THE CUMULATIVE METHOD AS A CENTRAL APPROACH IN THE MATHEMATICS CLASSROOM

LORELEI THOMAS

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INTRODUCTION

As a teacher of mathematics, I have long used the strategy of "reviewing" in my classroom. Throughout the years, however, this strategy has taken a dramatic turn, and as a result a different focus is now the guiding point of my reviewing. The two types of reviewing I have employed are unit reviews and, more recently, cumulative reviews. The shift from unit reviews to cumulative reviews came about as a result of collaboration, investigation, experience, analysis -- both formal and informal -- and much information from students. As a teacher who spends my day almost completely teaching math at various levels in the high school realm, I noticed how students were reacting to this "new" reviewing method. Through this action research project I intend to present the evidence I have gathered for others to contemplate, consider and even possibly adopt. As the action research project developed, I saw the need to investigate deeper the value of the cumulative review method, as seen by the students, to validate and confirm my own observations and experience with it.

The cumulative review is not new in the mathematical field by any means. The "new" application of the cumulative review, which will be discussed later in this paper, is more a variance of focus on a type of review already well-known in math instruction. As I delved into the literature that yields knowledge on how people learn, their memory systems and understanding, I began to see how cumulative reviews fit into the puzzle. I hope to share my conclusions with other teachers, both in the

Cumulative Review

mathematics field and in other curricular areas, who would like to adapt the concepts to their subject discipline. I believe the cumulative review method is definitely something to be considered.

Unit Review

As most of us passed through the educational system, we remember the way we learned math and we remember the way we had unit reviews the day before each test. A unit review is just that -- it goes over the past unit's topics, ideas and concepts -- usually very close to the test date. Later on in the year, before the final exam, there was usually another extensive review for the whole course, probably during the last few days of classes. I remember experiencing this type of review myself and for many years used this method as a teacher in my mathematics classroom. During the last few years however, I have used the cumulative review method with all my math classes, ranging from grade nine to eleven. The cumulative review method I employ in my classroom is to give a review that not only covers the past unit's concepts but many of the concepts from the beginning of the course. The students are encouraged to use their notes, past examples and quizzes and ask questions about the cumulative review because I look upon it as a learning tool -- one that draws many ideas together on one review assignment. Now, instead of studying for the test and then possibly forgetting the ideas until the final exam, a student is making continual use and progress in all areas of the curriculum covered up to that point.

It is amazing to see how the students begin to really understand, gain

confidence and higher accuracy in the questions as they do them on each cumulative review. As well, I have employed the use of cumulative tests, one about every two weeks, in a similar way. Although there are more questions on the more recent material, there are representative questions from each unit covered on these tests, and that is where my action research project comes in. I was interested in determining students' perspectives on these cumulative reviews. Although I see various supportive evidence in my experience, am I interpreting it correctly? How valuable are cumulative reviews in the mathematics classroom? This action research project was a way that I could investigate the answers to these and similar questions.

METHOD:

OPENING ACTIVITY: TOP FIVE

What are the top five things that help you learn math?

My opening activity is one that could be the focus for an entire project, but I approached it as an opener to pursue my own interest in what students think really helps them learn math. Being a "mathematician" at heart, I was very concerned that I should not bias the students in this part of my project. I realized that if I biased the students in any way the results would be unreliable and no real conclusions or interpretations could be drawn. My underlying hope was that through this opener the students would identify "cumulative reviews" or "cumulative tests" as being one of the learning tools that is useful for the learning of math. I believe the whole process

of this question came about from my own curiosity about what students see as useful or beneficial. I wanted to know for my sake what they saw as valuable. I also realized that what they did not say also had meaning as well. The learning tools that I use and identify with in my classroom are only effective, I feel, if the students are learning and benefitting from them. I thought this would be an appropriate activity with which to begin my project; one that not only could add weight to my interpretations but one that could influence positively my work within my classroom.

Thus, without any preamble and at the beginning of my project I asked 55 grade nine students the question, "What are the top five things that help you learn math?" That was it; no real explanation except for stating that it didn't necessarily have to be something within the classroom. The students wrote their answers (labeled one to five) on a piece of looseleaf and put it on a pile at the front of the room. No names were attached to the responses. The results were tallied up in two ways: the number of times a response occurred, and a point value representation weighting the top answer with 5 points, the second answer with 4 points, down to the fifth most frequent answer. The results for Class 1 (my class of grade nine students) and Class 2 (another teacher's grade nine class that is also following the cumulative review method) are shown in Tables 1 and 2:

Table 1: Ranking of Top Five Helps for Learning Math: Class 1

A: By number of times a response occurred (calculated by: number of times a particular response occurred divided by the total number of all student responses)		**B: By point value assigned: total:** (calculated by giving #1 response = 5 points... #5 response = 1 point)	
1. notes/examples	15%	1. notes/examples	54
2. cumulative reviews	12%	2. cumulative reviews	52
3. group work quizzes	8%	3. teacher	34
		4. quizzes	24
4. teacher	7%	5. group work	22
5. cumulative tests review cafeteria breaks	5%	6. cumulative tests	20
		7. cafeteria breaks	19
		8. review	18
6. worksheets extra math help time assignments	4%	9. worksheets	14
		10. extra math help time	12
		11. assignments parent	10
7. homework games parent	3%	12. tutor	9
		13. friends	6
8. friends studying everyday money spending television tutor	2%	14. television do question over homework	5
		15. studying ask questions	4
9. calculator do question over ask questions tests on Friday less homework so more studying time long weekends	1%	16. games tests on Friday	3
		17. less homework so more studying time everyday money spending	2
		18. long weekends calculator	1

Table 2: Rankings of Top Five Helps for Learning Math: Class 2

A: By number of times a response occurred (calculated by: number of times a particular response occurred divided by the total number of all student responses)		**B: By point value assigned: total:** (calculated by giving #1 response = 5 points... #5 response = 1 point)	
1. teacher cumulative reviews	12%	1. teacher	49
		2. notes/examples	45
2. notes/examples	11%	3. cumulative reviews cumulative tests	30
3. homework	10%		
4. studying	9%	4. homework	28
5. cumulative tests	8%	5. studying	24
6. quizzes	6%	6. attention in class	10
7. parent	4%	7. quizzes friends tutor	9
8. oral question/answer friends assignments	3%		
		8. parent oral question/answer	8
9. attention in class review every other day ask questions other classes tutor games textbook	2%	9. games textbook	7
		10. assignments review every other day	6
		11. ask questions	5
		12. extra math help	4
10. review breaks help others problem of the day extra math help extra work practice tests	1%	13. other classes extra work	3
		14. breaks review	2
		15. practice tests problem of the day help others	1

One of my underlying purposes for asking this question was to see if the idea of cumulative reviewing/testing would be noted by the students without any prompting from me. I saw the usefulness of the cumulative method in the classroom, but would the students pick that out as a valuable way of learning math? They did. "Cumulative Reviews" ranked among the top three in both classes, along with "teacher" and "notes/examples" (see Table 3).

Table 3: Top Five Helps for Class 1 and Class 2

Class 1	Points
1. notes/examples	54
2. cumulative reviews	52
3. teacher	34
4. quizzes	24
5. group work	22

Class 2	Points
1. teacher	49
2. notes/examples	45
3. cumulative reviews cumulative tests	30
4. homework	28
5. studying	24

This is a very strong statement being made by the students and when I saw this result I was pleased and even more convinced that this project was worthwhile. The students did see the cumulative method as being one that is very useful in learning math. Throughout the last few years of teaching I had been noting the attitudes that students bring to certain learning methods. Now I had some data to support my thought that cumulative reviews are indeed valued by the students and seen as a valid and useful way of learning math. The fact that both the classes I surveyed with this question gave the same top three responses is indeed informative

and supportive of my project.

Thus, my rather quick question to students elicited some rather interesting data -- data that demonstrates students' opinions -- data that cannot be ignored. I would be very interested in doing this activity again with more of my classes simply to get further understanding of what the students see as useful to help them learn math. This question could also be extended to any subject or course. What an interesting way for teachers to keep in touch with their students! Now with my data in hand I was prepared to approach the more central part of my project -- focussing on the cumulative review method in my classroom.

THE "REVIEW" SURVEY

One of the best ways of finding out students' opinions in a short amount of time is to use a survey. I

realized that this survey could not be of too great a length or the students might rush over it. I also realized that the questions had to be worded very clearly. I tried to get the most information out of the least number of questions and thus my questions were thought through in great detail. I wanted to find out students' opinions because as a teacher, while you get the "feel" of your class, its ideas, opinions and attitudes as you teach, this is sometimes difficult to document. For example, during the last few years, I have been noticing the way students approach the cumulative reviews they are given -- the way they receive them, the effort put into them and even the learning that occurs through the whole process of doing them, marking them and analyzing them. I

had my own opinions of what students thought, but I needed a way to measure and document this. Thus the survey idea evolved. Now it was time to put all of these ideas into a survey that would, I hoped, display accurately what the students thought about this cumulative review process.

"REVIEWS" SURVEY DESIGN

The survey itself was designed to promote as much information as possible with the fewest number of questions. I also decided to use a five-point scale for most questions; I felt this would be convenient for the students to use as well as useful for me to analyze as it would provide numerical data. A few of the questions asked for written clarification. The wording of the questions was vital for the students' understanding, to give them every chance to offer an accurate representation of what they thought. Each question sought particular knowledge for the teacher's benefit. (See Appendix A for a blank survey.)

What follows is an elementary question analysis.

1. What type of review have you previously done in math? (Last two years, not the present year.)

2. What type of review have you done this year in math?

These questions were to validate that the students did indeed have experience with both the unit review method (in previous years) and the cumulative review method (the present year). If they had not had experience with both review types the

survey instrument would have been inappropriate and the results inaccurate.

3. Rate the amount of work necessary for each review type:

This item was included mostly to sense the students' perception of time necessary and effort required to complete the particular reviews.

