Improving Student Performance with the TI-Navigator™ System: A Pedagogical Journey

Case Study 20

Revised July, 2009

Teacher/Researcher – Derrick Driscoll, Westminster Secondary School, TVDSB, London, Ontario

Improving Student Performance with the TI-Navigator™ System: A Pedagogical Journey

Case Study 20
Revised July, 2009

Teacher/Researchers	Derrick Driscoll
Location	London, Ontario, Canada
Course	Foundations of Mathematics
Grade	9
Student Profile	Students who have failed the course at least once before
Technology	TI-Navigator system with TI graphing calculators

Formative assessment with the TI-Navigator system has helped this teacher to deal efficiently with misconceptions, and to use class time more efficiently. In the process, his thinking about teaching and learning has evolved.

Setting: I am working with grade 9 level weaker math students in a Foundations of Mathematics course. Most of my students have failed the course at least once before.

Curriculum & Teaching: My motive in helping these students has always been to improve grades, and to understand what impact pedagogy has on performance. In this quest, I am a teacher who found value in emerging technology. Riding the evolution of the technology has caused me to change the way I instruct students and how I think they learn best. Granted, my use with students at the start was more punitive and did not nurture the right classroom 'culture'. However, I learned how to nurture the right culture to help these students succeed.

Since 2001[1], I have been developing a pedagogical model which uses the TI-Navigator classroom learning system in conjunction with TI graphing calculators[2]. I have gathered both quantitative and qualitative data showing that my students are succeeding in ways they otherwise would not. Achieving this success has led me to some important insights about pedagogical principles, and the way I teach has changed substantially. I describe this change as a personal pedagogical journey. In this paper, I will first describe my pedagogical approach. Then I will present a detailed example of how I thought about the teaching of one typical topic in my Foundations of Mathematics class. Finally, I will present data I have gathered so far on the achievement of my students, and contrast that with the formative data. My pedagogy continues to evolve, but it is my hope that this detailed example of how I meld formative assessment, data-driven decision making and instruction using the TI-Navigator system will be of use to others.

---

[1] A report on my work from 2001-2004, *Inventory of Performance,* is available on request.
[2] Information on the TI-Navigator system is available at http://education.ti.com/educationportal/sites/US/productCategory/us_navigator.html

My Student-Centered Pedagogy

How do students reach a comfort level with the course content? When is the right time to test? These questions are extremely important in the teaching and learning equation. I would challenge the conventional norm that seems to be to test when the teacher is ready rather than when the student is ready. I have seen that different students need different amounts of time to reach a comfort level. I also would challenge the conventional norm that students like mine have trouble with math because it is difficult, or because they are less able. I have seen that most of the problems my students have with math are due to specific causes. I view my role as that of a detective: to discover the specific cause of a student's problem and to take action to resolve the problem.

I believe that performance on formal assessments will improve if:

1) The teacher can identify concepts that students are having difficulty with through a pre-test.
2) Students receive timely remediation of gaps and misconceptions. Then, if there is sufficient practice and students experience measurable success, their confidence and retention of the mathematical concept will improve.
3) Students perform well on a post-test with questions that are a similar type to the pre-test. This will result in improved performance on formal assessment.

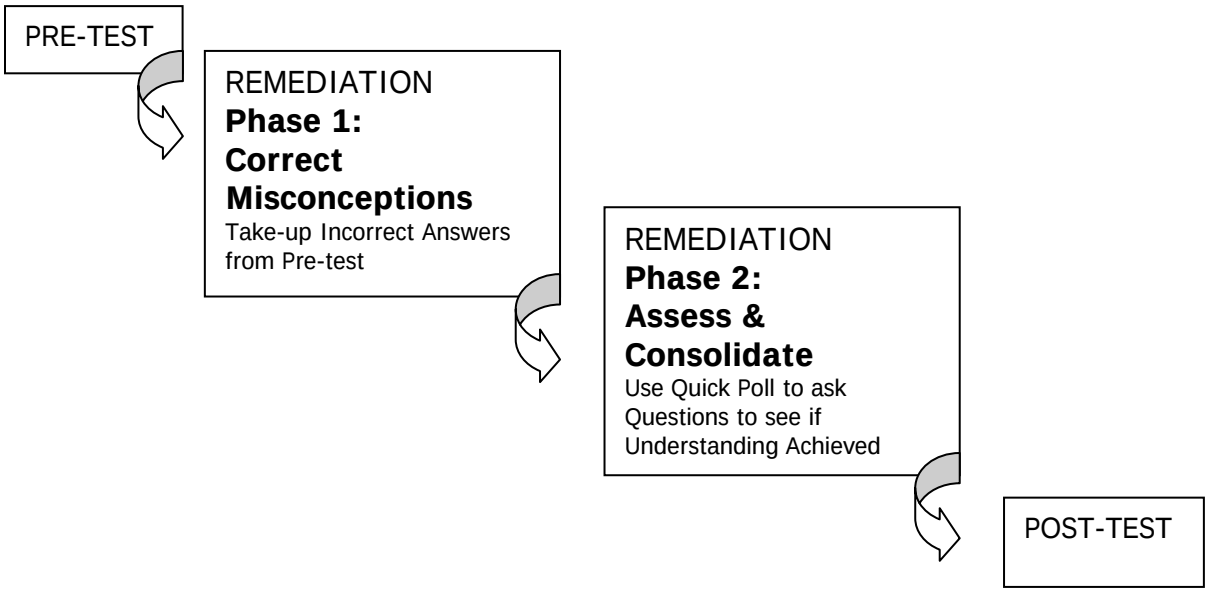
It is my belief that learning happens in a 3-step cycle:

1. Pre-test – Each student completes a set of questions to the best of their ability, even though they may not know the concept very well.

2. Remediation – Each student participates by completing questions, one at a time, devised to remediate the concept identified from the pre-test.

3. Post-test – Each student completes another set of questions similar in design to the pre-test questions to measure whether or not performance was better than the pre-test.

All students should take a pre-test, even though the topic has not yet been taught. Students may or may not perform well on a concept, but the pre-test makes it clear to the student what is to be learned. The pre-test should point to gaps or misconceptions held by individual students. Then the teacher must dissect, resolve and remediate the gaps or misconceptions through a differentiated instructional dialog that includes explanation, questions, practice and feedback. Please note that the remediation occurs in two distinct phases.



Phase One: Correct the misconceptions identified from the pre-test by taking them up with the class in a dialog.

Phase Two: Assess and consolidate. Give more questions of a similar nature to those identified from the pre-test, one at a time. Use Quick Poll to assess whether or not the misconception has been resolved by using the class performance as the indicator of success. Are my students getting it? If not, back to Phase One, to address the misconception or gap just discovered.

Once mastery of the concept is achieved, I can go on to the next concept. When there are no gaps or misconceptions remaining, then the class may be ready to engage in a post-test to determine if mastery of the concept has been attained.

Understand that there are 3 categories (Pre-test, Remediation and Post-test) comprising the Formative Assessment grade. Pre-tests are worth 33.3% of the formative assessment grade, the remediation phase is worth 33.3% and the post-test is 33.3% of the formative assessment grade. Within each category, the marks are weighted equally. In other words a pre-test out of 30 will have the same weight as a pre-test out of 15 within the category of pre-test. These grades are kept separate from Formal Assessment grades.

If a student has success on the post-test, having gone through a pre-test and remediation cycle, my data shows they will do better on the end-of-course formal test and have a better chance of passing the course. Failure rates using the pedagogy are substantially less than traditional class failure rates.

