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Department of CURRICULUM STUDIES

The University of British Columbia
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Date Sept. 14/2002
Abstract

The study examined student perceptions of global issues when introduced through their Logarithms unit in the Principles of Math 12 course and student opinions regarding the suitability of the issues within the course. Through journal books, the students expressed thoughts, ideas, and concerns related to the mathematics and the global issues.

With our global environment being threatened in numerous ways, a need to educate through 'responsibility' is essential. In mathematics, students require relevancy when expected to learn increasingly difficult material. The study addresses the questions of: do students concerns for global issues increase when viewed through a mathematical lens and do the students believe that the global issues have a place in the math class?

The findings were varied based on individual experiences of students within the study. In summary, the majority of the students gave positive feedback towards the use of the global issues within the math class. However, there were concerns from weak and strong students and from students currently studying similar topics in Geography. As well, several ESL students expressed concerns surrounding their difficulties with the written language, and anxiety regarding their emergent academic standing.

The students favoured global exposures in the math class when they were able to actively participate with a solution, and when direct links to the mathematics being studied at the time was relevant to the global issue. Conclusively, more accessible resources are required for instructors, and more time is needed in the classroom to effectively implement, for all learners, global issues in the mathematics course.
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INTRODUCTION

"The world is a good place, and worth fighting for"

-E. Hemingway

After the tests, the bubbles keep bursting. When I first began my journey into teaching 6 years ago, I never imagined a profession existed where a person’s everyday interaction with their clientele could have such a great impact. At age 23, I had finished my practicum certain of one unquestionable fact: I needed to experience more of the world to share with my future students. I pondered how to combine my love for teaching with my need to experience more of life outside my familiar shell. The answer came in the form of a small rural school in the village of Ponesai Vanhu, Zimbabwe, Africa.

Three weeks after my revelation, I joined a team of Americans who were volunteering as solidarity workers teaching street children from the city of Harare. There in Zimbabwe, we lived about one mile from the school in a camp built of wooden shacks and slept in beds entombed with mosquito nets.

My students included beggars, pickpockets, prostitutes, and street bullies. Many were orphaned, and all of them had a story. In their short teenage lives, they had seen more violence and despair than I ever would in my entire lifetime (and I was to teach them). A disturbing feature of Zimbabwe, and many other similar nations, was that many students were too poor to afford books, and opportunities to further ones education were highly dependant on class status. In my school day, I taught three classes of math and science classes, and I ran an optional typing class late in the afternoon. I thought typing was a good employment skill they could take with them anywhere. Actually, we did not
have any typewriters, so I stencilled the keyboards on construction paper. Eventually, I found two keyboards that we rotated and a broken typewriter that I fixed. Within my math and science classes, we were engaged in many great discussions mostly because their knowledge base was so little. They did not know of the planets, stars, or even the name of our 'earth.' Often, I felt like a 'messenger' who had this great opportunity to share my knowledge.

The conditions I lived in were very similar to those of the Zimbabweans around me. I had three simple meals a day, a few litres of drinking water, and several buckets of water for cleaning and bathing. Compared with my North American life style, my necessities in life became fewer, and my daily activities became much simpler. The amount of resources I consumed in Canada was astronomical in comparison to my Zimbabwean lifestyle. Wackernagel (1996) describes our 'ecological footprint' by comparing how much we consume with how much the earth's resources permit. He uses shoe size to contrast what we should be consuming to how much we actually are. Now in Africa, my North American size 10 boot had now become a Zimbabwean size 3 sandal. In many ways, I was happier, healthier, and in tune with my life. My purpose for becoming a teacher became clearer.

After my year abroad, I received a culture shock upon arriving home. The place where I had grown up was a hectic, over-consuming environment that knew very little of a simpler life style. Garbage containers were overflowing, edible food was constantly being discarded, and the monetary question of 'whether one could afford it' overruled the notion of 'whether one should consciously purchase it.' Carpooling was inconvenient; reducing water was pointless 'because it is free,' and my North American home town's
view of the state of the world could be dismissed with the flick of a channel. I was in turmoil. The place in which I had been raised had changed for me, by staying the same. Through soul searching, I became sure of two distinct conditions - First, being that I was unprepared to leave the only home that I loved, but second I needed to find reasons for staying.

"A gem cannot be polished without friction, nor people perfected without trials."
- Chinese proverb

At university, I received a Bachelor's degree in Science with a major in Mathematics. At this point, my teacher education was highly geared towards the teaching of high school mathematics. Unfortunately in teacher training, we dealt more with the best strategies of conveying the learning of the math as opposed to the reasons why math was being learned. In summary, I was taught the best ways to prepare students for writing a test. However, I felt if I could not answer with confidence why they were learning mathematics, I most certainly had to question why I was teaching it.

Soon within my North American classroom I routinely raised concerns for our environment, community, and world. The global issues relationship with mathematics I presented in class was minimal at best, and justification was always given from me such as, "caring for these global concerns is a great reason why I encourage you students to get a good strong education. As well, mathematics is a pre-requisite for many fields of study involving global issues...." Internally, I knew I had a message to say, but externally I was not saying it well enough through my methods of instruction. The global responsibility I intended to teach could not be the by-product of the lessons, but must be encompassed
within the lessons themselves. Students needed to see the problems of the world through a mathematical lens. Indeed, I wanted the math that I was teaching in the here and now to become empowering for them in the now (and in the here). My greatest challenge was figuring how such integration was to be done with such rigid curriculums and limited time frames.

**Mis conocimientos empiezen (My understanding begins)**

In the summer of 1997, I volunteered at an orphanage in Guatemala. To a great extent, my work also entailed my learning the Spanish language. Earlier in my personal education, I was terrible at languages and was very unsuccessful in school. As a result I had no second language, so the task in Latin America became very challenging at times in understanding how another language is structured and how it differs from our own. To be better prepared, I studied night and day to improve my Spanish for my purposes there.

My Guatemala experience had helped me to understand frustration when learning becomes disconnected from meaning. Frankl (1985) believes a person can endure any **what** as long as he has a reason **why**. I had my **why**. I was learning Spanish and these reasons helped me to persevere when the learning became confusing, tiring, and frustrating. At this time, I started to see why many students give up on math, whether it is in university second year, math 12 or math 8. If they cannot see why they are doing it, their reasons for choosing to endure the difficult course become less clear. Often, I ponder why Math is taken by 100% of all grade 8 students, yet from this initial population, approximately 50% of students eventually go on to take Principles of Math 12. Principles of Math 12 is an elective math course most commonly taken by students
continuing into post-secondary education with math as a requirement. As well in many universities, the percentage of students who take first year calculus, as compared to those who graduate in mathematics is astonishingly low. Somewhere along the way the system is discouraging math students from pursuing this line of study.

In the midst of my learning Spanish, I was able to acquire a book written in English entitled “Mathematics,” published from a 1960’s series of Time Life Books, that was donated to the orphanage. Whenever I needed a break from reading Spanish, I would read this brilliantly written math book. The book included historical attributes, applicable usages, and relevant subject matter. For the first time, I, a graduate with a math degree, was seeing the subject’s importance. After reading the mathematics book cover to cover and conquering my inability to learn another language, I then discovered what was missing from my math teachings back home.

Rationale for the Study

Currently in our world today, global temperatures are at record highs, the ozone layer’s holes are enlarging, curable diseases and starvation are running rampant in developing nations, and yet we are still advancing economically and technologically. Information about world calamities soon becomes desensitising when continuously listened to from a distance. Lack of involvement and a frustrating feeling of helplessness will cause people to learn to ‘tune out’ of problems. Not surprisingly, generations seem to blame the ones before and take no ownership of how they contribute to the global problems. For most people, exposure to problems alone will not cause proactive changes
to occur. Instead, educators must start ‘teaching’ about problems, rather than ‘telling’ about them.

Many students’ attitudes towards mathematics had always been less than favourable. With our society’s exponential increase, in technology, a need for genuine mathematical understanding has become an imperative. But to create this understanding, mathematics must be made relevant. As a teacher, I have found that the greatest deterrent for a student’s fondness of mathematics has been their lack of relevancy towards the subject. Over the years, my pupils have had difficulties in relating the subject matter to the ‘real-world.’ As well, the questions that were designed to bridge a relationship between mathematical applicability and student relevancy, in the form of word problems, were not being embraced. On the contrary, ‘word problems’ are found to be one of the most difficult aspects of almost all of my mathematics courses.

In the past, mathematics has been taught in an authoritative fashion where applicability, outside the impending test, was never really understood by the learners. I believe some progress has been achieved in terms of ‘giving meaning to the learning’ of mathematics. In Baxter & Newton’s (1975) textbook, “Mathematics For a Modern World,” questions are given much in the same way as they are in Alexander & Kelley’s (1998) Math 10 text. When comparing a topic such as ‘Equations of Lines using Slopes,’ the questions are very similar in nature with the exception of additional prompts in the modern text. In the 1975 text, a series of linear equations are requested to be drawn. An additional prompt asks, “What pattern do you notice?” (p.139). The 1998 Math 10 text has the same initial prompt asking for the linear equations to be drawn, but with additional questions, “Plot the graphs in each list on the same grid. Describe what you
see. Explain how the patterns in the equations account for the patterns on the graphs” (p. 219). Evidently, a shift towards a more open-ended, student-centered response is currently being asked, but the progress is still slow. The majority of the sections are still quite rote in the sense that the student memorization of various rules, with little understanding, would still be adequate to achieve all of the correct answers.

Purpose of the Study

The purpose of this study was to have Principles of Math 12 students at John Nisbet Secondary High School learn their Logarithms unit through the exposure to certain global issues. Evaluations were given through written journals asking students for their personal opinions on the issues they were being exposed to, as well as for the students’ personal assessments of their mathematical understandings. I shall refer to this researched study as ‘the Nisbet study.’ During the study, data was to be analyzed measuring whether the students’ mathematical relevancies had changed, as a result of global issues that had been exposed. As the study progressed, new factors emerged that helped to shape how the final portions of the study were to be conducted. Here, I, the researcher hope to find significant factors emerging that would cause the activity to become more successful if refined and replicated.

Assumptions

For the Nisbet study, it assumed that if factors existed in the combined study of math global problems that caused student success, researchers would be able to make recommendations for other teachers wanting to effectively implement this combination of
learning outcomes. A second assumption was made in regards to an educator's view of the shortage of time. In a senior math course, the perception being that time cannot be spared to implement any additional activities. My intentions are to show how minimal time can be used when integrating global issues in a math class, such as the Nisbet study, while creating student responsibility for global concern for the learners.

As an overview of the study, much research on math reform already has been conducted (Anderson, 1994; Cai & Jakabsin, 1996; Christiansen, 1997; Countryman, 1992; Dusterhoff, 1995; Elliot, 1996; Gerofsky, 1996). With respect to environmental education, a growing body of research is outlining environmental education's imperative implementation for the sake of the world's future (Chasmer & Perry-Globa, 1998; Dahlberg, 2001; Eames, 1992; Fortner, 2001; Hart, P., Jickling & Kool, 1999). At the senior levels of mathematics, little work has been explored in relation to bringing relevant global concepts into the curriculum (Iovinelli, 1997; Menghini, 1994). The Nisbet study's intentions are to combine the research involving mathematical reform at the senior level and research involving environmental education. Of particular interest, then, with the current changes in attitude towards the mathematics curriculum, is what types of exposures in this study are prompting students to change their social and mathematical attitudes and actions in daily living with regards to our environment.

Overview of methodology

A. Theoretical Framework: The Nisbet study is qualitative in nature. The collection of data was done through the use of written journals in the math class. The journal prompts varied in format, all involving written feedback of some sort. The data
was collected throughout the study and was analysed using the Constant Comparative Method (Glaser & Strauss, 1967). This method entailed an initial coding and categorizing of information from the data. A constant re-examination was necessary as more information was collected, causing emergent additional categories to be formed.

B. Selection of Candidates: All participants were selected from two of my Principles of Mathematics 12 courses at John Nisbet Secondary. I was the primary researcher involved in this study. The journal entries were a regular classroom activity in this researcher's class. A total of fifty-one participants took part in the study and none withdrew when asked to sign consent for the use of their work for the study.

C. Limitations of the Study: The study was exploratory in nature. This being the case, no attempt is made to generalize or quantify the results extracted. The intention is that the findings from the Nisbet study can be used as a foundation for further research and a basis for improving mathematical and environmental education at the senior level.

Conclusion

The problem before me is dualistic. I am struggling to bring relevancy with mathematics into my instructional practices, and equally important, to address the lack of global responsibility of our future citizens. The Nisbet study intends to deal with both of these pressing issues. The results are meant to empower the practicing educator to model the positive outcomes and to amend other instances to suit their personal situations. With
minimal work having been done in this field at this level, this study can serve as an initial step in benefiting our planet. The study has come about largely due to a personal definition of a good educator as opposed to a teacher. A good teacher is one who teaches things right; a good educator is one who teaches the right things.

In the comparison of shapes, the sphere can be viewed as the most unique of all the shapes. Its properties consist of having the greatest volume while allowing for the least amount of surface area. When a child blows soap bubbles from a circular shaped dispenser, she creates a spherical bubble. However, if she was to use a square shaped dispenser, a cubic soap bubble would not be formed, but as well a spherical one. This phenomenon helps to show the natural property of the most efficient of shapes, the sphere, seeking the greatest volume with the least surface area. With these facets, the sphere is also the most fragile of the shapes rendering it inadequate when even the smallest of portions is missing. When the tiniest piece of a soap bubble is tampered with, the entire shape bursts into nothing. In comparison with the properties of the sphere, we teach our students the maximum amount of 'volume' of mathematics in the least amount of time. The students are our bubbles, and after the tests, the bubbles are bursting. The learners are not retaining the quantities learned, which brings to question whether they understood the information to begin with. Consequently, we are losing attendance numbers when the grade levels increase as students become overwhelmed with the mathematics. Learners who are conditioned to pass the difficult tests, with or without mathematical understanding, will outperform many intelligent students seeking meaning in the math classes. This limiting aspect will cause only certain types of students to continue with their mathematical studies.