4. In your opinion, rate the difficulty of each review type:

This is a key item, one in which I was particularly interested. How the students find the difficulty level of each review will have a bearing on the overall results and picture later on.

5. What do you consider the value to be of the following review type for learning math?

This is a very subjective, yet enlightening, question to be looked at. How do students rate each review type's value in their own eyes? I wanted to see which review was rated higher in terms of students' opinions of this "value" aspect. I then also included a few blank lines to give the students an opportunity to respond in writing to explain why they rated a particular review higher. This brief writing section was more for my own interest than for detailed analysis.

I should also note here that when looking at this top part of the survey it is important to combine the data results to see the overall picture. For instance, which type of review is considered "more work" and which type of review is considered

"more valuable" is important because if one review is considered more work and more valuable at the same time, the students are definitely saying something important about the learning process. I see great value in looking at questions 3 - 5 as a whole statement to be made from the survey results.

6. How do you actually feel personally about reviews in math?

The reason I included this general question about reviews was to get a baseline response in order to make distinctions in the following breakdown between review types.

More specifically, how do you feel personally about each type of review in math?

Now, with the initial broad question covered, the students could go on and rate each type of review. I could now look back and see how they felt in general and if either of the review types seemed to be an improvement on how they felt about reviewing in math.

7. How prepared do you feel for the final exam after doing cumulative reviews for the whole course?

I had to limit this question to the current cumulative review method because that is what they had used for the course. I felt it would be inappropriate to include

this question for the unit review method because the students might not have remembered how they felt about the final exam after doing the unit review method. Also, because I administered this survey to my classes during the last two weeks of the course I felt that they were in an appropriate situation to answer it.

Do you feel more or less prepared to be tested on the math topics than last year?

This question is rather broad, being answerable only by "more", "less" or "same". However, I felt that this would at least give a general estimate by the students as to how they felt in terms of confidence and knowledge going into the final exam. Because it is very general, I felt the responses, although not very numerically analyzable, would give an indication of trends or preferences.

8. For your next math course, which type of review would you prefer?

The crux of my project is in this question. What do the students want? After thinking and responding to all the survey questions, and balancing out all the variables, what do the students want the most?

9. Looking at all the above, which type of review do you feel has more overall learning value?

I feel students can make informed decisions about the value of certain learning experiences in the classroom. This question provided the responses that contributed to the concluding statement of my survey. Do the students see more value in either

review type or are they considered equal? As teachers we must consider the opinions of students and how they feel that they can learn and what they see as beneficial in the learning experience.

10. What is your math average as of now? (Give estimate.)

This question was more for my general interest than anything else. I wondered if there was any correlation between higher marks with certain responses and lower marks with other responses. Although I knew this section could not be totally numerically accurate, I reasoned that perhaps I would be given a picture of how students with differing marks look upon the reviews. (I see a great possibility for inaccuracy, however, if students put the incorrect average down.) I thought I would see if there were any broad trends, for my interest.

11. Other comments:

This was added to allow the students a place to write down anything they wanted to include that had not been covered or clarified. It was like an open forum for them.

ADMINISTRATION OF SURVEY

The survey was administered to two grade nine classes who were both using the exact same cumulative reviews and cumulative tests. It was given during the last two weeks of classes for the course. Also important to note is that although I

administered the survey to both classes, by giving very brief instructions about circling the responses and not putting names on it, the two classes had different teachers. One was my own grade nine math class and the other was another math teachers grade nine math class. I wanted to see if the results from the classes of two different teachers would vary significantly. Basically, the survey was handed out one per student, brief instructions were given, the students filled it out individually and then stacked the completed surveys on the front table where I collected them when all the students were finished.

PRESENTATION AND DISCUSSION OF SURVEY RESULTS

Table 4 shows the complete results of the surveys given to the two math classes. For purposes of analysis and discussion, however, data from this comprehensive tabulation will be presented in appropriately smaller segments.

Table 4: Total Survey Results

SURVEY RESULTS (Results are shown for **Class 1/Class 2**.)

1. What type of review have you previously done in math? (Last two years, not the present year.)

Unit Review Only	Mostly Unit Review	Half Unit Review/ Half Cum Review	Mostly Cum Review	Cumulative Review Only
26%/32%	**44%/32%**	**19%/20%**	**7%/4%**	**4%/12%**

2. What type of review have you done this year in math?

Unit Review Only	Mostly Unit Review	Half Unit Review/ Half Cum Review	Mostly Cum Review	Cumulative Review Only
0%/4%	**4%/0%**	**12%/8%**	**48%/46%**	**36%/42%**

3. Rate the amount of work necessary for each review type:

Unit Review: 1 2 3 4 5 (LOW – HIGH) **3.2 / 3.3**

Cumulative Review: 1 2 3 4 5 (LOW – HIGH) **3.9 / 3.8**

4. In your opinion, rate the difficulty of each review type:

Unit Review: 1 2 3 4 5 (LOW – HIGH) **2.9 / 3.4**

Cumulative Review: 1 2 3 4 5 (LOW – HIGH) **3.7 / 3.5**

5. What do you consider the value to be of the following review type for learning math?

Unit Review: 1 2 3 4 5 (LOW – HIGH) **2.8 / 2.4**

Cumulative Review: 1 2 3 4 5 (LOW – HIGH) **4.0 / 4.8**

Choose the review you rated higher and explain why: (If both ratings equal, explain also.)

6. How do you actually feel personally about reviews in math?

1 2 3 4 5 (HATE THEM – LOVE THEM)

2.9 / 3.6

More specifically, how do you feel personally about each type of review in math?

Unit Review: 1 2 3 4 5 (HATE THEM – LOVE THEM) **2.3 / 2.4**

Cumulative Review: 1 2 3 4 5 (HATE THEM – LOVE THEM) **2.9 / 3.8**

7. How prepared do you feel for the final exam after doing cumulative reviews for the whole course?

1 2 3 4 5 (NOT PREPARED AT ALL – VERY PREPARED)

4.0 / 4.2

Do you feel more or less prepared to be tested on the math topics than last year?

MORE	LESS	SAME
58%/88%	**23%/4%**	**19%/8%**

8. For your next math course, which type of review would you prefer?

UNIT REVIEWS	CUMULATIVE REVIEWS
23%/0%	**77%/100%**

9. Looking at all the above, which type of review do you feel has more overall learning value?

UNIT REVIEWS	CUMULATIVE REVIEWS	BOTH SAME VALUE
12%/0%	**81%/100%**	**8%/0%**

One of the conditions that was absolutely necessary for this survey was that the students should have experience with both unit reviews and cumulative reviews. Because of the set-up of the students' current class I could ensure the cumulative review experience. I did assume that the students had also experienced unit reviews in the past. The data from question 1 (see Table 5) supports this assumption as it shows that almost all of the students had some experience with unit reviews in the past two years.

Table 5: Types of Review Students Have Experienced

1. What type of review have you previously done in math? (Last two years, not the present year.)

Unit Review Only	Mostly Unit Review	Half Unit Review/ Half Cum Review	Mostly Cum Review	Cumulative Review Only
26%/32%	**44%/32%**	**19%/20%**	**7%/4%**	**4%/12%**

2. What type of review have you done this year in math?

Unit Review Only	Mostly Unit Review	Half Unit Review/ Half Cum Review	Mostly Cum Review	Cumulative Review Only
0%/4%	**4%/0%**	**12%/8%**	**48%/46%**	**36%/42%**

A very small percentage of students claimed that they had only had cumulative reviews in the past two years. However, it would be my assumption that at some point in their schooling they would all have experienced unit reviews and would have some knowledge and experience of them.

The second question also supports this basic assumption in that the majority of students said that they had done cumulative review during the present year of math (see Table 5 above). Knowing that all the students had been involved in this process

does not account for the tiny minority that said they had only had unit review or mostly unit review. This should probably be counted as an error by these student in understanding the type of reviewing being done. One can easily see, however, the vast majority's answer of cumulative reviewing being done in the present year.

I was particularly interested in question three due to my observations as a teacher in regards to the amount of work necessary for the student to complete the cumulative reviews. The students in both classes rated the cumulative reviews to be more work than the unit reviews.

Table 6: Students' Estimates of the Work Demands of Review Types

3. Rate the amount of work necessary for each review type: Unit Review: 1 2 3 4 5 Cumulative Review: 1 2 3 4 5 LOW HIGH LOW HIGH **3.2 / 3.3** **3.9 / 3.8**

The amount of work was 3.2/3.3 for unit reviews and 3.9/3.8 for cumulative reviews (each out of 5, see Table 6). Perhaps this is due to the fact that finding material from the whole year of notes and examples can be time consuming and because the questions are from many units questions may be integrated which requires more time to connect thinking. It may not be necessarily due to the length of the assignment. This result is consistent with my observations of students and their comments in class.

The students also validated my idea that the cumulative reviews are more difficult from the students' perspective than the unit reviews. Both classes rated the

cumulative review as being more difficult, however, class 2's responses were quite close in terms of difficulty.

Table 7: Student Ratings of Difficulty of Review Types

4. In your opinion, rate the difficulty of each review type:

Unit Review:	1	2	3	4	5	Cumulative Review:	1	2	3	4	5
	LOW				HIGH		LOW				HIGH
	2.9 / 3.4									**3.7 / 3.5**	

(See Table 7 -- Note Class 1 rated unit reviews as 2.9 and cumulative reviews as 3.7 and Class 2 rated unit reviews as 3.4 and cumulative reviews as 3.5.)

Question five is purely the students' opinions about which type of review has more "value". I did not describe the idea of "value" in case I would bias the students by statements that would be made; I simply left it up to the students use their understanding of the word to answer the question. I was quite surprised by the strong statement made by the students. In comparison to the quite average results of 2.8 and 2.4 for unit reviews, cumulative review received results of 4.0 and 4.8 (totals out of five for value of each -- see Table 8).