How I Teach: An Example

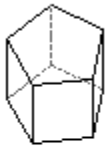
An authentic story/reflection of how I recently taught Volume of Prisms will illustrate the pedagogy. Using the TI-Navigator system™, I pre-tested, remediated problems and post-tested the topic. All the questions were multiple choice in nature and created using Infinite Pre-Algebra by Kuta Software[3]; an infinite item generator. The software allows me to construct questions quickly and in the moment. The TI-Navigator system connects all the TI-Nspire™ learning handhelds in the class, and instantly delivers electronic polls delivered wirelessly, one question at a time, until the class performance demonstrates mastery of the concept. Students complete a multiple choice question (MCQ) using paper and pencil and the TI-Nspire handheld, and then they register an answer choice (A, B, C, D, E) on their TI-Nspire handheld, and it is transmitted to my computer. By examination of the performance after each question, I can tune to the needs of the class and adjust my teaching from moment to moment, depending on what I see of each student's personal understanding.

Pre-test Phase

In this lesson on Volume of Prisms, the pre-test and post-test had 10 questions; 4 comprised of naming 3D prisms and 6 involved a volume calculation. Here are examples:

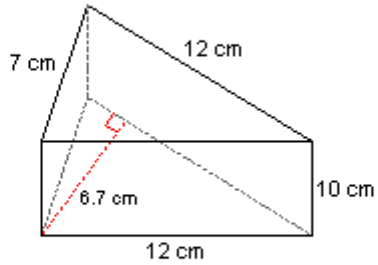
[3] Information on Infinite Pre-Algebra by Kuta Software LLC is available at **http://kutasoftware.com**.

Name each figure.



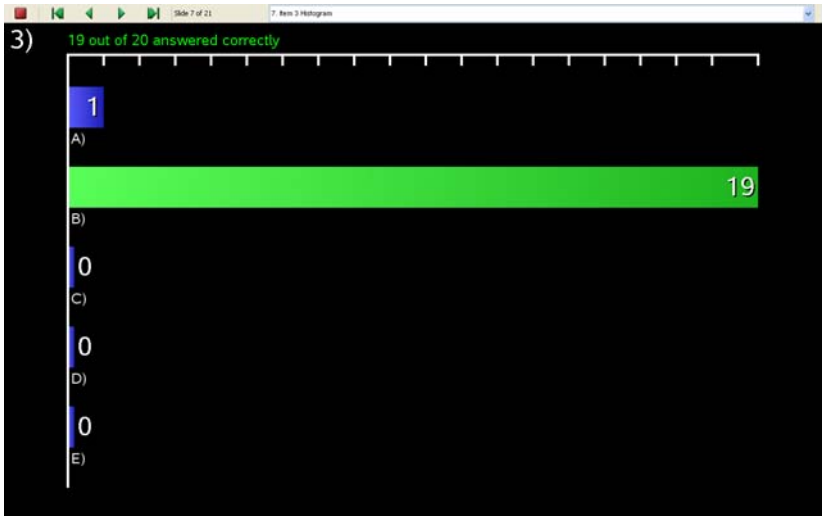
A) pentagonal prism
B) cylinder
C) square pyramid
D) rectangular prism
E) triangular prism

Find the volume of each figure. Round to the nearest tenth.



A) 1865.2 cm³
B) 804 cm³
C) 932.6 cm³
D) 1529.5 cm³
E) 402 cm³

There was no teaching of the concept prior to the pre-test. Students did use a formula sheet, given to them at the beginning of the unit, which contained formulas for the volumes of several 3D shapes. Some triangular prisms had right angled triangles as the base and some not. Some cylinders had the radius and some the diameter. Some problems had extra information. At no time did students have to calculate any missing lengths on the 3D object. The class average on the pre-test was 70%. After their files were collected by the TI-Navigator™ system, I used the Slide Show within the TI-Navigator software to show the class performance on each question and to share with them the correct answer.



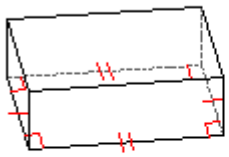
For question #3, the performance was very good. The green bar is the correct answer. The students corrected their own papers and gave themselves a score out of 10. I have an electronic record of their choice, but require them to keep track of their score for each question. Since the data showed there was no need for teaching here, I was able to move on to the next concept. In this way, I use class time to focus only on what's really needed.

Remediation Phase One: Correct Misconception

It is important for students to correct their mistakes. However, this is very challenging to monitor because there is great potential for students to become disruptive. Students who do well on the pre-test get bored easily and others that have done poorly (intentional non-learners) don't complete the corrections. Instead we work on questions together, targeting the questions that had the lowest class performance. I keep the students who got the question right involved by challenging them to help figure out why their peers erred. Then they help correct the gaps and misconceptions. The pre-test showed there was some difficulty with giving the appropriate name to the 3D prism. The following is #1 and #2 of the pre-test followed by the class performance.

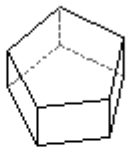
Name each figure.

1)

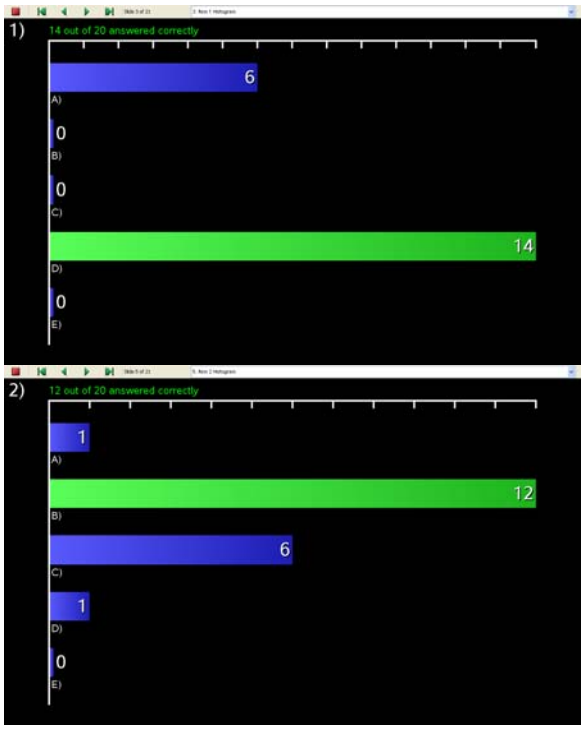


A) rectangular pyramid
B) triangular pyramid
C) triangular prism
D) rectangular prism
E) pentagonal prism

2)



A) square pyramid
B) pentagonal prism
C) hexagonal prism
D) pentagonal pyramid
E) sphere

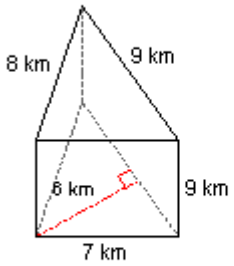


In #1, it was apparent that some students did not know the difference between a pyramid and a prism. I had 3D models of prisms and pyramids and used these to show the differences. We discussed how a prism has two identical faces that are perpendicular to the body of the prism, while a pyramid has one face that is the base with all other faces coming to a point away from the base. In #2, it was apparent that some students did not know that 'penta' in pentagonal meant 5 and 'hexa' in hexagonal meant 6. This was discussed.