Mathematics courses share many common characteristics as language courses. There are set rules to be understood in order to comprehend new course material. If
mathematics is to be treated as a language, instructions of lessons must be taught with meaning for the students, and interpretation towards new subject matter. The linguist Jakobson once said, “language without meaning is meaningless” (Pimm, 1987, p.4). If comparing understanding with a speeding boat, once meaning is attained in mathematics, one will soar through the waters no matter what the circumstances. However, by continuing our current methods of mathematics discourse, educators will continue creating empty vessels of students who are only capable of staying afloat. To counter this trend, educators must be made aware of successful alternatives that have provided students with greater meaning in mathematics. When exploring different methods of teaching mathematics, such as written journal work, we are allowing for a relevancy to emerge that is immeasurable. However, if this option is not explored, we shall continuously see the bursting of the ‘bubbles.’

In my opinion, a lack of perceived relevancy (i.e. the missing piece) is the root behind the learner backlash towards mathematics. We provide so many mathematical tools for our students, and after ‘the exam’ they retain so little. In many test instances, students are able to solve almost all of the questions correctly without knowing for what purpose they are even answering them. As a result, instead of the learners coming away with an ability to apply a learned proficiency, they are coming away with soon to be forgotten rules that bear no relevancy. Revisiting the sphere analogy, the ‘bubble’ can be seen as the learners of today, or can be viewed as our depleting earth. Either way, teachers can re-look at educational practices in order to prevent the bursting of these bubbles. In the future, I hope to use the role of a ‘messenger’ to share my experiences abroad, as well as my post-secondary mathematical education to bring meaning and
purpose to my students in class. Currently, the essential intention behind my research is
to re-examine how mathematics is being taught, and why we are teaching mathematics to
our students - to reshape the bubble into not the most efficient of shapes, but rather the
most meaningful.
LITERATURE REVIEW

For the literature I intend to present, I will focus on areas that directly relate to the Nisbet study. The literature involving a holistic need for the students and environment include global, developmental and mathematical. A comparison is made under the heading of ‘Current work in the field,’ which contrasts what is done in the Nisbet study to similar endeavours. For studies pertaining to the activities administered in class, ‘journal use’ is researched and promoted. In regards to what is discussed in the Results of this study, documented work with ESL learners and case studies is provided. This literature review will allow for a better understanding of the results and discussion of the Nisbet study.

Global Educational Need

"Education is a process, not a product, yet most educational programs are geared toward teaching people what to think rather than how to think" (Swan & Stapp, 1974, p.32).

Research indicates that education must make students more globally aware. Hudson (1990) worked on a project intended to develop materials and approaches for the math classroom using a global perspective. This research project’s intention addressed issues set forth by the 1976 UNESCO General Conference in Paris. The conference issued its Recommendation Concerning Education for International Understanding. Among the list of “major problems of mankind” this conference advocated that students
study: equal rights, human rights, economic growth, social development, natural resources conservation, cultural heritage preservation.

Hudson’s studies indicate that math classrooms can play a key role in implementing the UNESCO recommendations. Based on 127 countries, Hudson developed resources that include computer databases containing life expectancy charts, infant mortality rates, population growth projections, and other mathematical global issues. The project consisted of five high schools in the UK that were studied after these materials were implemented. In these schools, statistical analysis topics, required by the UK’s curriculum, now involved real data sets such as population growth, the arms trade, and energy consumption. Hudson notes that while the issues raised are very far reaching for the students, he is not concerned with the emergence of particular answers to certain global issues, “but that an awareness of the scale of inequality is appreciated and that important questions are raised by young people who are the future citizens and voters in our democratic society” (p.130). The response he received from the students and teachers who participated in the study was overwhelmingly positive towards the use of the new resources.

Hudson’s work provides great justification for integrating global resources. What his work does not address is whether students have a better appreciation of the mathematics due to the global issues they study. Unlike Hudson’s work, what I attempt to do in the Nisbet study partially deals with student understanding in terms of relevant appreciation for the uses of mathematics with the integration of global issues.
"Environmental education is a way of understanding environments, and how humans are part of, and influence, environments." – (BC Ministry of Education, 1995, Environmental Concepts in the Classroom, p.5)

Several studies relate the need for environmental education. Hart, Jickling, Kool (1999) examines how environmental education relates to ‘good’ education. Traditional environmental education is centred around science, outdoor, and conservation education, but this education should now go further beyond this, involving: community-based, values-based, interdisciplinary, participatory, critical, and inquiry-based practices in the classroom. The researchers state that there are many unknowns involved with environmental education, and many issues that do not contain scientific or technical solutions. This uncertainty will surely cause anxiety in the minds of teachers. However, according to these authors ‘good’ education should avoid indoctrinating students, and instead should encourage open-minded thinking. Hart recognises that students should be exposed to insolvable environmental problems: “to avoid controversial issues is to tell students that those issues aren’t important and that the students can’t make a difference. We also risk failing to prepare them to participate in a democratic society” (p.113). With greater exposure to these realities, a student can start to find meaning in their learning.

The problematic outcomes of global education research that date back over twenty years still remain. Swan (1974) describes the need for environmental education by rethinking the way we are educating. According to Swan, ways of teaching rely largely on the methods of industry. When viewing problems on city roadways, for example, people notice that society does not have transportation companies, but rather automobile companies. The bright minds of society, such as graduated university students, are
recruited to find ways of increasing automotive production, increasing sales, minimizing defects, deaths, and accidents. These students are not hired to look at the problem of transportation, but only to look at the automobile's relation to the problem. As a result linear, rather than holistic solutions fail to solve transportation predicaments. In turn, these employees for the company are finding efficiencies for the automobile, not for the people. The scholarship winners the schools graduate become so self-absorbed in this frame-like picture that they too have lost the intended meaning behind what they are doing. Today, this practice of efficiency for the company over efficiency for society remains stronger than ever.

As citizens of society, people are accustomed to following rules, as well as set routines. People are hired to perform an already established set of tasks in the same way classroom students produce the work that a teacher requests. Thus, neither the employee, nor the company are to blame for the lack of transportation solutions. 'Automobile companies' became set institutions long before society could have envisioned the implications. As well, students are not to blame for passing courses with very little understanding of what they have learned, or why they were learning it. In education, this routine has the capacity to change. What educators and society must do is reshape the structures that we have set in place to provide a more holistic education. This holistic view will allow for the entire scene of problems to be encountered, not solely the immediate problems.

A traditional form of conservative education has taught teachers to 'teach the facts.' Teachers then hope that they have taught those facts adequately enough for our learners to be concerned about the societal problems involved. However, without pre-
existing conditions, a negative effect could possibly occur. Swan (1970) examined an inner city school with student reactions to increased awareness on air pollution. He found that, in general, the more education the high school students received on air pollution, the lower their priorities were for spending personal time and government funds on cleaning up the air. This negative effect, according to Swan, was not due to the way in which the information was presented or to the quantity presented. Instead, the problem associated with the students' attitudes lay in the absence of certain attitudes. Swan (1974) states that environmental education can be successful if two preconditions are already in place. Initially, the students should have a certain concern or emotional feeling for the problem. Second, the learners should have a personal feeling that they can take steps to resolve the problem. If both conditions are present, a sense of concern can lead to proactive involvement. If these circumstances were present, the inner city school may have reacted more positively towards the pollution problem.

In regards to student involvement, Stapp (1974) examines the role of school systems to include environmental education to "provide the opportunity for youth to explore their environment, sensorially, physically, and intellectually, in order to obtain both the motivating concern and the factual knowledge necessary to become an environmentally literate citizen" (p. 51). He feels that it is the responsibility of schools to 'alert and inform' youth about the coming environmental problems. Stapp further believes that instructional programs need to be put into place to help develop skills, such as problem-solving, critical thinking, and social change strategies. These skills will assist pupils in effectively functioning to achieve goals that benefit the environment.
The implication of Swan and Stapp’s 1970’s research carries over into current global education studies (Gelter, 2000; Mortari, 2000; McBean & Hengeveld, 2000; Suave, 1999). Mortari (2000) advocates the need for students to derive their definition of a “good quality of life” and to have educators link their definition to the natural environment. The promotion of change towards the natural world will not occur solely by living, but a student must also think about the way they are living. In relation to Stapp’s promotion of outdoor education, Gelter (2000) outlines the Scandinavian philosophy and biology of friluftsliv. This form of environmental outdoor education “facilitates a true connectedness to the more-than-human world” (p.77). Students connect with nature on a daily basis and this is the product of their learning, not the by-product. Courses in schools will play a decisive role in allowing learners to think about their lifestyle choices.

In regards to long-term educational goals, Gough (2001) examines the present role of education in promoting to ‘life long learning’ towards environmental issues. Gough states, at the root of environmental problems are the very practices society is indirectly rearing our students to function in. The underlying conclusion of Gough’s research, is that education will not ‘Save the Planet,’ but instead education will be most effective as part of a larger strategy changing social behaviour. In the same way that our established practises have grown into enormous problems, such as air pollution, we can assist in minimizing our existing predicaments by educating alternate behavioural practices.

Developmental Need
Researchers involved with child development, Hess and Torney (1967) examined developmental stages in a child's self-concept and sense of citizen responsibility. Their research indicated how a person's high school years were formative in acquiring values, attitudes, and skills necessary to enable rational decision making. With this reasoning, it should be seen as critical that school systems become more embracing to the exposure of global problems for their students. If one could argue that an inherent root of our poor environmental state arise from lifestyles, then schools should become a forum in shaping the student's lifestyles.

Stapp (1974) outlines the major constraints to development, implementation, and evaluation of environment education. First in a student's primary years of education, organization and discipline is taught, as opposed to problem solving. To successfully implement education surrounding the environment, the students would need to have had problem solving integrated at many facets of their learning process. A second constraint revolves around an overwhelming amount of subject matter encased in such a compact time frame. Even though much of environmental education can be broached within several different curriculums, teachers and administrators are reluctant to 'squish it' into their already crowded time frame. Stapp's third hindrance involves 'value' or 'moral' education in which teachers have become accustomed to not preaching morality, or certain specific beliefs to students. 'Just the facts' style of education seems to be the safe way to teach around debateable topics. Unfortunately, as Hart et al (1999) has pointed out, this method will only serve to indoctrinate students into becoming closed-minded thinkers. Last the teachers themselves are not effectively prepared to integrate environmental education. The traditional method of this form of education is the lecturing
of information on specific environmental issues; unfortunately, this process has failed in
"helping students acquire beliefs, attitudes, values, or skills conducive to the development
of an environmentally literate citizenry" (p. 53). These are not exclusive limitations,
others that can also contribute to the lack of implementation of environmental education
are the following: funding constraints, inflexible scheduling, youth oppression, lack of
accessible environmental information, resistance and apathy on the part of the
community, administration, teachers, or students. With the obstacles environmental
education faces, a call for solutions is necessary.

Mathematical Need

The National Council of Teachers of Mathematics (NCTM) has emphasized
students' need for context bound and relevant mathematics in order to be successful,
beyond the test. NCTM (1991) states, "good tasks are ones that do not separate
mathematical thinking from mathematical concepts or skills, that capture students'
curiosity and that invite them to speculate and to pursue their hunches . . . they require
that students reason about different strategies and outcomes, weigh the pros and cons of
alternatives, and pursue particular paths" (p. 25). Thus, educators must harness all
opportunities to broaden mathematics. Resnick (1987) describes mathematical tasks as:

" . . . nonalgorithmic . . . the path of action is not fully specified in advance . . . [it]
tends to be complex. The total path is not "visible" (mentally speaking) from any
single vantage point. . . . [it] often yields multiple solutions, each with costs and
benefits, rather than unique solutions. Higher order thinking involves nuanced
judgement and interpretation . . . the application of multiple criteria, which
sometimes conflict with one another . . . uncertainty . . . self-regulation of the
thinking process . . . [and] imposing meaning, finding structure in apparent
disorder” (p. 3).

Allowing for meaningful mathematics to emerge in a math course will take ingenuity
beyond the provided textbook. Strategies beyond notes, homework, and tests will be
necessary. Furthermore, effective educators will be essential to teach beyond their
previous routines.

Klein, Pflederer, Truckenmiller (1998) implemented a program in a metropolitan
area high school designed to increase mathematical achievement by raising the
motivational level of students. Motivational levels were found to be low through surveys
of the targeted adolescents and data on the school’s high school drop out rate. The
program’s strategy took a three-fold approach:

1. Intervention targeting the students in order to raise their level of intrinsic
   motivation and to increase their sense of ownership and responsibility through
   student journals and surveys.

2. Intervention intending to raise the interest level and motivation of the students in
   the classroom using collaborative groups and multiple intelligence activities.

3. Final intervention involved classroom presentation incorporating strategies of
   writing through mathematics and solving real-life applications.