Table 8: Student Ratings of the Value of Review Types

5. What do you consider the value to be of the following review type for learning math?

Unit Review:	1	2	3	4	5	Cumulative Review:	1	2	3	4	5
	LOW				HIGH		LOW				HIGH
	2.8 / 2.4									**4.0 / 4.8**	

The students seem to realize the value of the cumulative reviews they have experienced and have shown this through consistently higher responses for the value of cumulative reviews.

The attachment to question five was to choose the review that was rated higher and explain why it was rated higher. Responses for unit reviews included:

- I chose unit review because it is a lot easier to do.
- Unit review is harder because you have to study more.
- Unit review, easier to understand.

Responses for cumulative reviews included (only a sample chosen due to numerous responses from this section):

- Cum reviews are of more value because they cover everything done so far.
- Cumulative review because they go over and keep adding information.
- Cumulative because you cover work from the entire year so you do not forget past units but take them all semester.
- Cumulative reviews give you a chance to remember everything; when you keep going over the material, you don't have a chance to forget it.
- Cum review is hard but it helps you think.
- It is difficult but it helps you study.
- I found cum reviews more helpful because they kept refreshing my mind of past curriculum.
- It was easier to remember material when the tests came along.
- I liked cum reviews because they went over everything, not just the one unit.

- Cum review is better because you will see a variation of things from different chapters. On unit review you only see one part of it.
- Cum review because you're reviewing everything so there's less chance of forgetting. You get to practice everything you've learned.

"You get to practice everything you've learned."

- I chose cumulative because it keeps you thinking about all topics throughout the year.
- Because with cum you don't forget as much as you would with just a unit review.
- Cumulative -- because it creates constant review so you don't have to cram too much for finals.

Of note here is that only 3 out of 51 rated the unit review higher in terms of value than the cumulative review (8 out of 51 rated them equal). That leaves 40 out of the 51 respondents who believe the cumulative reviews have more value than the unit reviews, roughly 78%.

The initial question posed in question 6 basically demonstrates how reviews in general are liked or disliked by the students. Noted are the fairly average responses which lend some credibility to the possibility that reviewing is not one of the highlights of the course for most students (see Table 9).

Table 9: Students' Feelings about Math Reviews

6. How do you actually feel personally about reviews in math?

1	2	3	4	5
HATE THEM				LOVE THEM

2.9 / 3.6

More specifically, how do you feel personally about each type of review in math?

Unit Review:	1	2	3	4	5
	HATE THEM				LOVE THEM

2.3 / 2.4

Cumulative Review:	1	2	3	4	5
	HATE THEM				LOVE THEM

2.9 / 3.8

The clarification of how much the students like reviewing demonstrates in both classes that cumulative reviews are "liked" more than the unit reviews by the students. There was an average of 2.3/2.4 in preference for unit reviews versus an average of 2.9/3.8 in preference for cumulative reviews. This is important data in that as a teacher I have seen the correlation between students' attitudes towards a concept or activity and their corresponding effort that influences their understanding and achievement. I have noted informally in my classroom that a good "outlook" increases the chance that the student will work more willingly and diligently and achieve more. The fact that the students have this "improved" outlook with respect to cumulative review is a matter of importance for me. We also see that Class 2 seems to like reviews more in all aspects of question 6, even when the question is further clarified into unit reviews and cumulative reviews. This data further

emphasizes the attitude with which the different groups approach different review processes.

Question 7 focuses on the final exam for which these students were preparing when they completed the questionnaire (see Table 10).

Table 10: Students' Perceptions of Their Readiness for Final Exams

7. How prepared do you feel for the final exam after doing cumulative reviews for the whole course?

1	2	3	4	5
NOT PREPARED AT ALL				VERY PREPARED
			4.0 / 4.2	

Do you feel more or less prepared to be tested on the math topics than last year?

MORE	LESS	SAME
58%/88%	**23%/4%**	**19%/8%**

According to this information, most students feel well prepared for the final exam. I was particularly interested in the responses showing that over half the students in one class and 88% of the students in the other class feel more prepared to be tested than they did in the previous year. I can conclude that the cumulative review process is contributing considerably to students' feelings of confidence on final exams.

The simplistic form of question 8 should not detract from the implications of the results. I am basically asking the students, very pointedly, if they had their choice which type of review they would choose (see Table 11).

Table 11: Student Preference of Review Type

8. For your next math course, which type of review would you prefer?	
UNIT REVIEWS	CUMULATIVE REVIEWS
23%/0%	**77%/100%**

The responses, 77% of one class and 100% of the other choosing cumulative reviews, are overwhelming. They confirm my own preferences, of course, but I think teachers have to be prepared to ask students questions such as these and be guided by the results so that they can continue to promote effective learning strategies in their classrooms. Students do have much to contribute regarding their preferences and what they think will benefit them more. They respond very positively to the opportunity to help their teachers make more informed teaching choices. In this particular case, the students are clearly advising their teacher to continue using the cumulative reviewing method.

Even higher responses were received on question 9 , which asked students to rate the "overall learning value" of each type of review. 81% in one class and 100% of the students in the other class chose cumulative reviews as having more overall learning value (see Table 12).

Table 12: Student Preference for Overall Value of Types of Review

9. Looking at all the above, which type of review do you feel has more overall learning value?		
UNIT REVIEWS	CUMULATIVE REVIEWS	BOTH SAME VALUE
12%/0%	**81%/100%**	**8%/0%**

These students, who have experienced both types of reviewing, are almost unanimous in their belief that the cumulative reviewing process is superior in value to the more traditional unit review method.

In the responses to question 10, regarding students' math average, I did not see any particularly strong relationship between the average of the student and their preferences for a certain type of review. This would require a different set of questions and a more specific matching of actual student results with their survey responses, something that was clearly beyond the intent of this study.

The "Other Comments" section elicited a number of varied responses ranging from positive comments about cumulative reviews and messages to me to opinions about math in general. The following is a sample of representative comments:

- cumulative is better for learning
- we don't forget with cum reviews
- you should stick with cum reviews, they work
- the cum reviews are hard
- I love cum reviews, it has brought up my mark 10%

"We don't forget with cum reviews."

- I learned a lot more about math
- I think cum reviews are a good thing cause you never forget what you learned at the beginning of the year
- it better prepares you for the final exam
- math is too hard
- keep up with the cum reviews.

This section added satisfaction to my personal interest, enlarging the emerging picture of the value and impact of the cumulative review process as these students were experiencing it.

OVERALL TRENDS

In seeking to draw conclusions from at where the overall survey I have concentrated on a few relationships among variables. (Note Appendix B for averaged results between the two classes.) Firstly, even though cumulative reviews are rated as being more work and as harder by most students than unit reviews, cumulative reviews are still rated as having a higher value by most and are liked more often by the students. That is quite a statement being made by these teens. Even though cumulative reviews are more work and harder work at that, they see the value and the benefits and the results in their own personal mathematical learning throughout the course and are obviously prepared to do the extra work that is required. Secondly, I can conclude from the results of this survey that students really do want to do well in mathematics. They have demonstrated this throughout the responses. This should be

very encouraging to the teachers of math! Thirdly, I am now more firmly of the belief that many, if not most, students do have important opinions and preferences about teaching style, along with the ability to realize how effective classroom processes can benefit them in their learning. Teachers can use this knowledge to promote more appropriate classroom engagement.

TEACHER REACTION/RESPONSES

One of the most compelling reasons encouraging teachers to consider the implementation of the cumulative review method can be found in the results that have been seen by other teachers who have used it. Actual responses from teachers allows professional colleagues to see more in depth the usefulness, the benefits and the drawbacks of this method.

Teacher Comments

Appendix E holds some other teachers' comments about cumulative reviews. For example, Elaine Dufresne, a mathematics teacher at Medicine Hat High School, sees many advantages to this approach. She gives examples of students doing better on final exams, having more opportunities for more cross-skill questions, keeping all math skills current for actual math problems that may arise, better memory of skills and even improved discipline. Linda Gagley, also a mathematics teacher at Medicine Hat High School, finds that the students who have had the cumulative method are "far stronger mathematics students

"...opportunities for more cross-skill questions"

than they would otherwise have been. They have learned excellent work habits and have acquired a method of gaining much better long term retention." Teachers can see the difference.

In terms of my own experience, I have seen how my students have benefitted from my use of cumulative reviews and tests in my high school mathematics classroom. Firstly, I notice the students feel more confident about the concepts as the year goes on because of the frequency and varying nature of the questions that keep arising. Secondly, students take more responsibility for completing the work assigned, specifically the cumulative reviews and even though they can be more work than a single unit review, the students see that the extra work does pay off. Thirdly, I feel from a teacher perspective that the students retain more concepts as time goes on and practice on the concepts is enhanced. Fourthly, I find that through the cumulative reviews I can tie concepts together in a more integrated way (e.g. I can use ideas from many units in a single question); this certainly does promote a more connected understanding of the concepts involved in my curriculum. This is perhaps one of the crucial advantages to cumulatively reviewing, the opportunity for a teacher to tie ideas together and encourage students to use the "whole" of their knowledge rather that brief segments of it. As we prepare students to function in our society, we are well aware that problem-solving situations that arise are rarely isolated events -- there is usually a complex of underlying ideas that must be considered and understood. Creating interconnected questions encourages the problem solving skills

Lifelong Learning

of students and gives them more experience at pulling various concepts together from the whole course. Fifthly, as the students see worth in this method, they become more motivated, thus promoting both important ideas and concepts involved in "lifelong learning" and individual responsibility for their learning. The students begin to realize that learning the concept now is important because it will be seen again! I have noticed that most students, from my experience, really try hard on these cumulative reviews and challenge themselves to get the right answers and seek out the best ideas through questions, group work and individual review. It is very rewarding to watch this as a teacher! I feel that if I can stress the importance of relating ideas and reviewing concepts on a continual basis the students will eventually adopt this strategy and grasp it for themselves! My experience has been very positive. I have seen and enjoyed many rewarding moments in my classroom as the students have been engaged in this process.