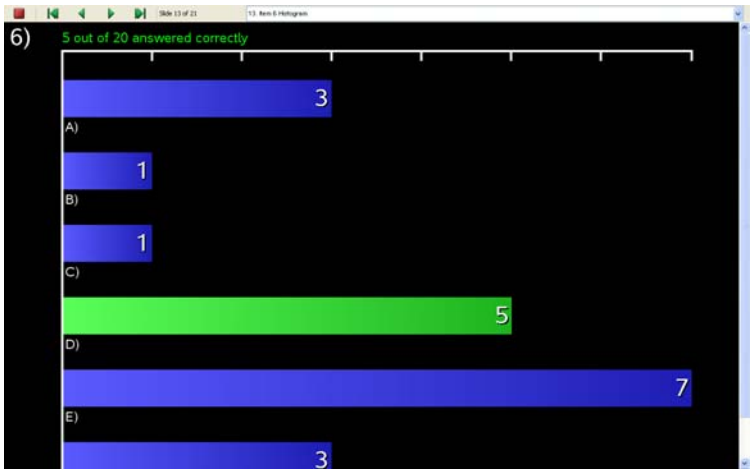
When I examined the class performance with my students, it was quite apparent that #6 gave them the most difficulty. The question and class performance are given below.

Find the volume of each figure.

6)



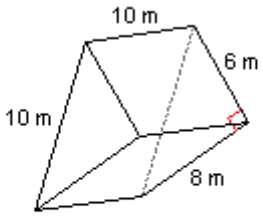
A) 102.1 km³ B) 96.4 km³
C) 81.7 km³ D) 243 km³
E) 121.5 km³



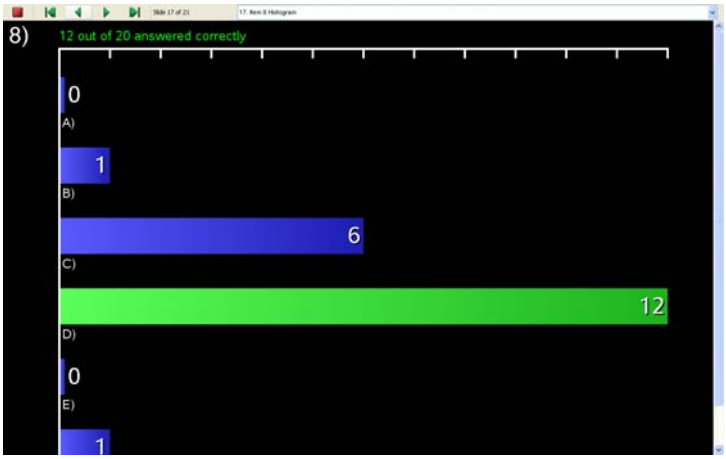
I saw that only 5 out of 20 students had the correct answer. I could not immediately understand why so many students had chosen E (121.5 km^3) as an answer. I asked the class about the answer. Students said that they found the area of the base, multiplied by the height and then divided by 2 because it was a triangular prism. I had never anticipated this as the difficulty. They seemed to know that the area of a triangular face was bh/2 and that the volume of a prism was its base area times its height. The extra division by 2 was a surprise. They thought that because it was a triangular prism they should take half the value of the volume calculated just like they did with area. This was a wonderful discovery of how they were thinking. It shows how most wrong answers are caused by specific misconceptions, not random errors.

Next, I decided to take up #8. The question and class performance are given below:

8)



A) 66.6 m^3 B) 73.9 m^3
C) 120 m^3 D) 240 m^3
E) 133.2 m^3



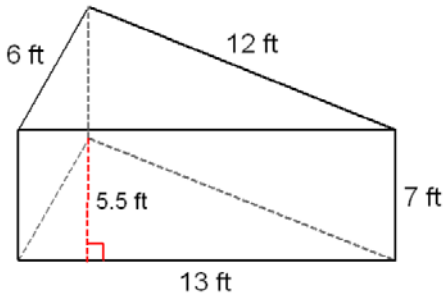
I saw that only 12 out of 20 students had the correct answer. As a class we established that students who chose the wrong answer, C, had performed the same mistake as in #6: they had correctly identified that they needed to take bh/2, multiplied by the height of 10 and then divided by an extra 2 because it was a triangular prism.

I did not anticipate the problem identified with calculating the volume of triangular prisms. I had anticipated that there would be more problems with finding the volume of cylinders (radius vs. diameter), but the results clearly indicate that this was not the real misconception. Without the data from the pre-test, I would have wasted valuable classroom time teaching something that was already understood, and I would have missed the real misconception–another way this style of teaching helps me target class time more effectively.

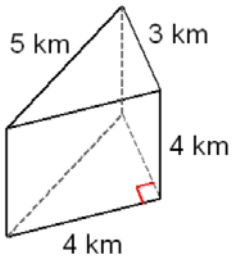
Remediation Phase 2: Assess and Consolidate

In this lesson, once I felt that the issue has been resolved, I post-tested to see whether or not the class performance improved. I was prepared to deliver multiple-choice questions using Quick Poll having a similar style as the pre-test. I used only the questions that were relevant to the need. Again, I used the Kuta Software to generate the questions of a similar type, so I had a file open with a supply of questions at the ready.

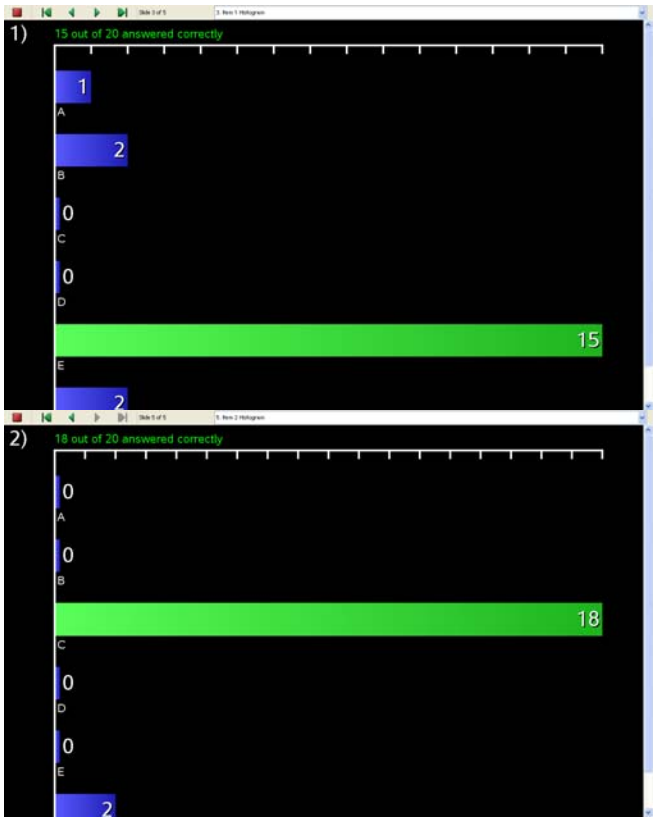
I usually keep doing questions, one at a time targeting the specific issue, until I get acceptable performance (usually above 80%). In this lesson, it turned out that I did not need many questions. By the second question all students had the right answer. Here are the questions and the performance demonstrated.