The students in this program were introduced to journal writing for the first time, and
were given the opportunity to reflect through journal entries each week. The results of the
study showed increases in class participation, completed assignments, promptness to
begin class, and attitude towards class.
Many educators will attest to a student's motivation having a great influence on their learning (Hicks, 1997, Hunter, 1982). Howard Gardner's work on 'Multiple Intelligence' values student results from non-traditional viewpoints in a classroom. Gardner's work can be seen as an attempt to raise the motivational levels of 'low' achieving learners. Keith (1990) states that writing, in their own words, in mathematics can be used as a powerful communication tool for organizing a student's mathematical understanding, developing a language for questioning, breaking down student fears, assisting learners to become self-regulated, and for enhancing the intrinsic value of math (as cited in Klein, 1998).

The Principles of Math 12 course in British Columbia is composed of seven basic units, with "Logarithms & Exponentials" being one of them. The Integrated Resource Package 2000 (IRP) gives suggestions on how to introduce the mathematical concepts to be learned and prescribes what the intended learning outcomes should be. There is no mention in the IRP in regards to the use of word problems with logarithms or exponents. Very little has been researched on this topic with the exception of a few cases. One such case, Iovinelli (1997) uses the growth model of moths to demonstrate exponential growth: "It is a reasonable question that allows the introduction of a function that models the situation better than the straightforward exponential function" (p.1). He begins with the question: Why has this little bug not taken over the world if it can grow so fast? Iovinelli's intention is to spark inquiry into the learner's mind before the mathematics is taught. The students' in the study found the growth model introduced at the beginning of the unit to be quite useful in their mathematical understanding. By stimulating the students' interest, they were more willing to learn the mathematics in the hopes of
answering the initial question posed to them. More work is needed in the connecting of real-life examples into the senior mathematics curriculum.

Innovative Mathematics Education

Currently, numerous educational reform and assessment initiatives have undertaken the issue of the assessment of students' communication skills in mathematics. Silver & Stein (1996) studied a project entitled QUASAR. QUASAR (Quantitative Understanding: Amplifying Student Achievement and Reasoning) is a US project designed to enhance mathematics instruction for adolescents attending middle schools (grades 6 - 8) in economically disadvantaged communities. The QUASAR Cognitive Assessment Instrument (QCAI) is intended to measure middle school student outcomes and development in mathematics and to help evaluate attainment of the objectives of mathematical instructional programs. The QCAI consists of a set of open-ended tasks that asks students to construct their responses, showing their solution processes and providing justifications for their answers. As well, the tasks allow participants to display various levels of mathematical understanding and communication. The program hopes this evidence of increased student communication will help teachers to become more competent in the assessment of their students' mathematical communication.

Researchers report on success of programs where students are given ownership of their learning. Neumann (1999) reports on the 1997 Oregon State University (OSU) innovative program entitled: Science and Math Investigative Learning Experiences (SMILE) Program. This initiative involves giving high school students the responsibility for monitoring indoor air quality (IAQ) parameters that may adversely affect indoor air
quality in schools, such as temperature, relative humidity, and carbon dioxide levels. In addition, yearlong educational activities teach high school students about indoor air quality issues and how to diagnose and prevent potential IAQ problems in their schools. After conducting a limited assessment of IAQ in their schools, students were also encouraged to present their findings to the local school boards.

The SMILE program, for grades four through 12, began in 1988 with the goal of improving minority representation in the sciences. This progressive project provides science and math enrichment to over 700 minority (mostly Native American and Hispanic) and low-income Caucasian students from 11 school districts across Oregon State. In 1996, the SMILE Program, in conjunction with faculty in the OSU Department of Public Health and the EHS Centre, received a four-year grant from the National Institute of Environmental Health Sciences (NIEHS) for a project titled "Improving Understanding of Environmental Health Science." This initiative is designed to enhance teachers, students, and community members understanding of health science issues through workshops, hands-on activities, community educational events, and Challenge Weekends. Each year, activities focus on a different environmental health science theme such as household chemicals, indoor air quality, water quality, and food.

The SMILE Program was specifically designed to engage minority and low-income students in science and math beginning in grade four, and the program encourages these students to continue through high school graduation. To date, the success of these learners has been exceptional. Both high school graduation rates and college admission rates are higher for students involved with the SMILE Program than they are for non-SMILE students. A major strength of the SMILE Program is the
emphasis on hands-on learning activities. Furthermore, Gibbons (1992) has shown that children arrive at school intensely curious about how the natural world works, but that by the fourth grade, minority children start to fall behind in science and math. In addition, Gibbons (1992) and Delacote (1998) report how many children being taught the facts rather than the use of hands-on activities are discouraged. The SMILE program provides opportunities for students to participate in weekly hands-on activities in which they explore and gain a basic knowledge both of curricular academics and of environmental health science.

Plans are being designed, and shared with educators, pertaining to environmentally conscious math projects. Anderson (1994) promotes two projects that look at the implications of wasteful packaging of products. The first project entails the redesigning of a consumer product box, such as a cereal box. With the same amount of volume needed, the package is to be redesigned to be less wasteful. The second project looks at the wasted space within various products, such as aluminium foil. The foil is wrapped around a tubular material where a hollow centre is created, causing an overuse of packaging materials. Here students are permitted to solve the problem in their own way, allowing for several different mathematical solutions to arise. According to Anderson, these prescribed projects are designed to equip math teachers with a prepared resource that is intended to enhance a "meaningful context for exploring important mathematics and an important environmental issue" (p. 146). Problems connected with environmental issues, such as responsible waste management, provide valuable opportunities for learners to use mathematics to examine current practices and potential solutions. As well, scenarios for students to learn and use mathematics by examining and
possibly improving packaging standards of real products shall empower them to understand why the study of mathematics is critical.

To engage students in the context of the project, questions are prompted such as: How often does one purchase some product and later realize, after using the contents, the extent to which the product is over packaged? Do we note how much space is unused in packaging? What of the multiple packaging of products? From questions like these, inspirations for relevant mathematical explorations can grow. For example, specific concerns such as, minimizing a particular product's package and still satisfy consumer and manufacturer concerns can lead into the designing of a measurement project. The purpose of these types of projects is to combine mathematics and science through the activities that involve higher order thinking and worthwhile tasks. Introducing mathematics that is relevant, and context bound, is not only desirable but also necessary to foster greater understanding. As well, being environmentally conscious can be viewed as equally desirable and necessary. The prospect of simultaneously achieving both would not only raise our students' awareness of our responsibility for the environment but would also clearly illustrate the important role mathematics can play in protecting our planet.

Journal Use

Journals, or learning logs, have been studied (Cohen, 1990; Parker & Goodkin, 1987; Santa & Havens, 1991; Scarcella & Oxford, 1992) with a vast array of benefits emerging. Anxiety from students can lead to a lack of true knowledge, and a journal can be used as a place for producing ones thoughts without the pressure of academic performance. A student is able to explore ideas, conjure up notions, and uniquely answer
a question. As well, it serves as a place where a one on one dialogue with the instructor can take place. Working with science classrooms, incorporation of writing activities at the beginning of a unit are put in place in order for students' prior knowledge to resurface for the new material (Santa & Havens, 1991, cited in Garaway, 1994). At the end of the section, students are again prompted to write so that connections can be made to bridge new and old information. This type of learning is extraordinarily valuable for not only its unique assessment qualities, but as well for the students' ability to reflectively observe what they have learned.

Conventional uses of learning devices such as 'writing' were used when a student knew what he wanted to say. However, Denzin (1994) concludes that when a person writes, it is their way of finding something out that they did not know when they first started writing it. The former describes a mechanistic, scientific, approach that would commonly be seen in a quantitative research study. This does not crossover well into the qualitative arena. Denzin furthers that this prescriptive model neglects writing as a "dynamic, creative process; it undermines the confidence of beginning qualitative researchers because their experience of research is inconsistent with the writing model" (p. 517). The use of writing to emerge new ideas from students can be seen as a dynamic device in a qualitative study.

Writing, in general, has also been considered as a tool to promote conceptual change towards a topic. Parker & Goodkin (1987) pronounces, "Writing can be transformational. Through writing we can transform our experience symbolically, creating new ways of seeing it, new meanings for it, and new relationships to it" (p. 49). Many times a person understands a notion better just by talking about it, much like
‘thinking out loud.’ I relate this to the act of self-reflection. By allowing a student to reason out, in a journal, what they have just been exposed to enables conceptions to be created that may not have formed otherwise. Fathman, Quinn and Kessler (1992) found students to have trouble learning new science concepts because of their difficulty in abandoning previously acquired knowledge. Much like climbing a ladder that is on the wrong house, every step you take leads you further and further from where you are trying to go. It is common for any person to have learned something incorrectly, but the difficulty will surmount once that knowledge is required in order to understand another body of information. Prompting pre-conceived information from students, and dispelling any misunderstandings, is a time efficient way of beginning a unit on the ‘right’ foot. If an instructor begins to teach a new unit relying on previous knowledge without ensuring that all participants are ‘on the same page’, an additional form of misinterpretation will just be deeper rooted into the pupils understanding. Activating students’ prior knowledge alone when teaching a new concept allowed misconceptions to become entrenched and more complex. With a prior writing activity geared towards current student understanding, a teacher can identify and address fallacies more effectively. Written work would not only allow a student to express their notions in their own words, but could also make possible a smoother transition into a new unit.

The NCTM (1989) promotes alternative forms of assessment in terms of Curriculum and Evaluation Standards for School mathematics. As suggested by the NCTM, the assessment of students' ability to communicate mathematics should provide evidence that they can:
- Express mathematical ideas by speaking, writing, demonstrating, and depicting them visually;

- Understand, interpret, and evaluate mathematical ideas that are presented in written, oral, or visual forms;

- Use mathematical vocabulary, notation, and structure to represent ideas, describe relationships, and model situations (p.214).

Among these forms educators can distinguish the promotion of writing, and journals. Liebars (1997) reports on the use of journal work at the elementary level as a positive experience for her and her students. The 'open-ended reflections' allowed for students, at the end of a lesson or unit, to formulate questions, voice concerns, and inquire about the functionality of mathematics. Through the pupil's use of these journals, the teacher was able to receive immediate feedback, identify where misconceptions were forming, and address concerns of the learners. Liebars used 'journal prompts' as well at the beginning of lessons, and comments to their positive reception from the students. Prompts for the elementary learners included examples such as, "What math means to me"(p.3). Entries such as these not only served as a reflection of prior knowledge, but also as a direction towards what is to be learned.

**ESL Learners**

Additional teaching strategies are needed in the educational practices for ESL learners. Garaway (1994) promotes the need for writing in the mathematics classroom for ESL learners. Many cultures have geared their education towards western technology, and in turn, a western style of education. However, a foreign learner will encounter many
difficulties of the new educational practices. Garaway states, "where the western system of mathematics and science is desired by those involved, bridges must be sought and found through dialogue, structures, strategies, positive reinforcement, and a re-evaluation of science and mathematics classroom discourse. The key is active involvement of those affected" (p.105). Furthermore, Crandall (1987) feels that writing in mathematics will not only help to create relevance for what is being learned, but will allow for clarification through communication. He feels that math has traditionally not been viewed as a subject area in which English learning was to be enhanced. Crandall emphasizes that the mathematics classroom "can be a language-learning experience in both the mathematics and the ESL class" (p.28). Crandall outlines the role of language in mathematical learning for ESL students in the following ways:

1. A high correlation is present between reading skills and mathematics achievement, and preliminary research indicates that this correlation may be even stronger for ESL students.

2. On a "deeper" level, language works as a mediator for metacognition and mathematical thinking. Furthermore, this mathematical thinking, mediated by linguistic processes, can be seen as a prerequisite for mathematics achievement.

3. A minimal level of proficiency must be reached in cognition with the academic skills required of mathematics and in the language skills used to express the mathematical skills.

4. Mathematical concepts, processes, and applications are intricately connected to the language used in mathematics. Therefore, instruction used in mathematics, especially for ESL learners, should integrate mathematics and language skills.
The former can be taken as prescriptive information when providing for the needs of ESL mathematics students.

Mohan (1986) emphasizes the careful consideration of structures incorporated in a math classroom that allows for language development. A range of opportunities must be provided for the students to communicate their understandings of the subject matter. However, these must not be left unmonitored. Crandall (1987) further emphasizes that teachers need to provide "students with extensive and varied experiences in which to apply the mathematical thinking techniques and the metacognitive behaviours, self-monitoring of mathematical processes they will need to develop to be mathematics achievers."(p.30) With this framework in mind, whenever possible, lessons should be built on real-life experiences and prior knowledge of mathematics. They must allow for situations involving interactions with the teacher and fellow learners. Crandall adds, "such activities stimulate both second language acquisition and learning"(p.30). A rich environment for mathematical understanding can be created with these circumstances involving real-life activities.

Garaway (1994) finds that for minorities, ownership, the sense of having a stake in a situation, is an essential component in promoting success in mathematics and science. In a study of Koori language peoples in Australia (Boulton-Lewis, Neill, & Halford, cited in Clarkson, 1991), the researchers found two main reasons for the deficient mathematical achievement by the children. The first relying on the lack of everyday relevance, and the second due to their inaccurate English use causing misunderstandings of concepts.
Case Study

The method of case study is only one of several ways that a person can conduct research. Yin (1984) refers to case studies as the preferred strategy when ‘how’ and ‘why’ questions are being asked in the study. As compared with other strategies, case study will be more useful if the “investigator has little control over events, and when the focus is on a contemporary phenomenon within some real-life context” (p.13). Case study is favoured when examining contemporary events, but when the relevant behaviours cannot be manipulated. The method’s unique strength is its ability to deal with a full variety of evidence, such as documents, interviews, and observations.