I am also very fortunate to be able to work around other colleagues who also share similar ideas. We have been able to work together to formulate and develop cumulative material that is shared among math department members. Through this collaborative approach, we are exposed to others' ideas, concept questions and materials. This has truly been a plus as we have developed the program we now use. The collaborative method is one where teachers gain from sharing -- gain new ideas for approaches, questions and teaching methods, gain opportunities to share and receive materials and gain discussion opportunities with others. We hope that this

Encourages Collaboration

cumulative review method will be encouraged and promoted in more schools. The total benefit to students is yet to be realized.

RESEARCH: OTHER EDUCATORS' INVOLVEMENT

Although cumulative reviewing is not new in math, it was very difficult to find any information on this topic in the sense and direction that this project has outlined in terms of cumulative reviewing.

Research???

In searching the Internet through many web browsers, many key words and through various departments of education and educational pages I found no evidence of literature, research or discussion on this topic. Searches through the university and college libraries also produced no significant results. The most that could be found on cumulative reviewing is reference made in a paragraph in a book about the idea of teachers doing cumulative tests (midterms) and reviewing for the final exam. No journal articles were found on this topic. Extensive searching for information proved quite fruitless. Little, if any, work has been done that I could find specifically on cumulative reviewing and the students' opinions on this.

Of course there has been considerable research on related areas of memory systems, reviewing in general and learning styles. However, in order to limit the scope of this project I particularly wanted to focus on the idea of the cumulative process as a central feature in the math program. With so little literature available, I decided then to "do my own research" by talking to as many people as possible who are knowledgeable in the mathematical area about cumulative reviewing.

My first contacts were university professors in the mathematical field. The professors/math specialists/secondary math education professors with whom I talked from The University of Victoria, The University of Calgary , The University of Lethbridge and Augustana College (Camrose), were not aware of any specific literature on this topic, nor did they know of other teachers who were employing this method in their classrooms. Many had not ever seen this method before in their experience, certainly to the extent to which the cumulative method was being used in my school. One professor from The University of Alberta had heard of one teacher, Lynda Hurd, who was using the cumulative method and put me in contact with her.

Lynda Hurd's cumulative approach (see Appendix E for some comments from her school) most resembles the cumulative method discussed through this project. She teaches at Ardrossan Junior/Senior High School in Alberta. I was so pleased to actually find another person with whom to share cumulative ideas! In her cumulative method, she gives only cumulative tests, with each cumulative test including the previous material. She began at the Math 30 level where she found it essential to keep reviewing the difficult, complex concepts. It has now been extended through the junior high level. One of the main benefits as she sees it is the ability to look at the past test's mistakes and review and test these on the next cumulative test. She did make reference to the amount of work involved in this. She also made reference to the learning benefits for the students. A difference that was noted between her method and the one I utilize is the frequency of testing. The students work hard Monday through Thursday on the new concepts and then are tested with a cumulative

test every Friday. She also gives one night per week of extra help for the students so they can ask her questions and work on improving their skills. As she was discussing her ideas with me, it was uncanny how much of what she said had already been written into this project. She stated ideas like "drawing connections" and "practicing skills". I saw exactly the same ideas emerging that I felt were happening through the cumulative review and cumulative test process in my classroom. It is very validating to find others who are enjoying similar classroom experiences.

The second avenue I chose to explore was that of other math teachers around the province of Alberta. I called a few from Calgary, a couple from Lethbridge and one each from Brooks, Dunmore, Bow Island and Spruce Grove to find out if this method was being used by them or if they knew of any other teachers who were using this method. Most teachers I talked with were quite interested in the topic as I briefly highlighted what it was and some of the results of the student surveys. Some of the teachers even recognized the value of the cumulative method and indicated they had been thinking of initiating it, but had not done so as yet. Many of the teachers regularly used "midterms" and final exam review with their students. Two of the teachers with whom I talked were using similar forms of the cumulative method with their students. The first teacher was using three major cumulative tests throughout the semester and then the final exam. Much of the student's mark was composed of the results on these tests. The cumulative tests were looked upon as a central focus in the classroom. The second teacher was utilizing the cumulative test concept in a Math 30 classroom. Testing was done every three weeks with a 40 minute

cumulative review just prior to the test. The test was composed of questions from the current unit as well as some "looking back" questions. This particular teacher was now looking into expanding this cumulative testing to the other classes that were taught. The teacher also made reference to when she was marking at the Math 30 diploma exams and item writing for the exams. She estimated that only one out of fifteen teachers had heard about the cumulative method and were using it in their classrooms. Most of the other teachers had never heard about this method.

Perhaps this project will help expand the literature base on the topic of the cumulative method in a math classroom. Although literature on this topic is sparse, there seems to be considerable teacher interest in this method. It is also important to note that there are some teachers around the province who are utilizing the cumulative method to a significant degree in their classrooms even now. I feel that many other teachers would benefit from hearing about this process and having an opportunity to talk to practitioners about it.

As far as the project itself is concerned, much more could be done to compare the results of various grade levels of students; to compare responses of students with different marks in a course; and to compare responses by students in different cultural areas among others. There is also the area of others subjects that could use this method to possibly deal with. Much more can be done in the area of this project; it can be looked into even more!

PROPOSAL FOR PRACTITIONER USE

The actual implementation of the cumulative review and cumulative test method is perhaps the most important aspect for other teachers to consider. The following could serve as a general guideline to be followed. (See Appendix D for a sample grade 9 time line, cumulative review and cumulative test.)

How can I implement this?

Step 1: Formulate your month plans to ensure curriculum is covered in the specified time allotted.

Step 2: Decide when you will give your cumulative tests. Perhaps you want to give them every other Wednesday or perhaps you want to give them at the end of each unit.

Step 3: Determine a cut-off date for material for the next cumulative test. Make sure to mark this on your month plans.

Step 4: Make your cumulative review. This is one of the most time-consuming parts; ensure the length of the review is appropriate (for instance something that could be completed in the equivalent of 2 - 3 classes, however, you may only allot 1 class and require other work at home). Teachers should ensure that an adequate balance of questions is achieved. For instance, I like to include more questions of the most current material while trying to make sure that the most troublesome concepts on the last cumulative review are covered again on the next cumulative review. I always include some questions from every chapter or unit that has been covered. I feel one of the best ways to encourage student understanding of

previous material is to put more than one concept in one question, if possible. This helps demonstrate connections between concepts. This is truly a great benefit of the cumulative review -- it fosters the ability to link and draw connections between questions of different "units". Questions that involve many integrated skills enhance the learning process immensely.

Step 5: Make your cumulative test. This is very similar to making a unit test except for the fact that material on this test comes from all parts of the course that have been covered. Of course, all concepts cannot possibly be tested every time but there should be some type of representation of most of the units somewhere on the test. Again, I put more questions of the most current material on the cumulative test than on the previous sections.

Step 6: Make sure to jot down notes, comments or other ideas about the cumulative reviews and tests (and the time line) as you do them with the students. I give the cumulative reviews out approximately one week before they are due and usually allow one class period in which students can work exclusively on the cumulative reviews. I always try to go through the cumulative review the day before the test (I make most of them for marks -- the choice is yours!).

In terms of implementation, the most time-consuming part is, of course, the actual creation of the cumulative reviews and tests. After these are created you as a teacher can work with them and the students to encourage growth in the subject and learning for the individual. The students will begin to see their strengths and weaknesses and work from there. I utilize much "tutorial" time to work one-on-one

or in small groups, dealing with difficulties encountered in the cumulative reviews. It is very encouraging to see how students develop in their desire to improve and learn!

Another important point is the explanation of this method to the students early in the course. For most it will be new. They may not understand or know what to expect. Try to have the students "buy into" this idea right from the beginning of the year as you explain it to them. Guide the students through the first couple of cumulative review and test processes to demonstrate the idea that they will see those ideas again on the next test as well. As time goes on, many students see great value in learning something well the first time because it will be seen many times before the final exam!

CONCLUSION

The idea of doing cumulative work in mathematics is not new, however, little has been documented on its use. Perhaps the newness lies in the approach being discussed here. The cumulative aspect takes on a primary focus in the math course, both in reviewing and testing.

As the students' responses to the survey show, the vast majority of the students who have experienced the cumulative method rate it highly in terms of learning value. For teachers who are committed to be looking constantly for learning and teaching methods that encourage growth of the student, these results should not be overlooked. Those teachers who use the cumulative review method concur that its potential is great for the promotion of the students' long term mathematical skills,

memory and integration and connection of knowledge. The cumulative method of reviewing and testing can give students the confidence and skills necessary to succeed in their mathematical career, both in school and beyond. The strategy of cumulative reviewing can take a central role in students' learning and the results, in my personal experience, justify any additional work on the teacher's part.

Appendix A

"Reviews" Survey

Please circle the answer to the following:

1. What type of review have you previously done in math? (Last two years, not the present year.)

Unit Review Only	Mostly Unit Review	Half Unit Review/ Half Cum Review	Mostly Cum Review	Cumulative Review Only

2. What type of review have you done this year in math?

Unit Review Only	Mostly Unit Review	Half Unit Review/ Half Cum Review	Mostly Cum Review	Cumulative Review Only

3. Rate the amount of work necessary for each review type:

Unit Review: 1 2 3 4 5 (LOW … HIGH) Cumulative Review: 1 2 3 4 5 (LOW … HIGH)

4. In your opinion, rate the difficulty of each review type:

Unit Review: 1 2 3 4 5 (LOW … HIGH) Cumulative Review: 1 2 3 4 5 (LOW … HIGH)

5. What do you consider the value to be of the following review type for learning math?

Unit Review: 1 2 3 4 5 (LOW … HIGH) Cumulative Review: 1 2 3 4 5 (LOW … HIGH)

Choose the review you rated higher and explain why: (If both ratings equal, explain also.)

_____

_____

6. How do you actually feel personally about reviews in math?

1 2 3 4 5
HATE THEM … LOVE THEM

More specifically, how do you feel personally about each type of review in math?