A) 430.4 ft³ B) 500.5 ft³
C) 731.7 ft³ D) 860.8 ft³
E) 250.2 ft³



A) 10.8 km³ B) 12 km³
C) 24 km³ D) 9.7 km³
E) 11.6 km³



During most of the assessment processes (pre-test, remediation via Quick Poll phases 1 and 2, post-test) students do not discuss their work so that I can get valid data from them. For the most part my students understand the rationale for this. It is not a punitive environment but one that does require students to be honest so that I can troubleshoot the difficulty. Trust is an essential ingredient. They trust that I am going to resolve the issues once they are discovered and I trust that they will provide me the environment with which to do it. We all are focused on the specific learning tasks, and it is a shared responsibility; there is no place for blaming or excuses. Students can't let themselves off just by saying "I'm dumb!" or "math is too hard!"

While I was teaching this lesson, the bar graphs of the TI-Navigator™ Quick Polls (which show whole class results) made me conclude that a large proportion of the students understood. But, there is always the chance that the whole class results mask an individual student who is performing at a very low level. I quickly checked this by saving the data to the Student Portfolio where I quickly analyzed the class performance to 'see' how many students improved their grades from the pre-test, while also identifying those who did not.

Below is a graphic of the performance of individuals on the Quick Poll questions (with names removed).

Student	Poll 11/27/08-Volumes Prisms
Class Average	83
A[redacted] M[redacted]	50
B[redacted] C[redacted]	100
B[redacted] J[redacted]	100
C[redacted] J[redacted]	100
F[redacted] A[redacted]	
F[redacted], A[redacted]	100
F[redacted] E[redacted]	100
G[redacted] A[redacted]	
J[redacted] E[redacted]	0
L[redacted] D[redacted]	100
M[redacted] J[redacted]	100
N[redacted] T[redacted]	0
N[redacted] H[redacted]	50
S[redacted] N[redacted]	
T[redacted] J[redacted]	
Z[redacted] J[redacted]	100
Z[redacted] S[redacted]	100
M[redacted] C[redacted]	100
R[redacted] J[redacted]	100
F[redacted] A[redacted]	
M[redacted] D[redacted]	100
A[redacted] B[redacted]	100
W[redacted] A[redacted]	50
S[redacted] S[redacted]	100
R[redacted] B[redacted]	100

Clearly, there were two students (JE and NT) who did not yet understand even though the class average suggested otherwise. I felt that the class was ready to move on, and so I progressed to the post-test phase of the lesson. But because I was aware of these two students, I gave them a personal visit to discuss their difficulties.

This marks the end of remediation phase 2 (Assess and Consolidate) unless performance on the post-test suggests that the problems identified by the pre-test were not resolved.

Post-test Phase

In this lesson, I answered two questions with the post-test.

1) Did the class average increase due to increases in student performance on triangular prisms?
2) Did the class continue to perform as well on the balance of the prism styles even though they were not discussed in the lesson?

The answer to both questions was YES, as shown by comparing pre- and post-test scores in the Student Portfolio report of the TI-Navigator™ system.

The Student Portfolio entries below again have the names blocked out. If we examine the entries we can clearly see that the class average increased from 70% to 81%. On an individual basis we see that 16 out of

20 increased their performance and 4 out of 20 did not. It is interesting that the two students I made an overt attempt to help during the post-test did not improve their performance, but actually *decreased* performance on the post-test. I did believe that I was helping them. Specifically, both had difficulties finding the base and height of the triangular face. In the remediation phases I had come up with a different way of showing them how to find the base and height because it simply was not obvious to them. I instructed them to find the square corner and look for two sides that touch this corner; one was the height and one was the base of the triangular face. This seemed to satisfy them, but clearly their post-test performance decreased. So, I knew that more diagnosis and remediation was needed for these two students.

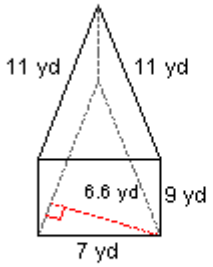
Student	Nov27-VolumesPrism-PostTest	Nov27-VolumesPrism-PreTest
Class Average	81	70
A[redacted] M[redacted]	100	90
B[redacted] C[redacted]	40	40
B[redacted] J[redacted]	90	80
C[redacted] J[redacted]	70	50
F[redacted] A[redacted]		
F[redacted] A[redacted]	90	80
F[redacted] E[redacted]	80	90
G[redacted] A[redacted]		
J[redacted] E[redacted]	50	60
L[redacted] D[redacted]	100	90
M[redacted] J[redacted]	60	100
N[redacted] T[redacted]	60	70
N[redacted] H[redacted]	70	70
S[redacted] N[redacted]		
T[redacted] J[redacted]		
Z[redacted] J[redacted]	80	60
Z[redacted] S[redacted]	90	30
M[redacted] C[redacted]	90	60
R[redacted] J[redacted]	90	90
F[redacted] A[redacted]		
M[redacted] D[redacted]	100	90
A[redacted] B[redacted]	70	20
W[redacted] A[redacted]	100	90
S[redacted] S[redacted]	90	80
R[redacted] B[redacted]	90	60

I also presented the class results to the students via the slide show to have the whole class correct their work as we had with the pre-test. I was focused on the results for questions #6, 8 and 9 as they were like the problematic questions from the pretest. The following are the questions followed by the class performance.

#6, 9 from Post-test were like #6 of the Pre-test

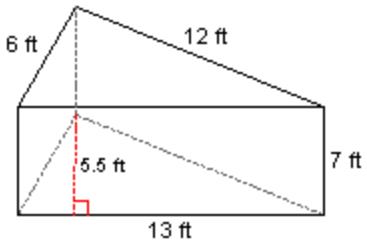
Find the volume of each figure.

6)

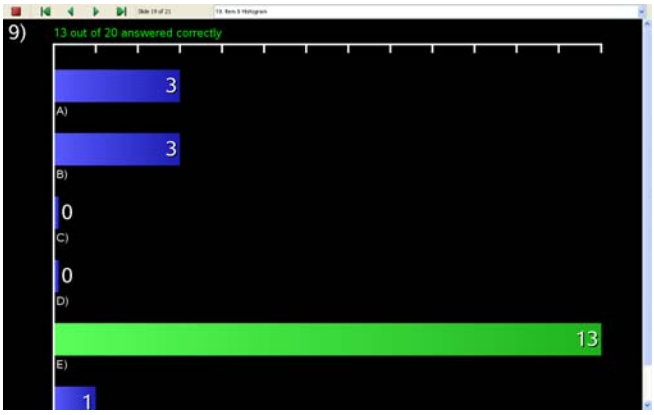


A) 326.7 yd³ B) 596 yd³
C) 261.4 yd³ D) 298 yd³
E) 149 yd³

9)

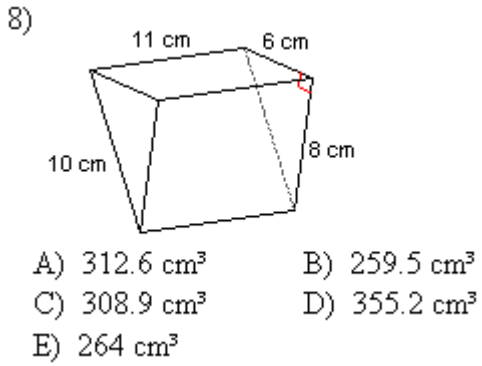


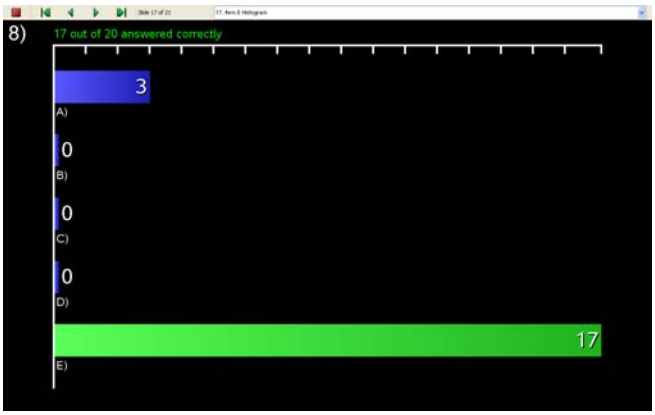
A) 430.4 ft³ B) 500.5 ft³
C) 731.7 ft³ D) 860.8 ft³
E) 250.2 ft³



During the presentation of the results for #6 and #9 on the post-test, I felt like dramatic improvement had been made but I also felt like more work needed to be done.