Case study research includes both single and multiple-case studies. There can be a variety of intentions for using multiple case studies. A researcher may wish to examine the commonalities of what was observed between the cases and generalize a conclusion. Alternatively, one could examine a variety of cases in search of unique attributes that have nothing in common with the other. The open-ended nature of case study research is what allows for the unknown to be discovered and to qualitatively make discoveries from data.

In the realm of qualitative research, case studies are an excellent form of data collection that can be used to better understand not only what has occurred within the study, but also the personal reactions by the participants. Stake (1995) puts value on the use of case study by drawing attention to what can be learned from the single case. It stands as both the process of learning about the case and the product of our learning. He identifies three distinct types of case studies. The first being intrinsic case study. This entails the better understanding of a particular case, but not because it generalizes to other
cases nor to construct conclusions. It is studied because the case itself is of interest, and can be seen to hold intrinsic value. The second type is called *instrumental case study* and its usage is secondary for the purpose of supporting a theory that has been put into place. The case is scrutinized and looked into with great depth in order to have external interests be pursued. The final type is entitled *collective case study* and involves the examination of a number of cases jointly. The intention is for a condition or phenomenon to be justified, or opposed, by the observations of these cases.
METHODOLOGY

Introduction

For the Nisbet study, I had chosen a qualitative methodology for several reasons. A fair amount of research has been conducted involving environmental issues in schools (Eames 1992, Dahlberg 2001, Fortner 2001, Hudson 1990, Nuemann 1999). Most of these projects involved implementation at the junior levels of mathematics, or solely in the science classrooms (Delacote 1998, Gibbons 1992, Silver & Stein 1996). Very little research has been devoted to the studying of student reactions towards mathematics specifically when paralleled with global issues at the senior level. Therefore, I had very little on which to base what I was looking for in terms of results. Implementing a rigid structure such as a statistical quantitative survey would only serve to answer a specific question. For this study, I was not searching for answers to precise questions. Instead, I was looking for responses that would increase my view of how the students' global concern through mathematical understanding was affected by the study, and these findings might consequently formulate into questions. A quantitative analysis is not taken, but instead a qualitative collection of student responses was gathered in determining how global understanding had been affected. In essence, I did not know enough to predict an outcome that would allow me to quantitatively measure a final result.

In order to achieve my desired qualitative methodology, I needed to explore the methods of data collection that would best suit the needs of the study. The methods that were available consisted of video, audiotape, written journals, and questionnaires. I have
chosen to use journal books for a variety of reasons. Educators choosing to assess personal written responses to questions or reflective evaluations may choose to use journal books. Prior to the study, journal books were already being used in my math courses. The journal books in my class were meant to bring additional mathematical topics into the classroom. I chose written work in journal books with two major objectives in mind. The first involved the legitimacy of the student responses. Prior to the study, students would be prompted to write in their journal books at least once a week. Since the use of a journal book was already a common practice in these particular Math 12 classes, I believed that I would get genuine responses from the participants. The second factor was the open-ended nature of the journal entry’s written responses by the participants. Students did not have to be shy about writing an opinion as opposed to voicing one in class. Journal prompts, and questions that I gave to be answered by the students were structured to provoke responses and opinions from the pupils.

When deciding on a framework in which to view my analysis, I gravitated towards Glaser and Strauss’ (1967) use of the Constant Comparative Method. I enjoyed its cyclic nature, as opposed to a linear one. I wanted my categories to emerge from the resulting data without me looking specifically for a particular occurrence. The Constant Comparative Method allowed for categories to surface from the data, in which trends could be detected. The method calls for a re-analysis of the categories until saturation, the point at which no new information is present. This re-analysis allowed me to revisit the journal entries from the students under different circumstances, analysing distinctive characteristics. I will review the methods used, including descriptions of why these
methods were suitable for the study. As well, I will elaborate with a detailed description of the study I conducted and the ways in which the methodology was applied.

**Theoretical Framework**

I used categories throughout the study by imposing certain categories myself, and by allowing categories to emerge once the data had been analysed. The categories I imposed did not come directly from the data, but instead were chosen by myself for its possible value towards the study. For example one imposed category chosen was the categorization of students I had never taught before versus students I had. Conversely, I followed the Constant Comparative Method in choosing categories that emerged from the data.

Glaser and Strauss' (1967) Constant Comparative Method is based on the premise of allowing categories to emerge during the study of a group of data. In this respect, the analysis is very flexible to what is occurring or has occurred in the study at its present time. In the study, the stages from the Constant Comparative Method that I have used are:

1. Suggesting initial categories
2. Comparing incidents applicable to each category
3. Comparing and integrating categories and their properties

_Suggesting categories._ The initial phase of the data analysis process included the evaluation of the continuous information being collected. From this broad view of investigation, incidents started to emerge that involved clusters of events occurring within the study. With the apparent realizations, preliminary categories were put forward and the data began to be classified within these groupings. The next phase dealt with the coding
of the data that had been collected, and advises the creating of as many categories as possible. Initial categories are ones the researcher had intended to use as well as categories that emerged during the analysis of the data. Within this study, the researcher used both of these forms of categories.

**Comparing incidents applicable to each category.** A basic defining rule for the Constant Comparative Method is the comparison of previous incidents. Coding an incident for a category with the same or different groups coded in the same category will allow for new compositions to form. The observation of the coding will enable a researcher to develop the patterns, which are emerging from the data. Glaser & Strauss (1967) states, “the analyst starts thinking in terms of the full range of types or continua of the category, its dimensions, the conditions under which it is pronounced or minimized, its major consequences, its relation to other categories, and its other properties” (p.106). The patterns that emerge from the data will guide the outcome of the study.

**Comparing and integrating categories and their properties.** During the categorization of data, incidents are compared with other incidents and grouped accordingly. In this stage, incidents are also compared with properties of the category. For example, I coded which students gave positive feedback in regards to how the mathematics was being introduced, and which gave negative feedback. I noticed that a high proportion of ESL students gave negative feedback. I then recoded the students to see who was ESL and who was not. I imposed this form of coding because of my suspicions of negative ESL responses. Properties of these students in this category surfaced such as their emergent academic standings in the class, and, their expressed
difficulty with the written English language. When these new classifications emerged, the results of the data began to unify.

In the planning of the study, I only needed a skeletal abstract for the type of material I was to present to my students because I knew that their responses were intended to help me shape how and what I was to introduce next. At the beginning of the unit, I knew what types of journal prompts I was going to present, and approximately how I was going to proceed. The journal prompts I had in mind revolved around topics such as population growth, resources, and sustainability. After giving the first journal prompt, I analysed the trends I thought were starting to develop. These trends allowed me to reshape certain further material I was to expose the students to during the rest of the unit, thereby creating new categories. For example, after evaluating the students’ heightened interest in the journals when directly relating the mathematics to the global issues prompt, I began to research more connected prompts for the next entries. The Constant Comparative Method is based on the premise of continually re-looking at the collection of information. I not only re-categorized data after looking at material several times, but I also switched my perspective in how I was looking at the data. For example, the ESL category was imposed after I noticed the emerged ‘Negative feedback’ category was composed of many ESL students. From this new perspective, I was able to re-look at the data identifying emergent categories dealing with the difficulty with the written English as well as the ESL students’ concerns for their academic standings in class. Using the Constant Comparative Method and my personal imposed categorization, the study could be redirected and reshaped according to any interesting findings that materialize.
Emergent and Imposed Categories

When analysing the data of the Nisbet study, categorizations were necessary to examine resulting tendencies. I consider emergent categories to be ones that became categories because of certain repetitions or aspects of interest that arose from the responses of the participants. Some examples of these emergent categories are: negative feedback, Geography students, favourite/most relevant journal prompts, student troubles with written English, concerns of academic standings. Imposed categories are categories that were imposed by myself after the data had been collected. A few examples of these categories are: New or Old student, ESL or not ESL, male or female, current academic standing (classified into A, B, C+, C, C-, F). Categories were made throughout the study by the looking and the re-looking of data, and only those that I found most interesting have I chosen to write about.

The Constant Comparative Method was considered applicable for this study because it is a primary stage in determining how material such as global concerns is to be implemented in a senior mathematics classroom. The categories that started to form could be further examined by redirecting the study during the analysis to justify the hypotheses that were being shaped. Then new categories could be classified, and original data would be re-examined to ensure sound assertions.

A case study had been formed by the selection of only two specific math 12 classes, both having the same teacher, although within this case study, two student case studies were examined. I have chosen to use intrinsic case study for two individual students both enrolled in the Math 12 course. They are not being examined for the
support of a theory, or for specific comparisons to one another. I am studying them for their unique characteristics in the hopes of bringing out a deeper understanding for their individual cases. With intrinsic casework, researchers' intentions are to make interpretations, and to allow for their readers to devise interpretations of their own from the isolated cases.

**Justifications For Methods Chosen**

Through the comparison of the Constant Comparative Method to other methods of data analysis, Glaser & Strauss' method best accommodates to the Nisbet study. Smith (1983) compares Glaser & Strauss' methods to Robert K. Merton's Logico-Deductive theory. In comparing these two qualitative methods, the author points to the present day social science problem that entails the "embarrassing gap between theory and research" (p.35). Glaser attributes the gap to theorists that make conclusions without data, and emphasize the importance of starting with the data, not the theory. Glaser & Strauss recommends that this gap can be avoided if researchers will take their own data and inductively discover the theories that are appropriate to this data. Glaser adds, "this does not preclude the use of well-known social-scientific concepts, but the applicability of these concepts is to be discovered in the process of research. The concepts are not to be imposed on the data before their relevance is ascertained" (p.35). Smith (1983) announces the importance of Glaser & Strauss' strategies when a researcher is studying a new substantive problem in a previously unexplored area. Then he concludes that Glaser & Strauss' methods are most appropriate for the early stages of a research program.
For this study, I preferred to use written work only, as opposed to interviews or video tapings. The advantages of interviews are greater clarity on ambiguous responses due to follow up questioning, a better impression of how the participants are responding to the queries being asked, and the ability to respond to questions being asked by the participant. The advantages of videotape are: the ability to re-look at what occurred in a classroom and the capturing of details in the study from the students and teacher. I did not use these two forms of data collection for two major reasons. First, written responses were more personal because they would not have to be voiced out loud, and therefore more genuine answers were more likely. As well, with such a sizeable group of 51 students personal interviews were not practical.

The second key factor in my decision to collect written work only was in keeping with the legitimacy of the responses. I had used journals in my classes on a regular basis during all the units from the beginning of the semester. Journal books were basically a key-tab, 32-page, three-hole punched booklet that the students were able to keep in their regular math ring binder. I used the journals for many purposes, such as introducing a lesson with a neat and interesting problem to be solved. Journal prompts were out of the ordinary and provoked interest from the students. They dealt with historical mathematical findings, brain puzzler questions, and problem solving issues from a societal, philosophical, and even ethical point of view. Also, the journal books were a way for the students’ to communicate with me. I would prompt them to comment on how they were doing in class and ask for critiques on how I was teaching them. Journals were a regular part of all of my math classes and were therefore nothing out of the ordinary. I felt their
answers would not be biased. If present I did not think apathy would be masked with the intentions of wanting to make a good impression.

**Written vs. Oral Responses**

In the Nisbet study, I have chosen to use written as opposed to oral responses from the participants. Galtung (1967) describes participant exposure to systematic vs. unsystematic responses to the same stimuli. From Galtung’s lens, I have used a formal unstructured setting to prompt written acts with questions involving open-ended responses. Galtung argues that if a stimulus is to be kept constant, a questionnaire method will contain greater validity for consistency than an interview method. In any interview, the questions will change with tones of voice, frames of reference, relationships with the individual, and moods and settings of the location. With this type of data collection, the risk deals with increased flexibility, which can inevitably endanger the desired consistency prerequisite. Galtung summarizes by noting, “with relatively homogenous samples, arguments in favour of the standardization offered by questionnaires are strong” (p.116). When debating responses that are written as opposed to oral, researchers must realize that a study is not confined to interview versus questionnaires. In this study, I used journal prompts that involved giving the same questions on the overhead and noted any oral responses from the participants in my personal journal.

**Open-ended vs. Structured Response Questions**

There are many advantages to using both open-ended and structured response questions. Galtung (1967) outlines the main advantage to structured responses is to
facilitate comparability. If the questions leave little room for differing personal 
comprehensions, the emergence of a common frame of reference will become more 
likely, and therefore comparability will become less biased. From the student’s point of 
view, if a straightforward answer such as a yes or no is prompted, a researcher will very 
easily determine exact results. A precise version of the question will be answered, and 
erroneous responses can be easily identified. If there were ten ‘no’ responses and twenty 
‘yes’ replies, with ‘yes’ being the correct answer, then a data collector can unequivocally 
conclude that one-third of the participants answered the question incorrectly. When 
comparing this type of questioning to open-ended questioning, the major advantage for 
the researcher relies on the freedom it permits. The respondent must find her own frame 
of reference to answer the question, and this self-evaluation can lead to the furthering of 
her motivation causing extensions to the enquiry being asked. Galtung further favours the 
open-ended response when the naturalness, versus artificiality, of the reply was uncertain. 
In short, the greatest benefit to an unstructured question is the flexibility permitted for the 
honest, yet unexpected response.

I specifically wanted to collect information on the student’s knowledge base for 
certain structured questions, such as “how is the human population growing?” However, 
in other instances, I was seeking their opinion to be interpreted in any manner they 
wished. On average, most of the journal prompts given to the students comprised several 
two-part questions. The first part required a particular reply, such as “How is the human 
population growing? (Linearly, exponentially, inversely, etc.) Explain, followed by the 
open-ended query: “What question does this raise for you in terms of the world’s growing 
population?” Explain. The ‘explain’ at the end of each question allowed me to analyse
whether I felt a certain level of comprehension was present in the structured prompt and to allow for greater expansion on a response in the open-ended prompt.