Unit Review: 1 2 3 4 5 (HATE THEM … LOVE THEM) Cumulative Review: 1 2 3 4 5 (HATE THEM … LOVE THEM)

7. How prepared do you feel for the final exam after doing cumulative reviews for the whole course?

1 2 3 4 5
NOT PREPARED AT ALL … VERY PREPARED

Do you feel more or less prepared to be tested on the math topics than last year?

MORE LESS SAME

8. For your next math course, which type of review would you prefer?

UNIT REVIEWS CUMULATIVE REVIEWS

9. Looking at all the above, which type of review do you feel has more overall learning value?

UNIT REVIEWS CUMULATIVE REVIEWS BOTH SAME VALUE

10. What is your math average as of now? (Give estimate.) _____

11. Other comments: _____

_____

Thank You!!!

Appendix B

SURVEY RESULTS (Results are shown averaged for grade 9 **Class 1** and **Class 2**.)

1. What type of review have you previously done in math? (Last two years, not the present year.)

Unit Review Only	Mostly Unit Review	Half Unit Review/ Half Cum Review	Mostly Cum Review	Cumulative Review Only
29%	**38%**	**20%**	**6%**	**8%**

2. What type of review have you done this year in math?

Unit Review Only	Mostly Unit Review	Half Unit Review/ Half Cum Review	Mostly Cum Review	Cumulative Review Only
2%	**2%**	**10%**	**47%**	**39%**

3. Rate the amount of work necessary for each review type:

Unit Review: 1 2 3 4 5 (LOW – HIGH) **3.3**

Cumulative Review: 1 2 3 4 5 (LOW – HIGH) **3.9**

4. In your opinion, rate the difficulty of each review type:

Unit Review: 1 2 3 4 5 (LOW – HIGH) **3.2**

Cumulative Review: 1 2 3 4 5 (LOW – HIGH) **3.6**

5. What do you consider the value to be of the following review type for learning math?

Unit Review: 1 2 3 4 5 (LOW – HIGH) **2.6**

Cumulative Review: 1 2 3 4 5 (LOW – HIGH) **4.4**

Choose the review you rated higher and explain why: (If both ratings equal, explain also.)

---

6. How do you actually feel personally about reviews in math?

1 2 3 4 5 (HATE THEM – LOVE THEM) **3.3**

More specifically, how do you feel personally about each type of review in math?

Unit Review: 1 2 3 4 5 (HATE THEM – LOVE THEM) **2.4**

Cumulative Review: 1 2 3 4 5 (HATE THEM – LOVE THEM) **3.4**

7. How prepared do you feel for the final exam after doing cumulative reviews for the whole course?

1 2 3 4 5 (NOT PREPARED AT ALL – VERY PREPARED) **4.1**

Do you feel more or less prepared to be tested on the math topics than last year?

MORE	LESS	SAME
73%	**14%**	**14%**

8. For your next math course, which type of review would you prefer?

UNIT REVIEWS	CUMULATIVE REVIEWS
12%	**89%**

9. Looking at all the above, which type of review do you feel has more overall learning value?

UNIT REVIEWS	CUMULATIVE REVIEWS	BOTH SAME VALUE
6%	**91%**	**4%**

Appendix C

SURVEY RESULTS (Results are shown for a **Math 20** class.)

1. What type of review have you previously done in math? (Last two years, not the present year.)

Unit Review Only	Mostly Unit Review	Half Unit Review/ Half Cum Review	Mostly Cum Review	Cumulative Review Only
15%	**5%**	**20%**	**30%**	**30%**

2. What type of review have you done this year in math?

Unit Review Only	Mostly Unit Review	Half Unit Review/ Half Cum Review	Mostly Cum Review	Cumulative Review Only
0%	**0%**	**5%**	**20%**	**75%**

3. Rate the amount of work necessary for each review type:

Unit Review: 1 2 3 4 5 (LOW – HIGH) **2.8**

Cumulative Review: 1 2 3 4 5 (LOW – HIGH) **4.4**

4. In your opinion, rate the difficulty of each review type:

Unit Review: 1 2 3 4 5 (LOW – HIGH) **2.5**

Cumulative Review: 1 2 3 4 5 (LOW – HIGH) **4.4**

5. What do you consider the value to be of the following review type for learning math?

Unit Review: 1 2 3 4 5 (LOW – HIGH) **2.9**

Cumulative Review: 1 2 3 4 5 (LOW – HIGH) **4.6**

Choose the review you rated higher and explain why: (If both ratings equal, explain also.)

---

6. How do you actually feel personally about reviews in math?

1 2 3 4 5 (HATE THEM – LOVE THEM) **3.2**

More specifically, how do you feel personally about each type of review in math?

Unit Review: 1 2 3 4 5 (HATE THEM – LOVE THEM) **2.7**

Cumulative Review: 1 2 3 4 5 (HATE THEM – LOVE THEM) **3.2**

7. How prepared do you feel for the final exam after doing cumulative reviews for the whole course?

1 2 3 4 5 (NOT PREPARED AT ALL – VERY PREPARED) **3.9**

Do you feel more or less prepared to be tested on the math topics than last year?

MORE	LESS	SAME
45%	**15%**	**40%**

8. For your next math course, which type of review would you prefer?

UNIT REVIEWS	CUMULATIVE REVIEWS	BOTH
15%	**75%**	**10%**

9. Looking at all the above, which type of review do you feel has more overall learning value?

UNIT REVIEWS	CUMULATIVE REVIEWS	BOTH SAME VALUE
0%	**80%**	**20%**

Appendix D

1995 Curriculum
Math 9 Semestered

1995 September 1995

add a day here.

SUNDAY	MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY	SATURDAY
			Aug 30 Divisibility Rules GCF/LCM Natural # wkst. ↳ Group p8-11	Aug 31 Prime/Composite Factors Integers +/- Whole # wkst ↳ Group p10-11	1 Integers x/÷ Order of Op Integer Assignment p20-21, 35-43, 50-51	2
3	4 LABOUR DAY	5 Quiz Ch 1/2 Fraction Rules (Rat'l #'s) ÷/-/x/÷ p64-71	6 Rat'l #'s - order ÷ compare p64-71	7 Rat'l #'s - Order of Operations p18-19, 74-75	8 frac → dec dec → frac p78-81	9
10	11 Review	12 Cum Test #1	13 Powers p92-94 P+A of ▭ p196-197	14 x/÷ Powers p96-98	15	16
17	18 Zero /- Exponents p100-101	19 Review Powers -wkst -Quiz P+A of △ and ▱ p197-199	20 Scientific Notation p102-104 A+C of ⊙ p202-204	21 Square Roots Area Combo & Review	22 Pythagorean Theorem Pyth Assignment	23
24	25	26 Test #2	27 Eq with Balance Scales - picture wkst (Number Tricks) P+A of Reg Poly p201	28 1 Step is Step Eq wkst 1 and 2 Area wkst (shaded)	Check-up is 29 Eq with Like Terms + Brackets wkst 3	30

1995

October

Math 9 semestered

1995

SUNDAY	MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY	SATURDAY
1	2 Equations with Fractions p169 Polyhedrons -construct p206-207	3 Eq Assignment Eq Quiz (after 170)	4 Eq wkst and quiz #1 p151 SA of prisms + pyramids p208-211	5 Eq wkst and quiz #2+#3 SA of cylinders p208-211	6 - Cum Review #3 - Math 9 Eq. wkst SA of cones p208-211	7
8	9 THANKSGIVING	10 Eq wkst and Quiz #4 Review	11 Cum Test #3 (give Cum Rev #4)	12 Volume of Prisms and Cylinders p212-215	13 Volume of Pyramids and Cones ("Quiz after 211") p212-215	14
15	16 SA + V of Spheres p212-215 and wksts. Quiz - "Ch 7" (2 pages)	17 Quiz 7D Review Booklet Questions	18 Quiz #2 - groups Assignment - 3 pages on SA + V Stats Lesson 1 p. 343	19 Review	20 Cum Test #4	21
22	23 Stats lesson 1 and Stats Graphs - interpret - draw - misinterpret p343-347	24 Circle Graphs Histograms (give Stats Assign) p351-353	25 Stem + leaf $\bar{x}$, M, mode p352-353	26 Probability + Predicting p352-357	27 Stats Assignment Quiz	28
29	30 Ratios and Sharing p268-271	31 ½ pg Check-up Proportion Scale Drawings p272-275				

Math 9 Semestered

1995 **November** 1995

SUNDAY	MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY	SATURDAY
		*Do speed, distance, time problems p278-279 Sometime this week	1 Check up 9B Rates %/dec/frac p276-277 p282-285	2 Check up 9C % of a # find # when % known p255-259	3 Check up 9D Discount + Sales Tax p290-291 Group Q Creation Assign "Ratio, Rate, % Quiz"	4
5	6 Ch 9 Assignment Interest + Profit p292-293 (give Cum 5)	7 Cum Review #5	8 Rev	9 Cum Test #5	10 X	11
12	13 X	14 Cartesian Planes p308-309 worksheets Battleship	15 Real World Graphs p310-312	16 Graph a Line p310-313	17 Check up after Graph Unit y = ax + b Intercepts (Non-linear Graphs?) p310-313, 317	18
19	20 Check-up Ch 10 Geom defn ∠ pairs p244-245	21 ∥ lines and angles p246-249 Review Ch 10 Check-up ½ pd	22 Cum Review #6	23 Quiz on Ch 10 Review	24 Cum Test #6 (give Assignment #8)	25
26	27 ∠'s in ○'s p248-250	28 ∠'s in △'s p251-253 wksts - Solving Angles	29 Construction Day 1	30 Construction Day 2		