#8 from post-test was like #8 of the pre-test:





These results clearly show an improvement over the pre-test performance for this style of triangular prism. Therefore, the class average did increase as a result of better performance on the post-test with this style of question. This addressed the first question: mainly, "Did the class average increase due to increases in student performance re: triangular prisms?"

The performance on the other set of questions revealed similar results to the pre-test, and thus answered the second question: "Did the class continue to perform as well on the balance of the prism styles even though they were not discussed in the lesson?" Increases in student performance as a result of naming the prisms better did occur and did contribute to the increased class performance on the post-test as well.

This example shows that I am macro-analyzing performance for much of the lesson. I also micro-analyze– but only what the data says I need to. This targeting is fundamental for differentiated instruction to be efficient and effective. I examine the Quick Poll results to look for students who had low performance so that I can offer further assistance to them specifically during the post-test. Thus, when I micro-analyze, I not only know *that* some students had low performance, I know *that a misconception* caused the problem.

The class performance was 83% on the post-test, demonstrating that the class as a whole increased as a result of the pedagogy employed. We did examine the correct answers for the post-test so that they could score their own paper and I could determine if there were still any gross misunderstandings. There was nothing glaringly obvious. Homework was assigned. Students were asked to look at their incorrect answers to try to determine where they made their mistake and to redo the questions they had wrong. I do believe that students will learn if they correct their errors, but this seems to be the thing they like to do the least when they work on their own. However, because students were working on paper at this point (rather than on the networked graphing calculators), it became very difficult to monitor who was correcting their errors, and I probably had only about 20% of my students try to do so. This illustrates the disadvantage of paper-based work, when compared to work done on the network of calculators.

End of Year Results

I have approached the analysis of this year's data with three main questions:
1) What is the relationship between the formative assessment system's data to the end-of-course data?
2) What is the effect of this teaching model on student success?
3) How do my results compare to similar classes with similar students in my school, taught by my colleagues, without use of my pedagogy?
I will present data summaries to answer each of these questions.

Formative Assessment

In my pedagogy, the purpose of formative assessment (pre-test and the Phase 2 Quick Poll questions) differs from a conventional unit test or end-of-course final exam. Using the formative assessments, I aim not only to measure proficiency in a skill, but also to check for underlying misconceptions and to verify deep conceptual understanding. So, in many ways I'm more interested in the exact errors each student makes than I am in whether the student got the answer to each question. And, because I use these formative assessments daily throughout each lesson, they are very detailed. By contrast, a final exam is only about measuring proficiency, and it can only be a sample of some subset of what a student can do. Because of these different purposes, it is important to understand the relationship of the three different kinds of tests I use.

The following are key topics in each strand of the grade 9 course that were involved with formative assessment.

Topics in the Number Sense and Algebra Strand

Integers (Addition, Subtraction, Multiplication, Division, Order of Operations)
Ratio, Rate, Proportion and Word Problems
Fractions, Percent and Decimals
Rounding Off
Square Roots
Sales Tax and Discount
Exponent Laws

Topics in the Measurement and Geometry Strand

Basic Angle Properties (Complementary, Supplementary, Adjacent and Opposite Angles)
Sum of the Angles in a Triangle
Quadrilaterals (Interior and Exterior)
Angles in Polygons (Interior and Exterior)
Pythagorean Theorem
Perimeter, Area of 2D Figures
Perimeter, Area of Compound Figures (2D)
Volumes Prisms
Volumes Pyramids
Volumes of Cones

Topics in the Linear Relations Strand

Rates of Change
Rates of Change in Context
Interpreting Graphs
Constructing Relationships

The Number of Assessments in Each Strand by Assessment Type

Semester 1 – MFM 1P1

Number Sense and Algebra (NS &A)

Assessment Type	Number of Assessments
Pre-tests	11
Remediation	7
Post-tests	22

Measurement and Geometry (Mea&Geo)

Assessment Type	Number of Assessments
Pre-tests	6
Remediation	6
Post-tests	16

Linear Relations (LinRel)

Assessment Type	Number of Assessments
Pre-tests	4
Remediation	3
Post-tests	3

Totals

Assessment Type	Number of Assessments
Pre-tests	21
Remediation	16
Post-tests	41

Semester 2 – MFM 1P1

Number Sense and Algebra (NS &A)

Assessment Type	Number of Assessments
Pre-tests	12
Remediation	22
Post-tests	31

Measurement and Geometry (Mea&Geo)

Assessment Type	Number of Assessments
Pre-tests	10
Remediation	12
Post-tests	22

Linear Relations (LinRel)

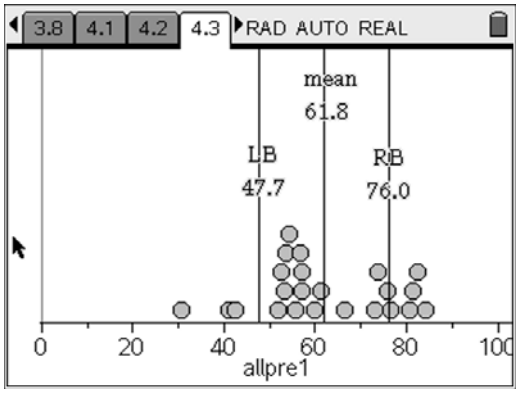
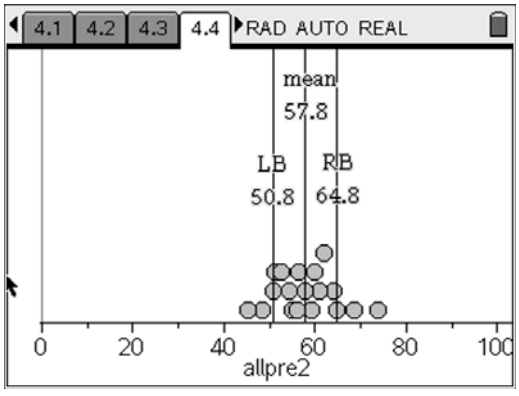
Assessment Type	**Number of Assessments**
Pre-tests	1
Remediation	1
Post-tests	4