Written work as a source of data collection allowed me to not only read all of the students' writings, but to classify them into categories as well. Using this form of data collection, I was able to use a large population because of the sole use of written work. Collecting only written work allowed me to introduce each journal prompt only twice per day, once for each class, and immediately I would have fifty-four responses by the end of day. This form of data collection was very time efficient not only for the students, but for me as well. Without a videotape of how I introduced each journal prompt, the possibility exists that I may have unknowingly biased their responses or may not taken into account their moods for that day. However, I did keep a journal of my own, and I would write in it immediately following the lessons to record how I did my directions and their responses.

Prof. Susan Pirie, my faculty advisor, examined the categorization of my results, using the Constant Comparative Method. Given the definitions used in the categorization of the data in the Nisbet study, she was able to categorize the data in the same way. As well, a third party was asked to classify the information according to the criteria, and she too remained consistent with the findings. The reliability of the data categorization for the Nisbet study is reinforced through the other coders verifying the fit of my analysis.

The Study

The participants used in the study were two classes of math 12 students varying in mathematical ability and previous mathematical experiences. The study was designed to
teach the Logarithms unit for Principles of Math 12 using journal prompts at the beginning of particular lessons. The journal prompts involved global issues that could be viewed through a mathematical lens. The intention of the study was the examination of whether the students' concerns for the global issues had increased and if the global issues belonged in the math class.

The setting of the study took place in John Nisbet Secondary, where the grade levels ranged from 9-12. The school is in a slightly higher socio-economic area compared with its neighbouring schools. Approximately 65% of senior students enrolled in Principles of Math 12. With 1000 students at Nisbet, the school has an international program and ESL program consisting of 75 students being classified as international and 43 as ESL. The international students identified here are international learners who as well, do not have English as their first language. For the purpose of the Nisbet study, I shall refer to both ESL and International participants as solely ESL students.

The intended audience for this thesis is teachers who want to bring global awareness and mathematical relevance into their senior math classrooms. I hope to outline the strengths of the study so that it can be replicated for other classrooms. As well, I shall profile the variables to be considered that caused an emergence of negative attributes towards aspects of the study.

The Participants

Both of my Principles of Math 12 classes were used in the study, and all students in each class took part. Class one was comprised of 23 students, 13 male and 10 female. Class two had 28 students, 15 male and 13 female. From the 51 participants studied in the
two classes, 32% were classified as ESL. This categorization entails being listed as an ESL or an International student by John Nisbet Secondary. Approximately 30 students from the two classes were previous students of mine in mathematics. Nisbet was on the semester system, and I had used the journal books since the beginning of the first semester. The journals had been a safe place for students to express their ideas and comments to various questions I posed. Journal prompts ranged anywhere from tricky mathematical problems having little to do with our current lesson, to an introduction of a concept used in another discipline, such as logic for the purpose of becoming a lawyer. For the journal prompts, I asked students to make comments on the class, on my teaching, and even on their seating preference. In many ways the journal book is my way to communicate one on one with each of my students. The students know that the journal books are a safe place where they will receive a mark out of 5 just by participating.

I began the design of the study by submitting the proposed thesis topic to UBC’s Ethical Review Board. Once approved, I received signed permission to continue with the study from my school’s administration. Students were assured that their standing in the class would not be affected in any way by their participation or lack thereof, with the study. I explained how students would be assigned identity numbers to maintain confidentiality regardless of whether they participated. I explained that with the use of the identity numbers no person in or out of the classroom would be able to determine their identity. They were asked to bring home consent forms for their parents, requesting that they indicate, by circling, whether or not the student’s work was allowed to be used in the study. The study began on the first day of the Logarithms unit, and continued until the end of the twelve-day unit. All students agreed to participate.
Data Collection

The study took place over a three-week period in the first semester of the school year. Principles of Math 12 is comprised of seven units, and Logarithms was the third unit to be taught. Before each journal was given, I reminded the students to be as honest as possible, and not to worry if they did not know the answer, but only to try to the best of their ability. I reminded them that a journal mark is not given for accuracy, but only for participation. I believe that I gave a generous amount of time to complete each journal entry, approximately 8-10 minutes. The students were on task for every entry and seemed to be taking each very seriously. Once I felt that the majority had finished, I asked that they begin to take their notebooks out preparing to start the lesson. I re-emphasized to those still writing that they would be allowed to continue if they needed more time. Minutes later when it seemed almost everyone was ready to begin with the lesson, I announced that if more time was needed to finish writing the journal, that they would be able to do so at the end of the lesson. My intent for being generous with the time allotment was to ensure no participant was rushed to write content that did not reflect his or her true viewpoints towards the issues. I believe this allowing for time is a crucial point to be made for teachers intending to implement these strategies. The students must be given time for themselves to fully understand what is being presented. As well, this time allotment and self-reflection is necessary if the process is to be worthwhile. Most importantly, the students must accept the value of participating in such an activity, because any negativity towards journaling might compromise the study. I felt that my good relationship with the students would help to avoid this risk.
The Logarithms unit took exactly twelve days to be completed. The last two days comprised review for the test and the test itself. From the actual nine teaching days of the unit, I only gave seven journal prompts, which included the mid-unit, pre and post-unit journal prompts. In my regular teaching practices, I never give journals everyday to my students. I will not give entries on days due to a shortened class period, a quiz that I know would take up a sizeable portion of class time, or a day after a difficult concept was taught. On days when students arrive to class with many questions from the day before, I immediately assess their anxiety and postpone a journal prompt. I have specifically noted these times of withholding a journal prompt because I believe a teacher must be flexible and adapt to the students needs, as well as the unpredictability of a school day.

For every journal prompt I introduced, I would collect the students’ journal books and read them either immediately or in the following days, giving checkmarks or underlining interesting remarks as a reminder to myself. I would not give written feedback, since I did not want to sway the students’ next journal entry response one way or the other. Even the poorly answered or blank responses from participants, I did not comment with the exception of one ESL student who was not doing the entries at all. I approached him the day after one of the lessons reminding him that just by responding to the journal prompts as an exercise, he is given a mark and that all students must do it. He said it was the difficulty of understanding the language that was preventing him from responding.
The Entries

To fully understand what had taken place in the study, the description of the seven entries I gave to the students throughout the unit is necessary. I will outline my reasons for why I felt certain aspects were important for the study.

Journal One (Pre-Unit)

I entitled this first journal prompt as the ‘pre-unit’ prompt. To better understand the time frame for each entry given, I will state which day I introduced each entry. Including only weekdays, the first entry was given on Day 1 of the unit. The pre-unit questions included the following questions:

1. Approximately how many people are on Earth?
2. How is the human population growing? (Linearly, exponentially, inversely, etc.) Explain.
3. What question does this raise for you in terms of the world’s growing population? Explain.
4. What do you see as a strategy to address your question of current human population growth? Explain.
5. Is math related to this subject? Explain.
6. How might math be used to address this question? Explain.

The purpose of the questions was to collect a perspective of the students’ knowledge of basic facts about population, and what the students viewed as the mathematical relationship to the population issue. At the end of the unit when more information was
collected, a change in attitude and understanding by the end of the unit could only be assessed by first knowing where the students were starting.

Journal Two (Water Conservation)

The school had shortened class periods on Day 2, and I did not feel there was enough time to give a journal prompt. I introduced the Water Conservation journal prompt on Day 3 of the unit to the students by posing a scenario that allowed for participation. I started by orally asking the students’ if they knew ‘where the greatest amount of water was wasted in their home?’ Students called out various answers, such as ‘washroom,’ or ‘sink,’ until finally I acknowledged the correct response of the ‘toilet.’ I then described, with a sketch on the white board, how a basic toilet tank operated. I explained that with every flush one drains away ten litres of water in the tank, and five from the bowl making fifteen in total. The numbers may vary a little depending on the type of tank, but it was not critical to my example. I then asked what recommendations are often made for saving water from the toilet. A good response was given immediately in both classes with “put a brick in the tank.” I responded with asking ‘why?’ With no response from the students’, I explained that the toilet tank always fills with water until the valve supplying the water is shut. A clever device made from a lever and a rubber ball is placed in the tank controlling the water’s limit. When a flush takes place, all the water is removed and the ball falls to the bottom of the tank. Since it is hollow, and less dense than water, the ball then floats to the surface as the water fills back in. When the lever attached to the ball reaches a 90-degree angle, the water stops flowing in. Assuming a brick is placed into the tank, less water will be needed to raise the hollow ball back to its
90-degree position because of water displacement. Many of the students seemed to understand this concept quite quickly.

I estimated the volume of a brick to be approximately one litre of water. I prompted the class to estimate how many flushes people use in their households. A common response was five per person. So I used the number five for my example. I then asked the students to figure out how many litres of water would be saved per year from one individual. After a minute, students answered: $5 \times 365 = 1825$. I then explored the question by asking how many people lived in the students’ household. I now asked how much would be saved per house. I moved the question further by asking, how much would be saved in a lifetime. Finally, I asked how much would be saved if a two-litre bottle were used instead of a ‘brick.’

After the students had completed their computations, I posed two questions on the overhead:

1. Is putting a brick in your toilet tank a worthwhile investment?
2. What percentage of your classmates, who are capable, will actually go home and do this? Why?

I orally explained what I meant by investment by asking the class “how long do you think it would take to put a brick or bottle in the toilet tank?” Many answered 5 or 10 minutes, and I clarified that this was the ‘investment’ I was referring to. I expanded on the second question’s reference to ‘who are capable’ by describing how some people may not be in a position to alter their tank, possibly because their parents will not allow them, or that they already have a new smaller tank.
The first question, “Is putting a brick in your toilet tank a worthwhile investment?” was given in order to allow the students to identify whether they believed the effort of taking time to alter a tank was worth the amount of water to be saved. The second question, “What percentage of your classmates, who are capable, do you think will actually go home and do this? Why?” was given as a type of realistic scenario to be considered. The question was to give insight into the human condition of individual responsibility, and societal apathy. This realistic query was intended for the participants to realise why the problems of the world have become so large, even though many solutions were attainable through personal choices.

The water conservation entry served a dual purpose. I wanted the students to see the abundance of water used on an everyday basis given personal habits; as well, I hoped to empower them to help the environment by incorporating educated methods for water reduction. Although quite mathematically basic, I felt the students would be empowered through the use of their math abilities to uncover for themselves how much water was being used with every flush. All the students used a toilet, so it was familiar, and the concept of avoiding waste was nothing new to any educational setting. When I introduced the brick method, or 2L bottle method of water conservation, I felt it necessary for the participants to calculate the savings. As the students multiplied to find the amount of water saved per flush, per day, per year, per person, per lifetime, they would soon realise that they had the ability to make change on an individual level. This realization was a very important aspect driving me to use this journal prompt. Furthermore, this journal prompt was the only one that gave the students an actual immediate solution they personally could participate in towards servicing a current problem.
Journal Three (Population Growth)

By this day, I had already had a chance to read the previous days journal entries written by the students. Journal Three given on Day 5, related to the world’s growing human population. The previous day, Day 4, a lesson on logarithms was taught with no journal prompt given. The lesson taught on Day 4 showed students how to set up word problems dealing with compound interest, population, and growth and decay rates. Mathematically they were shown how to find a missing variable in a question when the variable was in different locations of the equation, such as in the exponent. The journal prompt for the day comprised two questions:

A Harvard study comments that population grows .677% each year. At our current rate of food and land consumption, we can only sustain our way of living, and eating, for an extreme maximum of 7.7 billion people. During which year will this maximum occur?

\[ A = P (1 + \%)^t \]

Is there anything that you personally can do to address this issue? Explain.

I explained to the students that they were not to yell the answer out, but to just write it in their journal to the best of their ability. I gave them the formula we used the day before regarding compound interest, noting that if they did not know how to solve the question, they were to think of the question in terms of the previous day’s formula. The answer to the question was approximately 37 years. This number being within the participants’ lifetime, I had hoped that it would create a more personal connection for all of them. My
intention was for the majority of the students to answer the first question correctly in order to individually comment on the written response query, “Is there anything that you personally can do to address this issue? Explain.” With the newfound realization that sustainability might be impossible in their lifetime, I was leading the students to conclude that the world must reduce the current rate of consumption.

After their journal entries were completed, I asked the students to put them away. I did not want them to write additional notes after other students had made comments. Once I saw that the journal books were put away, students made a few remarks, and I addressed one or two of them before beginning with the day’s lesson.