Math 9 semestered

December

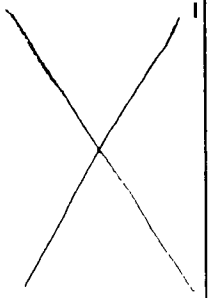
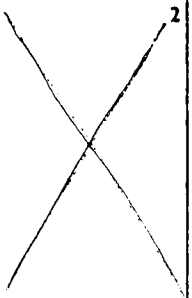
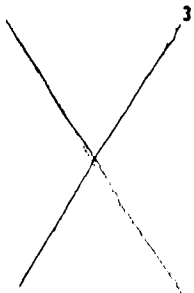
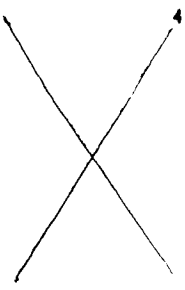
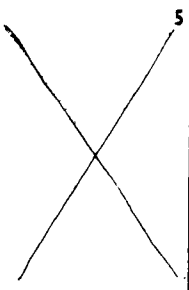
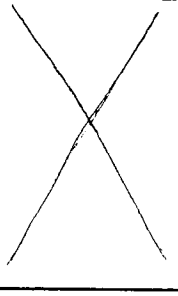
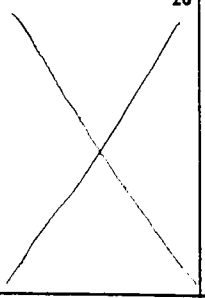
1995 1995

Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
31					1 Construction Day 3 -Quiz Congruent Triangles p244-255	2
3	4 Algebraic Expressions p126-129	5 Alg + and with ( ) (combining like terms wkst, Poly Quiz #1) p130-131	6 Cum Review #7	7 Review	8 Cum Test #7	9
10	11 Alg — with ( ) p132-133 and Obj #8 wkst	12 x mono wkst mono x poly (simplify poly -wksts) p134-135	Quiz-Ch.5 13 ÷ (mono by mono, bi by mono) p138-141	14 bi x bi -wkst and back of quiz Ch5 p142-143	15 Review Alg -Continue on simp poly wkst #1-2 -Quiz-Math9	16
17	18 work on Com Rev #8? simp poly wkst #3 Quiz-Rev Ch5	19 Cum Review #8	20 Review give "Final Rev #1"	21 Cum Test #8	22	23
24	25	26	27	28	29	30

Math 9 semestered

January

1996 1996

SUNDAY	MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY	SATURDAY
	1 	2 	3 	4 	5 	6
7	mark Fin Rev#1 8 Lesson 5A: Writing Eq Solving Problems wkst #4 (#1,2) p176-177 (#2)	SQ1 9 Lesson 5B: wkst #4	SQ2 10 Word Prob Quiz wkst	SQ3 11 Mult Choice Rev wkst Inequations 178-181 selected (#4, 5odd) (p178-181)	Rev Quiz#2 12 Inequations + Graph -wkst I -numeric response sheet (HW)	13
14	SQ4 15 Review Quiz #3 Inequations Quiz Review Check-up	16 Review -SQ5 -SQ6 -Exponents Review wkst -Review Quiz #1	17 Review (Groups) -SQ7 -SQ8 -SQ9 -Mult Choice Review wkst	18 Review -"Math 9 Final Rev" (mark at end of class)	19 Cum Test #9 give "Cum Rev after Ch 10"	20
21 (optional? Cum Test #10)	22 Practice Final -numeric response sheet	Problems sheet 23 Review	24 Part A of Final Exam	25 	26 	27
28	29	30	31			

Due Date: _____

Name: _____

MATH 9
Cumulative Review 7A

1. Kim buys new shoes every 9 months; Ken buys shoes every year; Kari buys shoes every 18 months. How often will they all buy shoes in the same month?

2. If the initial temperature is 7°C and the temperature changes as shown, what is the final temperature?

Temperature	Time Passed				
	1 h	2 h	3 h	4 h	5 h
	+2°C	-3°C	-5°C	-3°C	+1°C

3. Evaluate the following:

   a. By how much does (-4) - (-5) exceed 8 + (-2) - 7?

   b. Cara had half a dozen cans of dog food. Her dog could eat ⅔ of a can per day. How many days (whole number) will her supply last?

   c. $(3 + 2)^3 - 4^2$

   d. $\sqrt{25} \div \left(\frac{1}{5}\right)^{-1}$

   e. $(-5)^0 + (5^2)^3 \div (5^{-3})^{-1}$

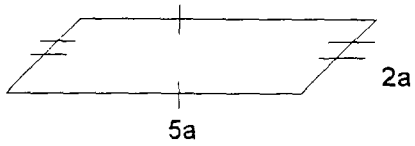
   f. $(-2)^{-3}$

   g. If there are 5.3×10^8 atoms in each gram of a substance and you have 4.8×10^4 g of the substance, how many atoms do you have?

4. Change to $\frac{a}{b}$ form: a. 5.9 b. $0.\overline{23}$ c. $-1.08\overline{2}$

5. Show all work: Evaluate $a^2 + b \div c$ if $a = 1\frac{1}{4}$, $b = -3\frac{3}{4}$, $c = -1\frac{1}{2}$

6. Calculate the perimeter of the following:



7. A soup company makes cans of soup in 2 sizes: cans with a 3.5 cm radius and 9 cm height OR cans with a 5.0 cm radius and a 14 cm height. If the smaller can is \$0.79 and the larger can is \$1.29, which is the better bargain? Prove it!

   How much tin is needed to make the smaller can?

8. Find the volume of an Egyptian pyramid with a square base of 75 m and a pyramid height of 50 m.

9. From question 8, what would be the height of one of the triangular sides?

10. Solve the following:

a. $x - 5 = 8 - 2(x + 2)$

c. $8y + 3 = -37$

b. $\frac{5m}{6} + \frac{2m}{3} = \frac{9}{2}$

d. $3 - (2 + 4x) = 4 + 2(3x + 1)$

11. Len's marks on his science tests were (in %):

58, 64, 72, 69, 77, 70, 77, 81, 81, 84

What are the mean, median and mode?

What is the probability of him getting a mark of >75% only based on this data?

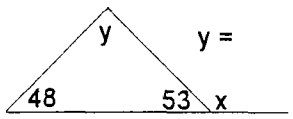
12. a. Kali bought a T-shirt for $13.99, jeans for $58.99 and a belt for $9.50. She gets a 15% discount for being an employee. What is the total she must pay (including tax)?

b. The angle measures in a triangle are in the ratio 3 : 4 : 5. What are the angle measures?

13. Sally read 117 pages of her book. This is 65% of her book. How many pages does she have left to read?

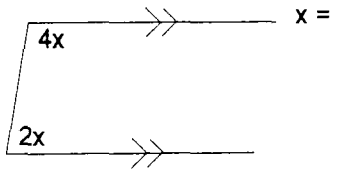
14. Graph y = -2x + 4. What are the x and y-intercepts?

15. Solve the following:

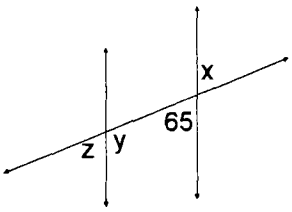


x =

y =



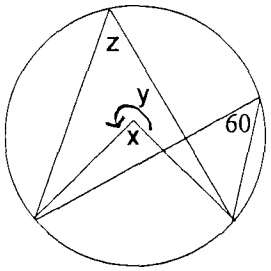
x =



x =

y =

z =

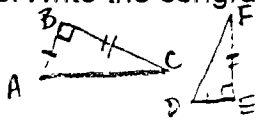


x =

y =

z =

16. Write the congruency statement if the triangles are congruent.



17. Sketch an isosceles right triangle.

18. What is the complement and supplement to 68°?

supplement =

complement =

MATH 9 CUMULATIVE TEST # 8 NAME:

PART I: Record your multiple choice answers here.

	A	B	C	D
1.				
2.				
3.				
4.				
5.				
6.				
7.				
8.				

	A	B	C	D
9.				
10.				
11.				
12.				
13.				
14.				
15.				
16.				

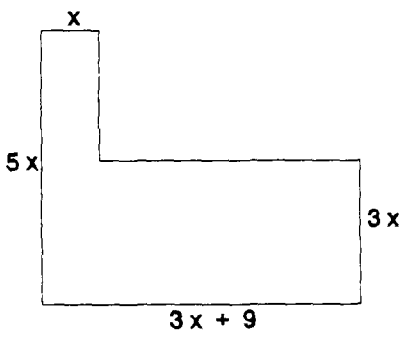
	A	B	C	D
17.				
18.				
19.				
20.				
21.				
22.				
23.				
24.				

PART II: Record numeric response answers here.

1.		6.	
2.		7.	
3.		8.	
4.		9.	
5.		10.	

PART III: EXTENDED RESPONSE: Be sure to fully explain all answers and show all work. Even the work that you do in your head. Answers will only be awarded 1 mark.

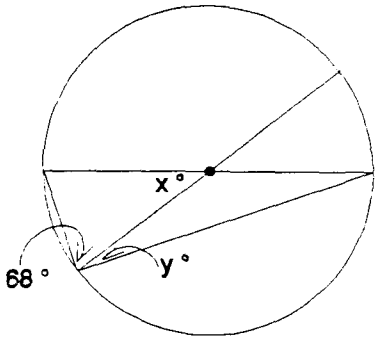
1. a) Find the perimeter of the figure in the diagram that is below. [2 marks]



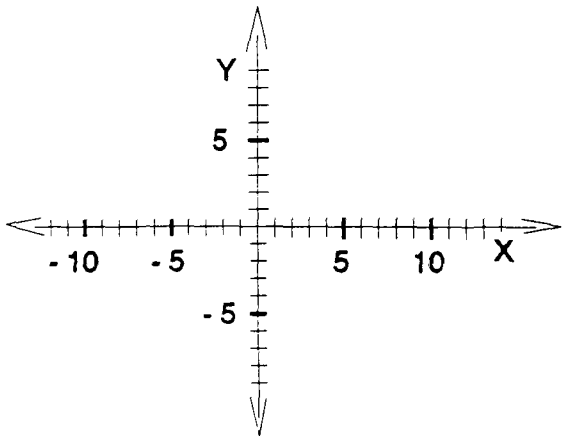
b) Find the area of the figure above. [2 marks]

2. $\dfrac{36\,m^7 - 9\,m^4 + 3\,m^2}{3\,m^2} =$ [2 marks]

3. Find the value of x and y in the diagram shown below. [2 marks]



4. 6x - 5y = - 30 is the linear equation of a straight line. Find the x- and y-intercepts of the line. Use these intercepts to graph the line. [2 marks]



PART 1: MULTIPLE CHOICE: Choose the best answer and record your choice on the answer key provided.

