Dr. Raymond Grinnell for his editorial comments.

significant higher in the slow pace (Y) group compared to the normal pace (F), p-value = 2.378e-06. Neither the proportions passed nor the group averages were significantly different with x = 14. (Tables 3, 4 and Figures 4, 5, 6).

Table 4. *Averages of weaker students (DT ≤ 12) in the two groups MATA32F/Y*

Group	MATA32Y	MATA32F
Number of Students	63	306
Mean	60.78	50.30
Median	60.00	51.00
Standard Deviation	16.38	16.30

Figure 4. *Proportions of weaker students (DT ≤ 12) passed in MATA32F/Y*

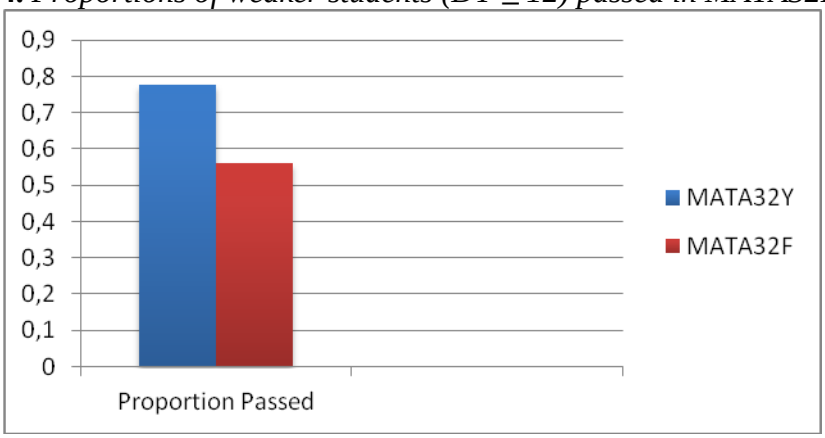


Figure 5. *Histogram of grades of weaker students in the MATA32Y group*

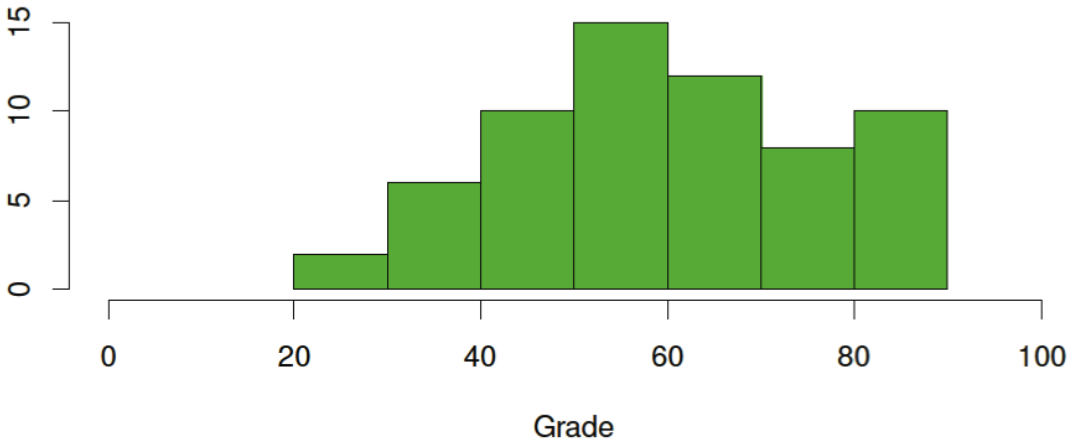
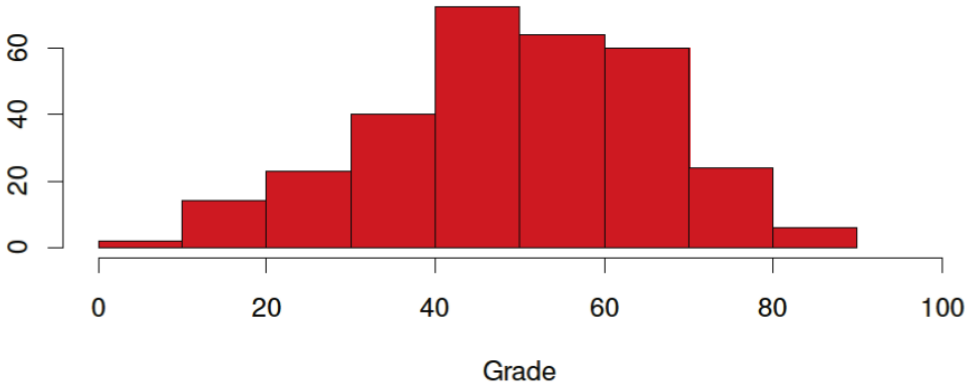


Figure 6. *Histogram of grades of weaker students in the MATA32F group*



In summary, the data show that the weaker students are more successful and perform better in the slow pace group. However, there is no significant (statistically) difference in the performance of the average students in the two groups. In fact... *slow does it* for the weaker students but not for the average ones.