Journal Four (Density/Quotes)

I distinctly remember the uniqueness of the day I gave this particular journal prompt. It was Day 6, and I did not plan on giving a prompt on this day, nor did I have one ready. At the beginning of the day, I noticed how the lesson for the grade 12’s was a short one, and would not take up the entire class. The day was ideal to have the students’ respond with a journal prompt. During my preparation period, I looked through some resources and was able to put two interesting tidbits together. Unfortunately, they really had little to do with each other. The first was extracted from ‘Facing the Future: Global Issues in the 21st Century.’ Statistics were given on various country populations and areas. The table then gave each country’s population density. For instance: Canada’s population was 29.4 million, and had a land area of 10 000 000 square kilometres. Therefore, Canada had a population density of 2.94. The book gave statistics for Canada, China, the US, Hong Kong, Australia, and Brazil (Chasmer, p.60). I presented the
information to the class by showing them Canada's population and land area on an overhead. I further explained how the statistic was slightly outdated. I did not tell them how to calculate the density, but prompted them to figure out how. I then asked them to find the densities for the other countries; I only gave them, on the overhead projector, the countries population, and area as seen below:

**Table 1: Population Density**

<table>
<thead>
<tr>
<th>Region</th>
<th>Population (000 000)</th>
<th>Area (000 000 km²)</th>
<th>Density (People/km²)</th>
<th>Dense/Sparse</th>
</tr>
</thead>
<tbody>
<tr>
<td>Canada</td>
<td>29.4</td>
<td>10.0</td>
<td>2.94</td>
<td>Sparse</td>
</tr>
<tr>
<td>China</td>
<td>1221.5</td>
<td>9.6</td>
<td></td>
<td></td>
</tr>
<tr>
<td>U. S.</td>
<td>263.3</td>
<td>9.4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hong Kong</td>
<td>5.7</td>
<td>0.001</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Australia</td>
<td>18.1</td>
<td>7.7</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Brazil</td>
<td>161.8</td>
<td>8.5</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

(Source: Statistic from *World Resources, 1996-97*)

(Chasmer, p.60)

The second portion of the journal entry required that the students' in their journals for the following three quotes make comments. The overhead transparency read:

*Comment on the following passages:*

"The 20% of people living in the richer countries consume 86% of the world's resources"
“In 1976 Switzerland was 50 times richer than Mozambique. In 1997 it was 500 times richer.”

“When Gandhi was asked for his views on Western Civilization he replied:
‘I think it would be a good idea.’”

I asked the class to comment on either one or all of the passages. There was no discussion in class afterwards when they had finished writing. We immediately followed into the lesson for the day.

This entry was chosen because of its mathematical component, albeit simplistic. I wanted to keep the journal prompts relevant to a math classroom. With hindsight, I do realize that the first part of the journal prompt lacked connection to the second portion of the prompt.

Journal Five (Mid-Unit Comment)

Day 7 of the unit occurred on a Friday. The students had received two journal prompts over the last two days, and I felt one more on this Friday would be overkill. So, I decided to ask them to comment, for Journal Five, “how they liked/disliked the ways that I was using the journal for this unit.” I told them that their response to this prompt was very important because their entries would help me to shape the rest of the unit and possibly future units. I reminded them to be honest and said that my feelings would not be hurt if they were not enjoying what I was doing.

I collected the journal books that day and brought them home over the weekend to read. Overwhelmingly the response was positive, which helped me in knowing that the
students did not resent what I was doing. Not to say every student enjoyed the journals, but I was relieved that many did. The evaluation of the students’ responses up until this point helped me to develop what I was to give next. The ESL populations of the class made up the majority of the negative feedback. In the Results Chapter, I will address these responses and their possible underlying causes.

Journal Six (Temperature Increase)

Journal six took place on Day 9, a Tuesday. Day 8, the Monday, I taught a lesson with no journal prompt given. The lesson dealt with Arithmetic and Geometric sequences. After the lesson, the students were able to distinguish the difference between a series of numbers that were increasing, or decreasing, arithmetically and geometrically. In addition, they learned to determine exact values of specific terms, and to find the sums of either type of sequences. On Tuesday, I was teaching Infinite Geometric sequences and needed to quickly review the last day’s lesson. The Temperature Increase journal prompt conveniently satisfied the necessary review. With an overhead, I showed the students the following statistics on Global Temperature Change:

Table 2: Global Temperature Change

<table>
<thead>
<tr>
<th>Year</th>
<th>Temperature (°C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1950</td>
<td>14.86</td>
</tr>
<tr>
<td>1955</td>
<td>14.92</td>
</tr>
<tr>
<td>1960</td>
<td>14.98</td>
</tr>
<tr>
<td>1965</td>
<td>14.88</td>
</tr>
<tr>
<td>1970</td>
<td>15.02</td>
</tr>
</tbody>
</table>
Global Temperature Change since 1950
(Source: Goddard Institute for Space Studies, New York, January 1996)
(Chasmer, p.311)

Journal Six prompted the students' to answer three questions:

1. Is the temperature of the world growing arithmetically or geometrically? Why?

2. Which would be worse, if the temperature increased arithmetically or geometrically? Why?

3. It is predicted that the world’s temperature will increase by 3°C over the next 100 years. Is this increase consistent with the data above?

As the questions were given, I orally expanded on the type of answer I was looking for when I prompted the ‘Why?’ after each question. I explained that the ‘why’ was intended for the students to explain why they had answered the first part of each question in the ways that they did. If one was to graph out the points on a grid, which the students were not required to do, both an arithmetic or a geometric sequence could be argued as an
answer. With the numbers starting to rise dramatically over the last ten years, 'geometric growth' may be argued as the better response. The purpose of this first question was not for them to arrive at a correct answer, since it could be argued either way, but instead for them to justify mathematically 'why' they chose the one they did.

A brief discussion ensued in both classes after they had finished writing. The second class had one student doubt that the growing numbers were geometric or arithmetic. Within the Discussion Chapter, I will further explore several answers given by the participants. I sensed that the second class needed some reassuring why I was prompting such questions. Therefore I commented how I wanted the students to see mathematics related to real problems because people will never be able to solve these pending predicaments until we are fully able to understand them.

Journal Seven (Post-Unit Questions)

Day 10 and 11, Wednesday and Thursday’s classes, were used to review for the test on Friday, Day 12. I did not want to give any journal prompts so close to the test. I felt that my students would feel anxious, and may feel resentment towards the journal use. I asked the final journal prompt on Monday, Day 13, at the beginning of the next unit’s lesson. This prompt was the closure to not only the unit, but to how the unit was taught, and consisted of the six questions below:

(Be as truthful as possible)
1. During the last unit, which journal entry did you most enjoy, or find the most relevant? (Population growth, Quotes comments, Temperature increase, Water conservation) Why this one?

2. Would you like to study one of these topics within our math class in more depth, perhaps as a project? Why or why not?

3. Has your view on certain global issues changed since the beginning of this unit? How?

4. Has your view on mathematics changed? How?

5. Comment on the following passage “Even though population growth from developing countries is much greater than first world countries, there is a greater threat to our globe from first world population growth.” Do you agree with this statement? Explain.

6. Do you believe the issues addressed in this unit belong in a math class? Explain.

Additional comments:

The first two questions were intended not only as a source of data collection for this thesis, but also as a resource to be examined for future use of this type of activity, not only for me, but for any mathematics classroom. The third and fourth questions were meant as a type of self-reflection for the students, as well as a survey to establish the effects that the study possessed. The answer to the fifth question I thought would be used as a way of assessing the participants understanding of the various prompts to which I had exposed them throughout the unit. The final question was intended for the students to write their opinion on how they thought of learning math in this way.
My Journal

During the course of the study, I decided to keep a personal journal. This journal helped me to develop my ideas, as well as recording my observations on a daily basis. I thought that during the fast pace of the unit, I would surely forget the details that were occurring with each day’s journal prompts and the student’s reactions to the prompts. I would write entries such as:

Journal # 1 (Class one): introduced questions, took 10-15 minutes to complete, seemed very quiet, (students’) taking it seriously. Started class while one or two finishing (up). (Class two): much the same, Student 22 and 30 took longer to hand in. Some such as Student 40 went back to write more once he saw others were (still writing when he had quickly finished).

I also noted what was said by me, and by the students’, when discussion occurred after the entries. At the end of the school day I would detail my observations as quickly as possible in my personal journal, so I did not forget any of the major or minor, details. This personal journal served not only as a log for the aspects of what went on, but also as a ‘thinking place’ for the significance of what I had done and what I was about to do. On one of the days I decided not to give an entry, I wrote, “I feel they (my math 12 students) are a bit overwhelmed with all the writing in the journal books (we have been doing this week), so I will concentrate more on just the math today.” Statements like these were based from events such as students’ approaching me before class commenting that they did not finish some of their homework. The back of my journal was used to start formulating how I would start writing the thesis. Since the ideas were emerging during
the study, I felt the back of my journal was a great way to get my thoughts organized and recorded immediately.

Analysis of Data

When formulating how I would collect and analyse my data, I initially thought to use written work, through the students' journals, and then personal interviews from students who's written work I found needed clarification. After collecting all of the data, I felt that I was able to generally understand what each student was trying to say. I did not feel any personal interviews would be necessary.

I started the analysis of the data by first reading the pre-unit journal responses. I had an idea for what I would use for several of the journal prompts I planned on presenting to the students. By reading their pre-question responses, I hoped for insight on how to proceed. After one or two entries during the week, I would collect the journal books and read the students' responses. When returning the journal books, I only gave check marks to indicate that I had read them, purposely not wanting to sway answers to the next prompt I was to give. During the unit, I used the Constant Comparative Method to see if trends were starting to form. After accessing data at various stages, I was able to devise the successive journal prompts to be given. At the end of the unit, I analysed the pre and post unit journal prompts together.

The categories that emerged from my analysis were found by a sorting of information from the data throughout the study. From the reading of the students' work, I found diverse comments coming from several ESL pupils. Other students commented on how they were already studying similar topics in Geography class. I used 'Geography
students’ as a category due to its emergence from the data. As well, many students seemed to be favouring the same journal prompts when I evaluated the participants at the end of the unit. So, I chose to create a category ‘Favourite Journal Prompt.’ I used categories that were imposed by myself, and the others that emerged from the data. By the end of the study, I had columns under the following headings: ESL, Not ESL, Geography student, Previous student (of mine), New student (one I had never taught before), Favourite Journal Prompt (with sub-columns: Population Growth, Quotes, Temperature, Water Conservation), Student’s Current Grade (with sub-columns: A, B, C+, C, C-, and F). By forming these categories, I was hoping to strengthen some of my observations and to see if a trend was present that I had not noticed. I took different colour pens, and made a cross comparison searching for different tendencies or possible conclusions. Categories had been formed such as Male/Female, Students with trouble with written English, Students with concern for academic standings. These are examples of categories that were formed, but not expanded upon due to insignificant or uninteresting attributes.

After recording the outcomes I noticed from the cross comparisons, I then reread the students’ journal books, particularly Journal prompt Five, which asked them to comment on whether they would like me to continue with this style of teaching for the unit. The process I was conducting follows in line with the Constant Comparative Method’s continuous analysis of data and further refinement of emerging relationships. From the readings of the pre and post journal prompts, I particularly isolated certain students’ work that I felt was worth writing about. Going back into these participant’s journal books was very useful in gaining added insight into how they felt not only at the
beginning and the end of the unit, but during as well. At this point, conclusions were being formulated, and I felt that rereading student entries would ensure I was not making incorrect presumptions.

Many aspects of the Nisbet study could be focused on. Although, I have narrowed these items to only three because I felt that this study was a prescription for teachers to view if wishing to implement global issues. Knowing this, I felt it would be beneficial to focus on the variables that would ensure the greatest amount of success. I therefore have chosen to look at:

1. Categorization

2. Positive and negative student reactions

3. Case Studies (of two selected participants)
RESULTS

Introduction

The main purpose of the study centred on the analysis of two Math 12 classes determining whether the students' concerns for the presented global issues had increased because of their understanding through a mathematical lens. Equally as important, the students were being surveyed to reveal if the use of global issues was suitable in their Logarithms unit. The study was conducted through written journal work at the beginning of various lessons. During and after the study, the student journal books were collected as data and then synthesized. Three major areas developed from the data that I have chosen to focus on:

1. Categorization
2. Positive and negative student reactions
3. Case Studies (of two selected participants)

The study examined student reactions not only to the daily journal 'awareness' prompts, but more so to the idea of learning mathematics in this way. In the following section, categorization is helpful for a teacher to identify what is surfacing from the study. To evaluate effectiveness of the journal prompts, positive student comments are discussed towards learning mathematics combined with relevant global issues. ESL reactions are examined in light of issues that arose from feedback during the study. These ESL reactions are crucial to understand language and cultural differences in mathematics education. At the end of the unit, students were asked to identify the journal prompt that they found to be most relevant or interesting. Interestingly, the students' seemed to
favour the two entries on ‘Water Conservation’ and ‘Population Growth.’ The analysis of how these prompts were introduced can assist in future effective implementation of global issues. As well, I have used Stake’s (1995) definition of intrinsic case studies to expose the unique findings from two selected participants. From these results, a teacher can better understand the circumstances that may lead to successfully implementing this type of global awareness into the senior math 12 classrooms.

Categorization

Using the Constant Comparative Method, categorization occurred several times during the unit. After Journal One (Pre-Unit), I collected the students’ journals and read all of their responses thoroughly. As suggested in the first stage of the Constant Comparative method, I formed suggested categories after the initial evaluation of the data was conducted. From these reactions, I imposed the following categories:

1. Current academic standing. Each student was placed with an A, B, C+, C, C- status according to their current mark in class. I was curious to see what reactions came from the various high versus low-end math learners.

2. New or old student. The student was either taught math by me before, or they were not. I was uncertain whether my previous teachings would play a role in student attitudes towards what I was doing.

After Journal #5 (Mid-Unit Comment), I collected the journal books and re-examined the new responses. With the newfound tendencies starting to emerge, I added the category:

3. Negative feedback. This category was used to see if clusters of students were forming across categories that did not like the journal prompts.
4. *ESL or not.* The ESL students were identified when language difficulties and criticism of the journals began to emerge. At the end of the unit, I collected the journals a final time to analyse the participants’ work. By evaluating the data as a whole, I was able to add two additional categories:

5. *Favourite/most relevant journal prompts.* Students chose from among the four possible unit related journal prompts (Water conservation, Population growth, Temperature increase, Population density/Quotes). Clusters started to form for which prompts were most favoured. I felt this trend should be closely analysed and compared with the other categories.