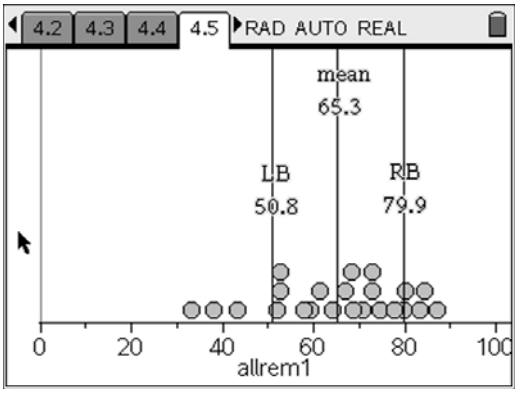
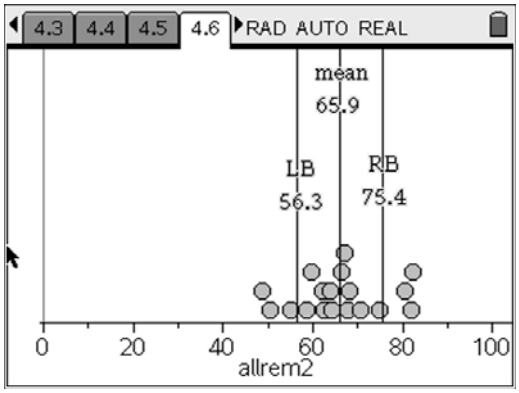
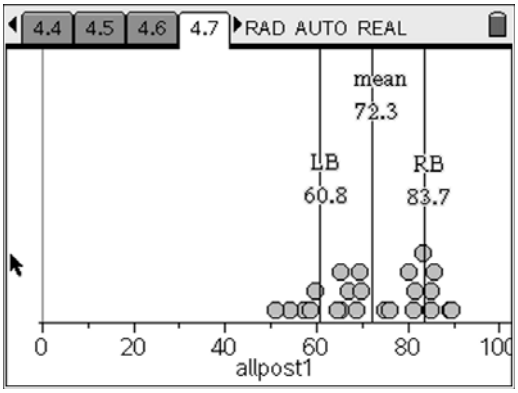
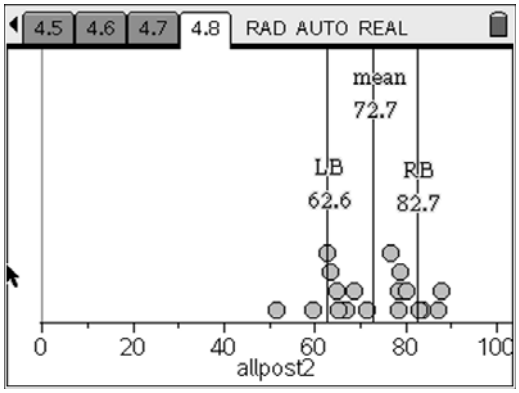
All Strands Together

Assessment Type	**Number of Assessments**
Pre-tests	23
Remediation	35
Post-tests	57

In performing the analysis, all assessments were given equal weight regardless of the number of questions. That is, a remediation score out of 4 was given the same weight as a remediation score out of 12 (pre-tests and post-tests usually had 10 or 20 questions, remediation assessments usually had fewer than 5 questions). In this way, I can see the impact on performance because one assessment does not overpower another (however, the shorter the test, the less reliable it is). Note also that I am tracking performance for only those students who finished the course. Students who write the final exam and EQAO, the provincial exam, are deemed to have completed the course. This eliminated from analysis one student in Semester 1, and 6 students (3 chronic non-attenders, 2 that changed schools and 1 that dropped for medical reasons) in Semester 2.

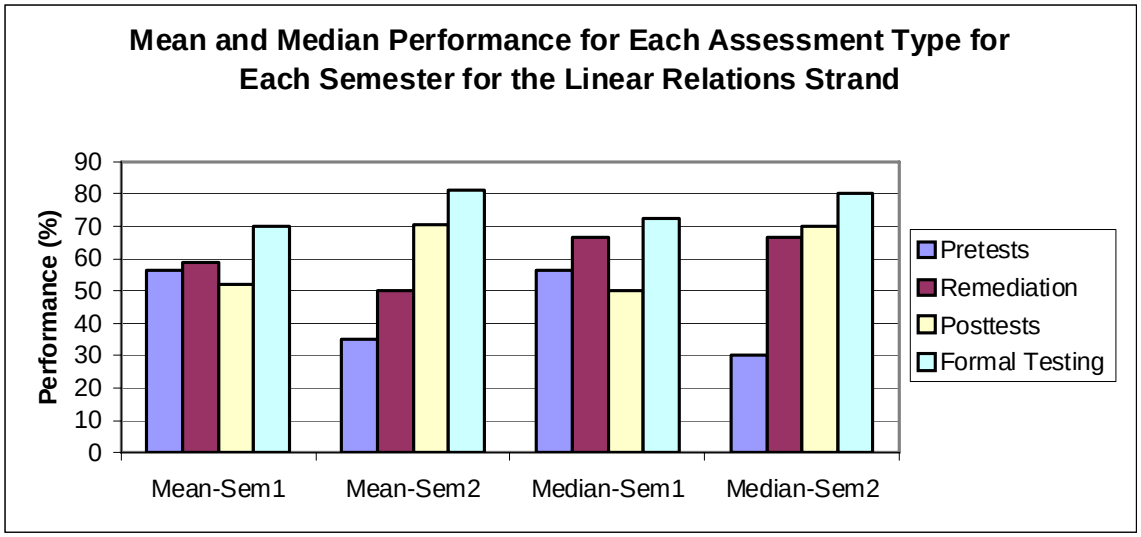
The analysis below averages all strands. It shows that in the first semester, the pre-test-to-post-test gain on average was 10.5%. In the second semester, the average gain was 14.9%.

Assessment Type	**Semester 1**	**Semester 2**
Pre-test *Mean* Sem1: 61.8% Sem2: 57.8% *Standard Deviation* Sem1: 14.1% Sem2: 7.1%		

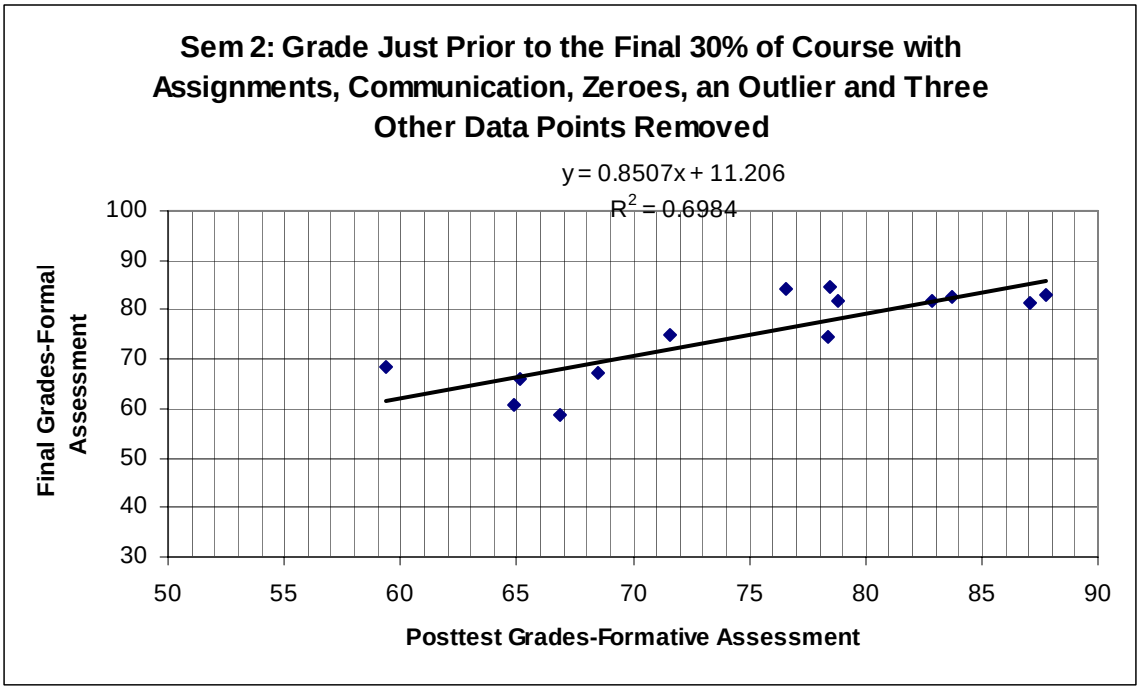
Remediation *Mean* Sem1: 65.3% Sem2: 65.9% *Standard Deviation* Sem1: 14.6% Sem2: 9.5%		
Post-test *Mean* Sem1: 72.3% Sem2: 72.7% *Standard Deviation* Sem1: 11.5% Sem2: 10.1%		