Here is a list of formulae that can be used. Triangle--A = bh ÷ 2; rectangles and parallelograms-- A = bh; circle--A = πr^2 and C = πd; cones--LSA = πrs; prisms and cylinders--V = Area of base × height; pyramids and cones--V = Area of base × height ÷ 3; spheres--SA = $4\pi r^2$ and V = $4\pi r^3 \div 3$.

1. The correct order of $-\frac{6}{11}$, $-\frac{24}{45}$, -0.55, and $-0.53\overline{67}$ from smallest to largest is:

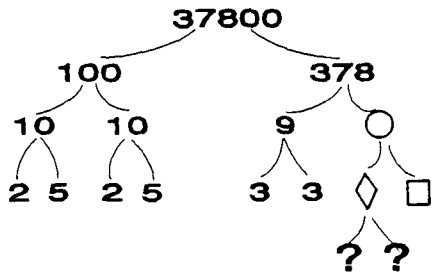
a) $-\frac{6}{11}, -0.55, -\frac{24}{45}, -0.53\overline{67}$

b) $-0.55, -\frac{6}{11}, -0.53\overline{67}, -\frac{24}{45}$

c) $-\frac{24}{45}, -0.53\overline{67}, -\frac{6}{11}, -0.55$

d) $-0.55, -\frac{6}{11}, -\frac{24}{45}, -0.53\overline{67}$

2. An unfinished factor tree is shown below. The value of "○", "◇", and "□" respectively are



a) 369, 361 and 7
b) 54, 18 and 3
c) 48, 24 and 2
d) 42, 6 and 7

3. The square root(s) of 156 to the nearest tenth is :

a. ± 12.4
b. 12.4
c. ± 12.5
d. 12.5

4. When $(-5^3)^{-4}$ is simplified and expressed as a power of 5, the value of the exponent is

a) - 12
b) 12
c) - 7
d) 7

5. Solve $\frac{3x + 7}{2} = 14$ is solved, the solution is 7. Which of the following is an incorrect way to start the solution.

a) Multiply the 3x, the 7 and the 14 by 2.
b) Cross multiply, by multiplying the 3x + 7 by 1 and the 14 by 2.
c) Divide two into 3x and 7 to get 1.5x and 3.5.
d) Multiply all numerators by 2, then divide the products on the left hand side of the equation by 2.

6. Emily's and Kent's ages are represented by the numeric expressions shown in the chart below. In 11 years their ages will be represented by the expressions

Names	Present Ages	Age 11 years from now
Emily	3x - 2	
Kent	x	

a) 3x - 11 and x - 11
b) 3x - 13 and x - 11
c) 3x + 11 and x + 11
d) 3x + 9 and x + 11

7. Melissa's business made a profit of $10 569 in December, and lost $4 670 in January. The business made an overall profit of $8 442 for the three-month period of December, January, and February. In February, Melissa's business

a) did not make a profit or a loss.
b) had a profit of $ 2543.
c) had a loss of $ 2543.
d) had an overall profit of $14 341.

8. A scale drawing uses the ratio 1 : 500. A rectangular building on the drawing has the dimensions of 5 cm by 7.5 cm. The difference between the length and width of the building is

a) 10 m
b) 3500 cm by 2500 cm
c) 6000 cm
d) 12.5 m

9. A board is divided into two parts that are in the ratio 5 : 8 . The actual difference in lengths of the two boards is 450 cm. The length of the original board before it was cut was.

a) 1200 cm
b) 4.5 m
c) 13 m
d) 19.5 m

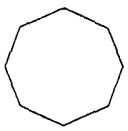
10. A sphere has a diameter of 19.2 mm. The surface area of the sphere is

a) 289.39 mm^2
b) 385.84 mm^2
c) 1157.53 mm^2
d) 3704.09 mm^2

11. A regular septagon has sides of 14.8 cm and an apothem of 15.4 cm. The area of the septagon is

a) 398.86 cm^2
b) 797.72 cm^2
c) 1025.44 cm^2
d) 1597.64 cm^2

12. A polyhedron has triangular sides and a base as shown below. The name of the polyhedron is



a) hexagonal prism
b) hexagonal pyramid
c) octagonal prism
d) octagonal pyramid

13. If you want to draw a regular octagon to scale you could

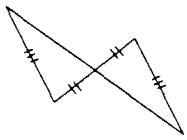
a) Draw a circle. Draw perpendicular diameters. Bisect the four angles formed making sure that the bisectors touch the circle. Use a straight edge and the points of intersection on the circle to draw the octagon.
b) Draw a circle. Use the same radius to measure off a series of arcs on the circle. Use a straight edge and the intersection points of the circles and arcs to draw the octagon.
c) Draw a circle. Draw an equilateral triangle in the circle. Bisect the angles of the triangle. Use a straight edge and the intersection points on the circle to draw the octagon.
d) Draw a circle. Draw a right angle at the centre of the circle. Copy the right angle. Now use a straight edge and draw the octagon.

14. 56° is complementary to angle A. Angle B is supplementary to 98°. In triangle ABC, the measure of the third angle, C, is

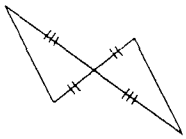
a) 26°
b) 42°
c) 48°
d) 64°

15. SAS can be used to decide whether or not two triangles are congruent. Below are four diagrams. The two triangles that are congruent by SAS are

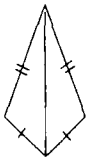
a)



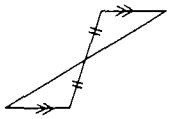
b)



c)



d)



16. To find the y-intercept using the equation, you

a) Substitute x = 1 in the equation and solve for y.
b) Substitute y = 1 in the equation and solve for x.
c) Substitute x = 0 in the equation and solve for y.
d) Substitute y = 0 in the equation and solve for x.

17. (0, - 5), (2, 1) and (5, □) are collinear points. The value of "□" is

a) 5
b) 7
c) 10
d) 12

18. The points (5, - 8) and (- 3, 8) lie respectively in quadrants

a) I and II
b) IV and III
c) I and III
d) IV and II

19. A bag contains 650 cards, parts of many decks. If a random sample is withdrawn that contains 18 hearts, 15 spades, 7 diamonds and 10 clubs, ~~marbles~~, the most likely distribution of card suits in the bag is

a) 234 hearts, 195 spades, 91 diamonds and 130 clubs.
b) 180 hearts, 150 spades, 70 diamonds and 100 clubs.
c) 200 hearts, 190 spades, 102 diamonds and 158 clubs.
d) 268 hearts, 201 spades, 56 diamonds and 125 clubs.

20. To find the median of 8 pieces of data you

a) find the piece of data that occurs most frequently.
b) add the 8 pieces of data and divide by 8.
c) add 4 and 5 together and divide by 2.
d) find the value of the fourth and fifth largest pieces of data and divide their sum by 2.

21. A spinner contains the colours red, yellow and blue in equal sizes. The probability of spinning blue and tossing a 5 on a fair cubic die is

a) $\frac{1}{3}$

b) $\frac{1}{6}$

c) $\frac{1}{18}$

d) $\frac{1}{2}$

22. The product of $(2m^2 - 2)(2m + 7p)$ is

a) $4m^2 + 9m^2p - 4m + 5p$
b) $4m^3 + 14m^2p - 4m - 14p$
c) $4m^3 + 9m^2p - 4m + 5p$
d) $4m^2 + 14m^2p - 4m - 14p$

23. When $(4x - 2)$ is multiplied by $15x^3$ and then the result is divided by $- 5x^2$, the result is

a) $- 12x^2 + 6x$
b) $- 12x^2 - 30x^3$
c) $55x^2 - 35x$
d) $55x^2 + 35x$

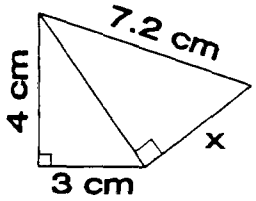
24. The number of terms in the expression $8(3x^3 - 2x^2 + x - 1)$ is

a) 4
b) 5
c) 6
d) 8

PART II: NUMERIC RESPONSE: Record your answers in the appropriate spaces provided on the answer key.

1. The value of $(-2)^{-1} + 5(-3)^0 - 4^{-2} + \frac{9}{25}$, correct to the nearest hundredth is _____.

2. The value of x in the diagram below, correct to the nearest tenth of a cm is _____.

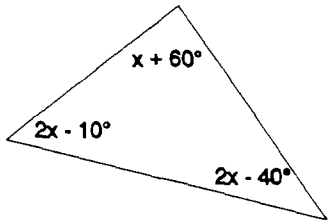


3. Solve $5(m + 2) = 6(m - 3)$. The value of m is _____.

4. The formula for the volume of a solid cylinder is $V = \pi r^2 h$ or $V = A_B h$. A cylinder has a volume of 3014.4 m^3 and a base area of 200.96 m^2. The height of the cylinder to the nearest m is _____.

5. Angles A and B are subtended by the same arc of a circle. Angle A is a central angle and angle B is an inscribed angle. The measure of angle B is 56°. The measure of angle A is _____.

6. Triangle ABC is shown below. The value of x is _____.



7. 37.5 % of 15, correct to the nearest tenth is _____.

8. The mean of 55, 60, x, and 50 is 57. The value of x is _____.

9. $y = \frac{1}{2}x - \frac{3}{4}$ is an equation of a line. If $x = 3\frac{1}{2}$, then the value of y is _____.

10. $(5x - 2)(3x + \square) = 15x^2 + 14x - 8$. The value of "□" is _____.