6. *Geography students.* Due to several comments regarding overlap of topics covered in Geography, I felt it necessary to determine which participants were experiencing this repetition.

Throughout the collections, during the Logarithms unit, of the journal books to be evaluated, I reshaped how, when, and what prompts I was to proceed with. The comments, attitudes, and responses were providing a non-direct dialogue between the students and myself. This process is consistent with the Constant Comparative Method’s form of data collection, in which new categories form from old ones, and helps to shape further data collection. Throughout this entire process, I kept my own personal journal to record thoughts and ideas. This personal journal helped me to shape what my future prompts were meant to bring about from the students.
Positive and negative student reactions

At the midway point of the two-week study, a journal prompt was given asking the students whether they wanted to continue to learn mathematics with these types of prompts. ‘These types’ referred to provocative journal prompts that require reflection, writing personal opinion, and mathematical calculation. A category was formed dividing the students’ into ‘liking’ versus ‘not liking’ the journal prompts of this unit. To be classified, as ‘liking’ the prompts, positive responses must have been stated such as, “I am really enjoying,” “I like what we are doing,” or “I find this very relevant.” Any form of negative response was considered to be ‘disliking.’ There were a few neutral comments, such as “I do not mind learning in this way,” and comments left blank. These were classified as ‘neutral.’ I chose to itemize the neutral comments in this way because my intention was focused on the reasons why the participants who liked the prompts. Among the fifty-one participants, 33 were classified as ‘liking,’ nine as ‘non-liking,’ and nine as ‘neutral.’ Almost two-thirds of all the students surveyed commented on how they liked the way in which they were learning the mathematics in our Logarithms unit. These positive comments included statements such as Student 1: “It is different but I like it because we can see where everything in the world use(s) math. We can apply the work to our daily lives because it affects our lives in ways I didn’t know.” The majority of the ‘liked’ responses were very similar to Student 1’s. Here I am finding that the global learning is beginning to enhance the mathematics being learned.

Within the course of the Logarithms unit, I was able to observe changing attitudes towards mathematics and global concerns from the participants. The pre-test questions provided me with insights on how much the students knew about the world’s population
and how the students related to mathematics' global issue of population. Through the collection of all the data, I could compare how a particular student’s attitudes had changed over the unit. The post-worksheet prompted questions such as “Has your view on mathematics changed? How?”

Student 12 responded, “Yes, because I learned how to calculate interesting things that I sometimes think about or question.”

Specific attitude changes were observed with the statement “Has your view on certain global issues changed since the beginning of this unit? How?” The majority of the students’ answered ‘yes’ to the latter, and lightly elaborated with statements such as, “I had no idea we could run out of resources one day.” However, the few students who admitted to not having their opinions change always explained why. Student 43 responded “Not really because it would take a lot more in depth explanations and facts for me to be worried or be concerned.” This type of response reinforces my belief that the participants were not shy to write their true opinions, which further strengthens the validity of the data collected. An emergent category could have been formed from Student 43’s comment consisting of categorizing students as either “worried” or “not worried” for the globe after being exposed to the global issues.

Student 38 had very positive comments about the way in which the unit was taught. However, certain responses reveal inherent reservations that she held. Her responses to the Post Unit journal prompt follow:

1. During the last unit, which journal entry did you most enjoy, or find the most relevant? (Population growth, Quotes comments, Temperature increase, Water conservation) Why this one?
Water (conservation) because I like knowing how to save the environment. Quotes (comments) I like seeing other (people's) philosophy on everything.

2. Would you like to study one of these topics within our math class in more depth, perhaps as a project? Why or why not?

   No, because I am studying the same stuff in geography. Gets boring.

3. Has your view on certain global issues changed since the beginning of this unit? How?

   Yes, I didn't realize how out of hand our population, environment, and global issues in general.

4. Has your view on mathematics changed? How?

   Not so much, but now I see WHY we do some stuff. No other teacher tells you WHY we learn what we do! Thanks.

5. Comment on the following passage “Even though population growth from developing countries are much greater than first world countries, there is a greater threat to our globe from first world population growth.” Do you agree with this statement? Explain.

   I agree because the first world is the world that creates pollution, uses all the resources, and makes the money.

6. Do you believe the issues addressed in this unit belong in a math class? Explain.

   Yes, I believe they help understand why and where the math comes from just as long as not too much time is wasted on the topics.

7. Additional comments:

   KEEP UP THE GOOD WORK!
I would classify Student 38 as a person who viewed the unit as a success when logarithms were taught in this way. However, what I would like to address is the statement in response to question 6: "...just as long as not too much time is wasted on the topics." The 'topics' refer to the prompts being introduced at the beginning of the lessons. The word 'wasted' brings on notions that lead me to believe that this student, even though enjoying what was introduced, does not believe this entirely belongs in a math classroom. Further sentiments are shared by other classmates who worry for their marks, such as Student 20 who writes in response to question 4: "My view on Mathematics has not changed because I am still a little intimidated by it. In the future I would have liked to have a better understanding of logarithms including more relevant notes for questions in the booklet."

Student 6 remarks to question 6 by saying, "I believe these issues belong in a science room because science is involved more with global affairs than math is." Student 6's statement almost adheres to the traditional forms of educational practices; and, that is one of compartmentalization - keeping numbers in mathematics, experiments in science, writing in English, and drawings in Art class. With cross-curricular implementations being recommended throughout all subject areas, the attitudes of all the pupils, as can be seen by Student 6, are still not fully positive.

I had classified a 'neutral comment' as one that was either left completely blank, one that commented but gave no real opinion or one in which the respondent stated that they liked and disliked certain aspects of how they were being taught the unit. An example of a neutral comment is evident in Student 11's response to question 6: "Yes and
no because it can be relevant at times, but if you're taking a Geography or Geology class then they talk about it as well." From the Constant Comparative Method's stage involving *integrating categories and their properties*, I combined 'blank' responses as being neutral comments. Only one student gave a 'blank' response. A total of nine students were classified as having a neutral comment.

A negative contingency consisted among the responses, as well as a neutral one. A sub-category involving ESL students had emerged from the negative comments toward the global journal prompts. Participants were categorized as ESL students if John Nisbet Secondary classified them as either ESL or International students. I have classified twelve students as being ESL, and among these only five commented on liking the way the math was being taught. The ESL students' concerns toward the study were very similar in that they had difficulty with the language. Several students commented in their journal prompts that they did not understand the questions due to their limited English or were unsure what was an appropriate way to respond. Student 36 answered the majority of the questions in Journal #8 (Post-Unit) with "?,” because of his lack of understanding of the queries. Question 7 prompts for "Additional comments:" in which Student 36 writes, “I didn't get most the questions in this journal. Sorry, I just didn't get what its mean.” One particular ESL student was not doing any of the entries at all during the first week. When I realized this, I spoke with him reminding him that the journal work was part of the class and a mark was given based solely on participation. He explained that the language was very confusing, and that he did not know what was being asked most of the time. I encouraged him to clarify the questions with me or with a partner.
The cultural aspect of how the ESL students’ previous math education was taught plays an important part in understanding why a negative response emerged from the journal prompts. I feel that it is worth noting that the average final percentage of the ESL students in these Principles of Math 12 classes was 84%, which is above the class average of 74%. From their cultural backgrounds, I know that grades are a very important aspect when judging success in school. For these students’, the anxiety felt may have resulted from the open-ended nature of the journal prompts or the ambiguity of what was considered an adequate ‘answer.’ By knowing many of the ESL students’ personally, I felt that some individuals would have preferred to leave a blank answer as opposed to a possible wrong one.

The other emergent sub-category of negative respondents involves three non-ESL students from the math classes. The first respondent, Student 29, being a ‘C’ student specifically remarked on his apprehensions with math and specifically logarithms. When asked in the Mid-unit Journal Five to comment on what he thought of the way I was using the journals and teaching the unit, he says, "For the last couple of days we started three different (topics), which is confusing. When I start understanding the logarithms you give us graphing and compound interests, which is a lot in 2 or 3 days. I think we should spend more time reviewing." Interestingly this student does not comment on the use of the journal, nor the global issues. He is only deeply concerned with the time constraints of the course. Another participant, Student 20, being categorized as neutral, comments much in the same way. He is quoted as saying that he likes the way in which the math is being taught, but dislikes the journals in the sense that he is weak in the subject and can use the time towards more mathematical review. The second respondent,
Student 34, a high ‘B’ student comments to the mid-unit journal: “I have no problem with the subjects, but I don’t like doing all of the writing.” The third non-ESL student classified in not liking the new method of learning had comments in relation to his positive previous experiences with the use of the journal. I had taught him math since his grade ten year, and the journal was used in the grade ten as well as the grade eleven course. However, the journal prompts in these past courses were presented in more of a fun thought provoking, mind-puzzling manner. Students were proud when they were able to solve the tricky questions and very eager to hear the solutions to questions unanswered by the class. This third learner, Student 19, states in his response how he enjoyed the journal use in the previous way, “but I don’t know where you are going with (this new way).” I take this response to be negative because he contrasts the current journal prompts to his past positive experiences with the journals.

Case Studies

Using Stake’s (1995) definition of intrinsic case study, I have chosen to examine two cases from the study. They have not been chosen because they are samples representative of the majority, nor were they selected in order to support a generalized theory. These two cases may in fact do the latter. However, I have chosen these student reactions because their responses are of interest and can be seen to hold intrinsic value. The first participant is Student 48 who is ESL. From the beginning to the end of the unit, a change takes place in the values discovered not only in what is being taught, but also in how the methods of the study are teaching her. The second case study involves a non-ESL participant, Student 44, who is very good at mathematics and was already very
globally aware before the unit started. Though, I do not believe she was challenged by the journal prompts presented to her. Even though she enjoyed the prompts, and comments on their continuation, I believe she is sceptical towards the ‘global issues’ place in the senior math class.

**Case One: Student 48**

Among my fifty-one students, twelve were classified as being ESL. From the remaining forty-nine participants, forty-three enjoyed the global journal prompts, making 88% of non-ESL participants in favour. Five of the twelve, 42%, ESL students commented positively on the global issues. I think Student 48 is unique, even amongst her other ESL classmates who liked the use of the journal books, because of how she reacted and how her attitude changed from the beginning of the unit. The following is a summary of Student 48’s responses to the journal prompts for the Logarithms unit. Certain journal entries were deemed irrelevant and therefore are not included. The following journal entries were chosen to show evidence for changes in thinking.

**Journal One (Pre-Unit)**

1. Approximately how many people are on Earth?
   
   35 000 000 000

2. How is the human population growing? Linearly, exponentially, inversely, etc.

   *Linearly.*

   Explain.
Because the population is rich and strong and safe countries are getting smaller. The Population of poor and dangerous countries are not growing. Because many people are killed and many women are making children. (sic)

3. What question does this raise for you in terms of the world’s growing population?

   How many people want to get their children?

   Explain.

4. What do you see as a strategy to address your question of current human population growth?

   Explain.

   I think many women want to work. So it's getting smaller.

5. Is math related to this subject?

   Explain.

   No. I don’t think so because math always needs exact answers.

6. How might math be used to address this question?

   Explain.

   Graphing.

Journal Two (Water Conservation)

As described in the Methodology, this journal prompt consisted of the teacher describing how placing a brick or a 2L bottle into the toilet tank could save a large amount of water. After the students calculated how much could be saved per day, year, lifetime, they were then prompted to answer the following. Student 48’s responses follow:
1. Do you think this (altering your toilet tank) is a worthwhile investment?

*I don't think so. Because this is a really important things for us and for earth.*

2. What percentage of your classmates, that are capable, do you think will go home and do this alteration?

*5%. Because most of us don’t want to open the tank of toilet.*

Journal Three (Population Growth)

A Harvard study comments that population grows .677% each year. At our current rate of food and land consumption, we can only sustain our way of living and eating for an extreme maximum of 7.7 billion people. During which year will this maximum occur?

\[
A = P (1 + \%p)^t
\]

\[
A = P (1 + 0.00677)^t
\]

\[
7 = 6 (1 + .000677)^t
\]

\[
\log 1.2283 = t \log 1.00677
\]

\[
t = 36.97 \quad 37 \text{ years}
\]

Is there anything that you personally can do to address this issue? Explain.

*I think the only thing we can do is to collect money from rich countries and rich people and share it with all people who live in this world.*

Journal Five (Mid-unit)

Students were asked to comment on what they thought of the way the unit has been taught so far and how the journals have been used? (They were told that their comments
might reflect how the rest of the unit would be taught and how the units following might be taught.

*These journals are good for our knowledge of society. While studying math, we can think about the world problems, too.*

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**Journal Seven (Post Unit)**

(Be as truthful as possible)

1. During the last unit, which journal prompt did you most enjoy or find the most relevant? (Population growth, Quotes comments, Temperature increase, Water conservation) Why this one?

   *Temperature. Because I was thinking about the temperature with math. Like Arithmetic or geometric.*

2. Would you like to study one of these topics within our math class in more depth, perhaps as a project? Why or why not?

   *Yes. I want. Because I think those topics are good for us. We need to think about those things.*

3. Has your view on certain global issues changed since the beginning of this unit? How?

   *My view was changed. Because when I see the graph. I can think about how will it go after.*

4. Has your view on mathematics changed? How?

   *My view of mathematics was changed, too. I thought “math is difficult and not important,” but now I found math is really useful.*
5. Comment on the following passage “Even though population growth from developing countries is much greater than first world countries, there is a greater threat to our globe from first world population growth.” Do you agree with this statement? Explain.

I agree with this. Because developing countries can't do much work like first world countries.