LB – Left Bound of interval defined by 1-standard deviation from the mean
RB – Right Bound of interval defined by 1-standard deviation from the mean

The standard deviations suggest this is not an artifact of the distribution. However, in most strands, the post-tests showed a lower standard deviation. In a mastery learning system, this can be an expected pattern if other issues (such as reliability) can be ruled out.
The relationship between the formative assessment system and the formal tests grade produced using end-of-unit tests only; excluded final exam and assignments) is shown in the bar chart below. Comparison of the means shows that most of the gains in the formative assessment system were in Semester 2, and that relative to the formal tests, the formative assessment system appears to underestimate performance (i.e., taken together, the formative post-tests help prepare students for formal tests).



From this analysis, I conclude that the formative assessment system appears to be fairly well aligned with the formal tests, and at the least it does not create a false sense of confidence for me or my students. A linear regression plot shows the relationship most clearly for Semester 2. The plot below compares the totals of the formative assessment system (with one outlier student data point removed and 3 others that exhibited patterns unlike the other students) to performance on the formal tests (grade just prior to final 30% of course with assignments, communication and zeroes removed for absenteeism removed).

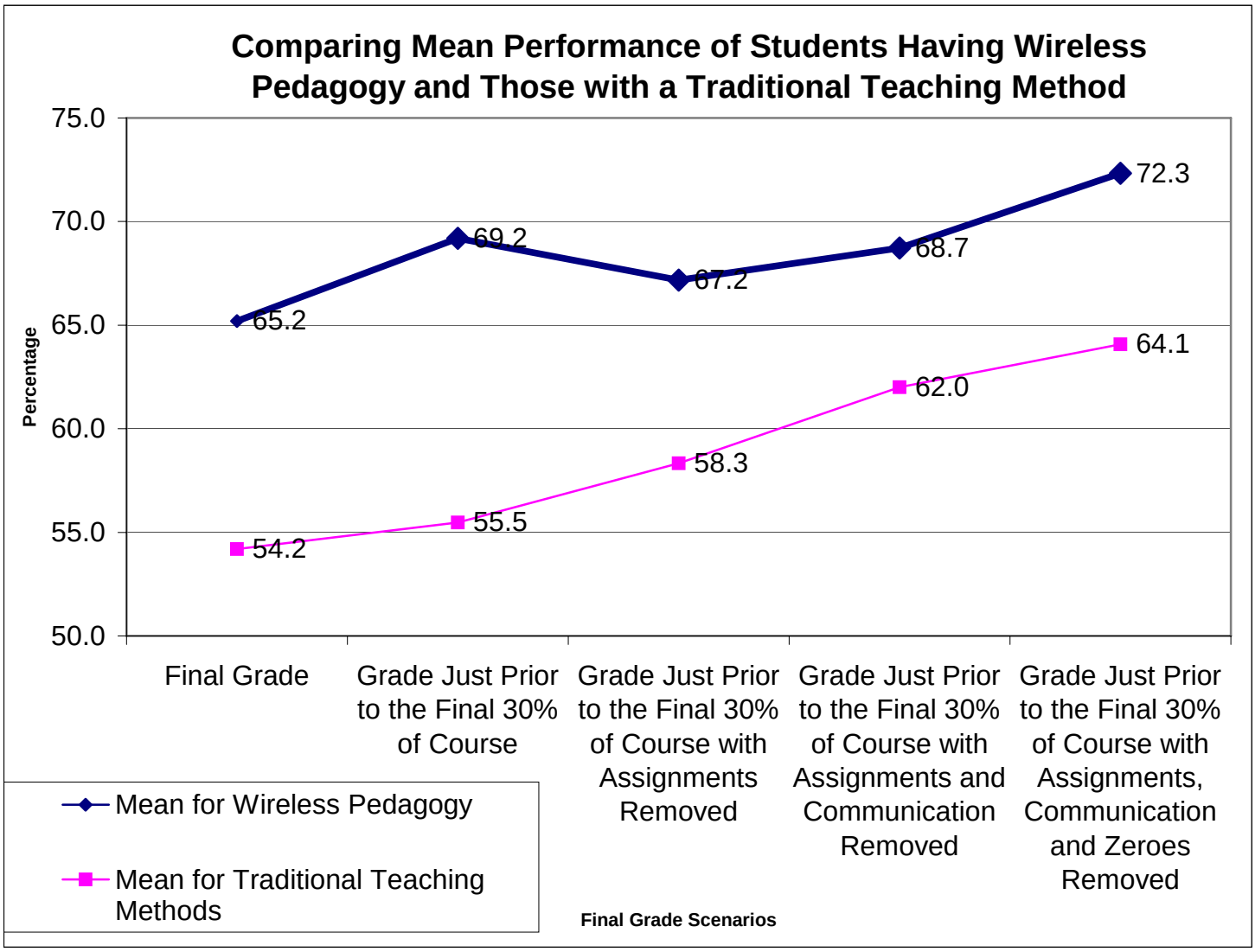


We see that 14/18 students have a slope of 0.8507. This is a strong correlation: not all students conform to this pattern, but most are. The correlation was 0.8357, indicating a strong positive connection between the attributes. We can say that approx 69.8% of the variation seen in Final Grades-Formal Assessment is due to variations in the Post-test Grades-Formative Assessment. Also, it would seem that the students Final Grades are not exceeding their post-test scores for this semester, which builds further confidence in the formative assessment system.