Appendix E

Cumulative Work in Mathematics

I teach mostly mathematics 30 and usually a couple of mathematics 9, 10, and 20 courses as well. I do cumulative work in all of my courses and have had occasion to teach students who have had anywhere from zero to three previous courses taught by this method. I find the differences among these students to be very significant.

In order to get students to do cumulative work, that is, study and continue to practise everything they have learned, it is necessary to do cumulative testing. I find that if their tests are not cumulative most students simply will not do the work. Over the past six years the diploma exam results of my mathematics 30 students have been consistently above provincial average, usually about 10%. I believe this is due, at least in part, to the cumulative work they do throughout the term.

Cumulative testing is most effective when cumulative review assignments are completed and discussed prior to each test. Cumulative testing means more work for the students and cumulative test results are slightly lower than unit test results. This means that students will likely have a lower term mark in a course that does cumulative work. However, the long term benefits by far outweigh the short term drawbacks.

After having done cumulative work for the duration of a course, last minute cramming for the final exam is unnecessary. Final exam results are much higher (upwards of 10%) for a class having done cumulative work. Also, students have much higher retention going into the next level or grade. I have had some students who have come through two or three years of previous mathematics courses based on cumulative work. I believe these students are far stronger mathematics students than they would otherwise have been. They have learned excellent work habits and have acquired a method of gaining much better long term retention.

I recommend cumulative work to anyone looking for ideas on how to improve student achievement in their classes.

Linda Gagley
Mathematics Instructor
Medicine Hat High School

I use the cumulative approach in my grade 9 math classes and in my Math 10, 20, and 30 classes. I have used this approach from the time we first thought of it. Together with other teachers in my school, I put together the reviews and the tests. My classes have been on this system for four years or 8 semesters.

A full cumulative approach (a cum review followed by a cum test that is considered major in contributing to the student's mark) has many advantages.

At first you notice the most obvious results when using the cumulative approach. Students do much better on final exams. The term mark is much closer to matching their final exam mark. Your evaluation of the students is more accurate because it truly reflects the amount of math skills that they can use to solve problems.

It is an excellent excuse to stop what you are currently doing and concentrate on maintaining all math skills that have been learned. Good cross-skill questions are less common than they should be and therefore we do not practice previously learned skills as often as we would like. Knowing the test follows the review gives purpose to the task of learning skills that were not fully grasped when the unit was covered. It also makes cross-skill questions more viable when placed on a test.

The cumulative approach fosters the idea that all mathematics learning is important and is used in many ways. It is important to keep each skill up to a ready-to-use standard so that it can be used at any moment to solve the vast mathematical problems that exist in the real world. Students on a cumulative approach can see the importance of maintaining math skills and they are better prepared to handle actual problems in the real world. Some problems need a variety of skills in order to solve them. Many problems can be solved with more than one method. Students that have maintained all their math skills are more apt to find new and interesting ways to attack problems.

When students become acquainted with the cumulative approach they know that it is much easier because they don't forget special skills that were learned in past units. This system tends to eliminate last minute cramming once a year for the final exam.

When planning time lines, teachers can put units that take time and effort to learn earlier in the school year enabling them to be 'cumed' more often, making students more proficient.

The cumulative approach is the best system that I have ever discovered. I shared my time line, reviews and tests with a teacher who was having trouble in all aspects of his class, from discipline to a low class result on the Grade 9 Achievement Test. He could not believe the improvement in the second semester. His discipline problems disappeared. His students learned and the results on the achievement test were drastically improved.

The cumulative approach fits with memory learning techniques. Concepts are repeated periodically and are forced back into the students mind enough times that there is a greater chance of these concepts going into long-term memory and becoming life-long skills.

Elaine C Dufresne
MHHS

Comments on Cumulative Review

A. Benefits:

1) Held accountable for past knowledge -- can't forget about a unit they did poorly on.

2) Before true understanding can occur, a student must look at examples more than once, thus enabling them to attempt application questions with more confidence.

3) Since students remember concepts from past units it is easier to make connections between related ideas -- they see important links.

4) Retention much better in next grade -- less review time.

5) For those that don't do much math outside of class, they know every Friday there is a test where they are responsible for that weeks' work and past concepts. The more they do, the better they become -- building their confidence and their attitude towards math.

B. Down side:

1) Marks are lower than what they would be with a "unit test approach".

Lynda Hurd
Ardrossan Senior High
Ardrossan, Alberta

COMMENTS ON CUMULATIVE REVIEW

1. BENEFITS

The odd gifted math student can be shown a math concept once or twice, understands it immediately, and because they understand the concept they might not do very many questions as practice. However, if the concept is not used on a number of occasions even gifted students may forget it. Most math students are not gifted and need a lot of practice before a concept even makes sense and often because they still don't really understand it they memorize a form or procedure to answer the questions on this concept. Two weeks later, if not used, the form or procedure is forgotten along with the math concept. I believe everyone has a better chance of remembering and understanding a concept if they are forced to use it a number of times over an extended period. If it is learned, forgotten, relearned, etc. over an extended time period eventually it will not be forgotten. Mathematics is probably the most difficult subject for most students because, to be successful, students must retain knowledge and procedures form years of math courses. Cumulative review and testing on a cumulative basis forces students to relearn material and put it all together. Step A leads to B to step C, etc. and often all of these must be used before a more advanced question can be successfully answered. Cumulative testing will force this cumulative review and makes complete sense. I really believe that the weaker the student the more the ultimate benefit, but all students will benefit.

2. STUDENT REACTION

I think students compare cumulative testing to perhaps a form of "tough love". So called good parents set rules, restrictions, etc. and force their kids to do jobs, etc. that they may not want to do and not allow them to take part in some activities that the child may think are all right. The child will often complain and whine but I think they usually secretly appreciate the concern being shown by their parents. Math students will often complain cumulative tests are too hard but as they see more and more concepts which they can successfully handle they understand the benefits and know they are becoming a better math student. They don't like the extra work they have to do but they know it works by the time they write a final. When our grade 12 results come in and our students perform at a level quite often much higher than provincial results there are a lot of very happy math students who are extremely proud of their math results.

3. COMMENTS

It really helps if this concept is used every year. Students find it difficult if they have not been expected to do cumulative testing in previous years, because they are not as solid in their understanding of mathematics as they will be if continually exposed to it.

K. Wells Ardrossan Jr/Sr High School

What Cumulative Testing has Done for Me

I've been in Mrs. Hurd's class for three years straight -- for Math 10, 20 and 30. Every year I've done better than the last. I contribute this to Mrs. Hurd's excellent teaching, enthusiasm, willingness to provide help if needed, and, to cumulative testing. I still retain a lot of what was taught to me three years ago in Math 10 even though I don't remember as much from any of my other grade ten courses. I believe this is because of cumulative testing. Cumulative testing meant that every math test we wrote was focused mainly on the unit we had completed at that time but also included questions from units we had learned before. This way Mrs. Hurd would motivate us to remember all the material we had covered previously and not forget it as soon as we finished the unit. She could also put questions that we had difficulty with on that unit's test on again and again on later tests until we learned the concept. I remember seeing a lot of questions on systems on our tests from the beginning of the year until close to the end before we learned it well enough that most people were getting them right.

I was confident going in the Math 30 diploma test. Last semester I had three courses to study for diploma exams: social 30, Physics 30 and Math 30. When I went back and reviewed material from the very beginning of the course in Physics and in Social I found that I didn't remember very much. It was very stressful and required a lot more time and effort to go back and try to relearn entire units which I had forgotten. When I reviewed Math 30 though, I discovered I still remembered and understood units from the beginning of the year all the way through to the end. I only had to briefly look at each again and do some examples.

When it came time to write the diploma, I knew I was prepared. A lot of this was due to the fact that Mrs. Hurd had kept us sharp by constantly testing us on every unit we had learned as we went along and testing us on our weaknesses again and again until we got them right. It ended up that I knew the material in the Math 30 course so well that I breezed through the test with about 30 minutes to spare. This is very unusual for me. As Mrs. Hurd can attest to, I am very slow at writing tests and I never finish with extra time. I usually just finish in the time allowed or I need extra. For my other two diplomas, I used the extra half an hour offered on top of the 2 hours allowed.

When my marks came back, the results of cumulative testing showed. My Social course work mark was higher than my mark for Math. But when the diploma marks were added to become 50% of my mark, my mark in social dropped, in Physics it stayed the same and my Math mark soared up to be much higher than either. My course work mark in Social was 93%, in Physics 84% and in Math 86%. However, on my Physics diploma I received 84%, on my Social diploma 89%, and on my Math diploma I received 95%. My mark in Social dropped 2% and in Physics it stayed the same. Only on the Math 30 diploma did I get a higher mark than my course mark -- 9% better. I was very pleased with that mark; I had conquered the most feared and difficult diploma exam of Grade 12. 95% was higher than I achieved for any of Mrs. Hurd's exams. Cumulative testing had paid off.

The Importance of Cumulative Mathematics

Math 30 is a very difficult and challenging course to take. The whole point of taking the course is to prepare yourself for your diploma exam. There is a lot of material that you need to know in order to succeed on this exam. It is very simple to forget some of the materials that you learn at the beginning of your course, so a cumulative lesson could be very beneficial.

In a cumulative math course, you have unit exams, but on them there is also review from other things you have learned during the course. This is to help remember the material, and is a very efficient and beneficial way of learning mathematics.

Math 30 student
Ardrossan Jr./Sr. High School

Appendix F

Credits and Acknowledgments

There are always teachers who can see a vision and work towards that vision. In terms of this project, two colleagues were key to the initial development of the cumulative method that is presently being utilized. Linda Gagley and Elaine Dufresne's assistance and ideas have proven invaluable as the whole idea of cumulative work in mathematics emerged. I could see the value of it and joined right in to the work in progress. As teachers, together we must validate our work and that is one of the beneficial results of working on the cumulative method together. Thank you, Linda and Elaine!

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