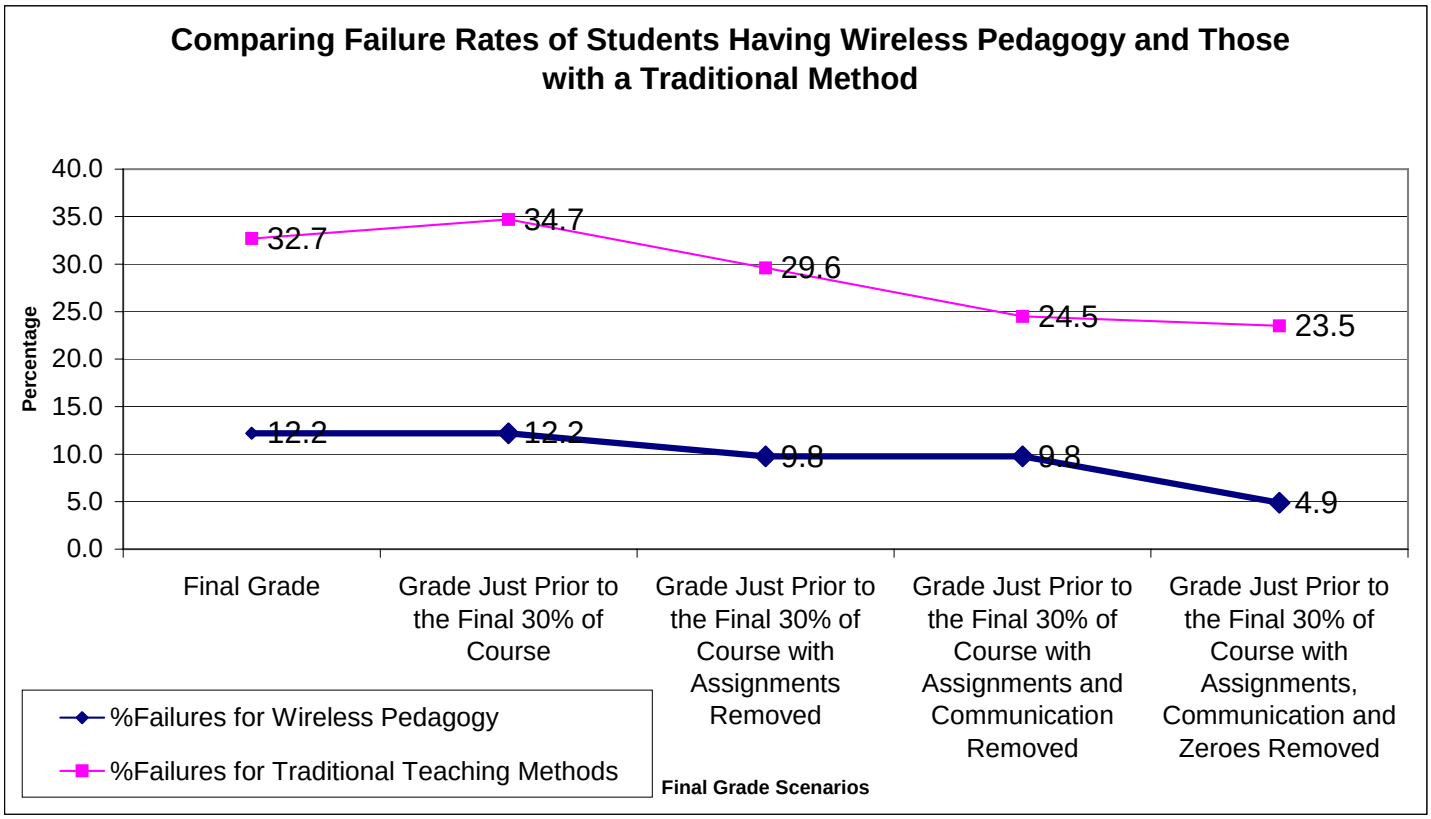
It appears that the Remediation Cycle for the formative assessment system, and the pedagogical model as a whole, functioned less well in Semester 1. However, Semester 1 data only included 16 data points, so this could be an artifact. In retrospect, however, I feel that in Semester 1 I did not do enough remediation (phase 2) that could be tracked, and did not dig deep enough. As I look to the coming year, and to use of this pedagogical model by other teachers, it is clear that this should become an important point in professional development. Discovery of this need demonstrates the power of data-driven analysis.

Effect on Student Success and Comparison to Other Similar Classes without Use of My Pedagogy

Thus far, I am the only teacher of *Foundations of Mathematics* in my school to use the TI-Navigator™ system or my pedagogical model. Since there is no practice of assigning stronger or weaker students to any one teacher, a baseline comparison of my results to those of my colleagues is meaningful. Our courses have two tests in common: the end-of-semester exam and the provincial test. Results of my two classes using my pedagogy are shown below, and compared to the combined data from five traditional classes. "Traditional" for the purpose of this analysis is used to indicate classes for which no use of my pedagogy was used. The final grade includes the final exam (30%), as well as the other tests, assignments and communication marks. Grades with contributing factors removed are also shown.



Similarly, upon analysis of failure rates, there is evidence to indicate fewer students will fail when the pedagogy used with classroom networking technology is used.



I conclude that use of the classroom networking technology using the pedagogical model described in this paper is having a positive effect, when compared to traditional methods.

Interestingly, a similar comparison using the provincial test (EQAO) did not show a difference between my classes and the traditional ones. There are many possible reasons, but I believe there are two potential causes:

1) There is a high proportion of ELL and ESL students in our enrollment (we are one of two magnet schools in the city). Since the reading level on the provincial exam is very high, our ELL and ESL students perform poorer on it than they do with course assessments and formative assessment. In addition, our ELL students often lack the contextual/cultural knowledge which the questions on the provincial test assume.

2) There is no connection between the style of the questions on EQAO and the way students learn and are taught in my classes. In the future, I will build in practice on questions similar in style to the EQAO.

For these reasons, I believe our common end-of-semester exam is a better indicator of learning than the provincial test.

Conclusions

The pedagogy described here is a basic change from the usual teacher-centered, lock-step class. In my classroom, learning difficulties are revealed to all by real-time data, and my students and I are engaged in a continuous process of improving performance. There is no blaming and there are no excuses. We are all detectives.

The methods described above allow me to see whether I have improved performance amongst my students, or whether it is decreasing. I can judge, in real time, which strategies have improved performance, for which students. The typical formal assessments and class average reports don't tell me what I need to know.

It is my current belief that changes to strategies that positively impact those students who are underperforming will not adversely affect the grades of those students who are already surpassing their formative assessment grades. Stated in another way, the strategies that I employ are delivered to the entire class, but the driving force behind the delivery of any strategy is to get those students who are underperforming to do better.

One must understand that I believe technology used in a particular way can impact grades, but it must also be used in tandem with other strategies to improve performance for those students who require it. In other words, reliance on only one strategy will not improve everyone's grades.

Reflecting on this data allows me to ask deeper questions about how my teaching can improve. For example, I must ponder the following questions.

1) Why are some students underperforming on Modified Term Work (Formal Assessment) compared to Formative Assessment? The term underperformance implies that a student had understood the concept during instruction. So what caused the problem during formal assessment? Certainly, there are factors that are difficult to measure but I am curious about the following:

    a) Did the student practice the concept (study) prior to test?
    b) Did the student complete homework leading up to the test?
    c) Did the student complete the review and practice test in the textbook prior to the test?

2) Are there other strategies that could help foster more confidence?
    a) More sample testing to prepare for evaluation.
    b) More sample questions to assist with learning.
    c) Increased instruction during class for students identified as having decreased performance in Mod Term Work results as compared to Formative Assessment.
    d) Increased Assessment/Feedback for students identified as having decreased performance in Mod Term Work results as compared to Formative Assessment.

I am operating under the assumption that no student wishes to fail. They have been conditioned to behave in a certain way. For this to work, they need to have a vested interest and understand my intentions. I wish to provide more remediation assessments, grading and feedback to foster better work habits. In the next analyses, I will determine whether this has had any positive impacts on the students identified.

Next year, I will experiment with transferring my methods to another teacher. This will involve another colleague to see if the results obtained by me are reproducible with another teacher.

This term's results are consistent with my previous (2006) study: both concluded that my students perform better with use of technology than without it. Given my beliefs at this point, I feel that it is unethical for me to deny this advantage to my students, so I will not sacrifice or set aside my use of any technology I use. I use it in all of my classes.