6. Do you believe the issues addressed in this unit belong in a math class? Explain.

I believe so. Good for us is good for everything. That means good for math.

7. Additional comments:

From the logarithm studies. I have learned lots of stuff and those are really useful for my life I think I can calculate lots of things by myself now.

When viewing this ESL student’s comments, it is apparent that some interpretation mistakes have been made in the translation of the questions, such as Post Worksheet question 5. I do not want to address the semantics of the questions that were clearly misunderstood. Instead, I hope to see the understanding of the whole through the changing responses of what has been displayed here from the start of the unit. I shall begin with Journal One (Pre-Unit). Student 48’s estimation of the world’s population is quite inaccurate, and she makes an additional mistake in how the population grows by not answering exponentially. In questions two, three, and four, she makes consistent assumptions of human population problems being associated to women and the numerical consideration of the children they conceive. In question five, Student 48 states that she does not think math is related to the subject of human population “because math always
needs exact answer(s).” When looking back at the previous questions, with her answers, one could speculate that she perceives the responses to the queries to be open-ended based on personal opinion. In her view, math could not be related to open-ended written questions because of mathematics need for ‘exact answers.’

Within Journals Three, Four, and Five, I find Student 48 to be very receptive to the journal prompts, as compared to the other ESL learners within the class. She does not give one word or short sentence answers, and she uses words such as “I think,” which allows her to further her personal opinions. These words, for me, are an indication that she not only comprehends the prompts, but is also participating in an engaging fashion. To further this, Cai’s (1996) research on mathematical communication outlines the need for prompts asking for expansions on mathematical tasks. The use of personal opinions can be seen as the true measure of whether a student understands not only the mathematical question at hand, but also the context in which it is being used. In Journal #2, I believe Student 48 misunderstood the first part of the question, which prompted whether she thought altering a toilet tank to save water was a worthwhile investment. She responded to the question by saying “I don’t think so,” but then follows with “this is a really important thing for us and for earth.” I assume that she intended to say ‘I do think so,’ but perhaps misunderstood the initial question. She identifies only 5% of her classmates as being non-passive enough to implement the endeavour. I believe an identification of society’s battle with apathy has surfaced for Student 48. In Journal #6, she responds to the use of the journal prompts in this unit with, “These journals are good for our knowledge of society. While studying math, we can think about the world problems too.” She uses the word ‘our’ implying the prompts benefit others too. In the
post-unit journal, she comments on question two’s query of the global topics belonging in
the math class with “...I think those topics are good for us. We need to think about those
things.” Once again, she refers to ‘us’ and ‘we’ possibly meaning her classmates, all
students, or even all society. Regardless, she sees the necessity for more than her
individual purpose. I feel that these journal prompts show that Student 48 has become
more globally aware.

What I find most interesting with Student 48 is her change in opinion by the end
of the unit. Just like many other students whose views changed, regardless of being ESL,
I feel that their previous math lessons were not giving them a strong enough reason to
connect with why they ‘should’ learn their math topics. Using word problems dealing
with compound interest, ski slopes, or speeding trains is the extent to which many math
teachers have implemented practical topics into their classrooms. Bernardo (2001)
conducted experiments with high school students with the intention of promoting
analogical transfer of word problems. The strategy involved the pupils devising their own
word problems allowing the learners to more actively explore the underlying
mathematics. In Bernardo’s study, the word problems used in math classes and the
methods in which students are taught were geared more towards the solving of
mathematics, rather than answering of the realistic problem. The greatest problem with
these so called ‘relevant’ questions is that many students do not find compound interest
or slopes of ski hills applicable to their personal lives.

By repeatedly reading Student 48’s journal entries for the Logarithms unit, I feel a
sense of enlightenment has occurred in this student’s learning. From her previous
experience in math education, I do not think a personal connection was commonly made
about why she was learning mathematics or how it related to something more meaningful. Her post-unit responses were so overwhelmingly positive that a change in attitude occurred over the course of the unit. In Journal Seven, question six prompts, “Do you believe the issues addressed in this unit belong in a math class? Explain.” She answers, “I believe so. Good for us is good for everything. That means good for math.” I interpret her response to mean that the topics are important for the students to study. This studying of the topics in turn will create a good outcome as people become more globally aware and possibly become more involved. This ‘good for math’ involvement will come back around in a cyclic effect by having more people understanding the subject’s importance, thereby creating greater interest in students furthering their mathematical abilities.

Case Two: Student 44

Student 44 can best be described as a non-ESL, high achieving student in mathematics. However, aside from being very academically adept, she is also already environmentally conscious. Student 44 participates with the school’s Global Awareness Club and has volunteered in the community. Her responses to the unit’s journal prompts were to be expected in some scenarios, but were surprising in others. In my opinion, she does not represent the common student in the study because of her above average interest in global issues. Her opinions are of great value to the study because she is already concerned with the global issues. Her opinions on the global topic’s place in a mathematics classroom will not be prejudiced, as opposed to another student who wants to learn more about the issues in place of the math. If she believes that the issues do or do
not belong in the math classroom, I must explore Student 44’s unique reasons for
thinking so.

Journal One (Pre-Unit)

1. Approximately how many people are on Earth?
   
   6 Million

2. How is the human population growing? Linearly, exponentially, inversely, etc.
   Explain.

   Exponentially, because at the moment we don’t really have any major factors
   controlling our growth.

3. What question does this raise for you in terms of the world’s growing population?
   Explain.

   Can we continue growing exponentially or will other factors begin to control our
growth, such as resources.

4. What do you see as a strategy to address your question of current human
   population growth? Explain.

   Figuring out the total maximum number of people that can survive on the amount
   of land and resources the earth has available.

5. Is math related to this subject? Explain.

   Math is related, because using it we can determine relatively what the population
   will be after a period of time.

6. How might math be used to address this question? Explain.
By calculating the total number of people that could survive on this planet, using that you could determine when the population would no longer continue at an exponential rate.

Journal Two (Water Conservation)
As described in the Methodology, this journal prompt consisted of the teacher describing how many litres of water could be saved by placing a brick or a 2L bottle into the toilet tank. After the students' calculated how much could be saved per day, year, lifetime, they were then prompted to answer the following. Student 48's responses follow:

1. Do you think this (altering your toilet tank) is a worthwhile investment?
   Yes, I think this is a worthwhile investment of time.

2. What percentage of your classmates, who are capable, do you think will go home and do this alteration?
   Maybe 15% because most of my classmates will forget the minute they walk out of class. They are also lazy and probably won't want to put in the effort.

Journal Three (Population Growth)
A Harvard study comments that population grows .677% each year. At our current rate of food and land consumption, we can only sustain our way of living, and eating, for an extreme maximum of 7.7 billion people. During which year will this maximum occur?

\[ A = P \left(1 + \frac{\%}{100}\right)^t \]

\[ A = P \left(1 + 0.00677\right)^t \]

\[ 7 = 6 \left(1 + 0.00677\right)^t \]
\[ \log\left(\frac{7.7}{6}\right) = t \log 1.00677 \]
\[ \log \left(\frac{7.7}{6}\right) = t \quad t = 36.973 \]
\[ \log 1.00677 \quad t \approx 37 \]

Is there anything that you personally can do to address this issue? Explain.

One way to solve this problem is to teach people to consume less, that way our resources will last longer. Also, policies like what China has put into place can be done worldwide. Only allowing couples to have one child. Personally I could use fewer resources, which would mean there would be more resources for future generations.

Journal Four (Population Density/Quotes)

Statistics were given to students to calculate population density and identify sparseness.

The following passages were then given for students to then comment on one or all of them.

Comment on the following passages:

“The 20% of people living in the richer countries consume 86% of the world’s resources”

“In 1976 Switzerland was 50 times richer than Mozambique. In 1997 it was 500 times richer.”

“When Gandhi was asked for his views on Western Civilization he replied:

‘I think it would be a good idea’”
People in Western countries consume the most of the world’s resources and live the most comfortably. Ghandi is saying, “I think it would be a good idea”, means it would be nice to be able to consume that much without thought.

Journal Five (Mid-Unit)

Students’ were asked to comment on what they thought of the way the unit has been taught so far and how the journals have been used? (They were told that their comments might reflect how the rest of the unit would be taught and how the units following might be taught.

I have enjoyed the way you have taught the unit. It is a good break from normal math that gives us a good chance to think about things in life, rather than just math.

Journal Six (Temperature Growth)

A table of data was shown outlining the world’s temperatures from 1950 to 1995. Students’ were asked to respond to the following questions:

1. Are the temperatures increasing arithmetically or geometrically? Explain.
   
   It appears to be increasing arithmetically, because there are such small increases or decreases.

2. Would it be worse for our world if the temperature were increasing arithmetically or geometrically? Explain.

   It would be worse for the environment if it were increasing geometrically because it would increase at a much faster rate.
3. It is predicted that the world’s temperature will increase by 3°C over the next 100 years. Is this consistent with the data above?

_This is not exactly consistent with what I believed._

Journal Seven (Post Unit)

(Be as truthful as possible)

1. During the last unit, which journal prompt did you most enjoy, or find the most relevant? (Population growth, Quotes comments, Temperature increase, Water conservation) Why this one?

_Population growth. It was neat to be able to calculate what our future population will be._

2. Would you like to study one of these topics within our math class in more depth, perhaps as a project? Why or why not?

_Not really. I would rather spend more time doing new stuff, or more math related topics._

3. Has your view on certain global issues changed since the beginning of this unit?

_How?

_Not particularly, I have always been fairly environmentally aware. I think it might have opened other people’s eyes though._

4. Has your view on mathematics changed? How?

_I have realised that it is more than just numbers. It is good to see how it actually relates to life._
5. Comment on the following passage “Even though population growth from developing countries is much greater than first world countries, there is a greater threat to our globe from first world population growth.” Do you agree with this statement? Explain.

Mostly I think yes. At the moment first world countries are making much more of a global impact with things like pollution, but if third world countries develop a lot more, they will become as much or more of a problem.

6. Do you believe the issues addressed in this unit belong in a math class? Explain.

Yes, I think that it is good to look at issues in all classes, and to see how many subjects can interrelate to solve the problem, or come up with the problem in the first place. I really like learning that there is a point to this math and it is not just something that I am learning “just because,” it actually has relevancy for things in life.

7. Additional comments: (Left blank)

When analyzing Student 44 at the beginning of the unit, I could see that she was familiar with the issues presented. She made a mistake noting that there were 6 million instead of 6 billion people, and she clearly did not see the humour in Ghandi’s whimsical quote, but her other replies were quite educated towards the issues. The types of answers she was providing, at the beginning of the unit were responses I would hope for from students at the end of successfully learning about mathematically related global studies.

From a researcher’s perspective Student 44’s responses raise questions on whether these global issues really do belong in the mathematics classroom. In the Mid-
unit Journal Five when responding to the way the unit had been taught up until then, she says “it (the journal issues) is a good break from normal math that gives us a good chance to think about things in life, rather than just math.” Inherently she seems to be implying that “things in life” are not things in “math”. I am curious to know what she would deem as not “normal math,” and whether this abnormal math should be taught in the math class. This ambiguity in Student 44’s written response could have been cleared if interviewing was used in the study. This issue becomes clearer in the Post-Unit Journal Seven, with question 2 asking if she would like to study these (global issue) topics in more depth in the math class. Her negative response comment “I would rather spend more time doing new stuff, or more math related topics” sends a clearer message that more pressing topics could be studied.

I felt that there was little doubt that Student 44 enjoyed the global journal prompts. Though if one were to ‘read between the lines’ of what she had to say in regards to the entries, I think she was expressing that if a teacher had only a small section of time to devote to an additional teaching of mathematics, then the teacher should pick topics ‘more’ math related, than the math used in the Nisbet study. I conclude that Student 44 would offer this opinion because the mathematics related to the global topics was not very challenging. Perhaps to satisfy Student 44, the same issues could be presented with more complex mathematics applied. Allowing for more complex mathematics to be introduced of course would require more time, which reinforces the ‘lack of time’ dilemma.

Student 44 can be classified as a person who is concerned with global issues. So any doubt of whether she is interested in the topics can be eliminated. The possibility
exists that Student 44 knows all she would like to about these global issues, or that she prefers to pursue more knowledge in a different setting. What I am concerned with is the possibility that a student who is concerned with global issues, and identifies its connection to mathematics, does not believe that it has a place in the senior math classroom. Perhaps mathematically the issues are not challenging enough to warrant a place in a Principles of Math 12 course. Or, maybe, the students have been subconsciously influenced to believe that topics such as these should stay in Social Studies. Whatever the case may be, further research and discussion are necessary to uncover all the variables in the Nisbet study's results.
DISCUSSION

General Reactions by the students

The majority of the participants in the study enjoyed the global issues presented through the journals. Reactions to the journals varied, but the majority of responses favored the process and the relevancy of the topics being introduced. Some commented on how the journal’s use was an enjoyable break from the usual routine of traditional mathematics, while others felt the importance lay within the topics. Since much of the subject matter, such as increases in population and global temperatures, affected all of the students’ lives, participants noted that learning about these issues was essential. During the midway point of the unit, only 9 out of 51 students said that they did not enjoy the way in which the unit was being taught and did not want to continue in that way. Six of the nine participants with reservations towards the journal prompts were ESL, and many of these people commented on their inability to interpret the tasks being required. As well, in other comments, struggling and anxious students expressed concerns about the Logarithms unit.

The underlying purpose of the study was to empower global awareness through mathematics and vice versa. From my experience as a senior math teacher, a lack of relevance and a sense of disconnectedness from the ‘real world’ are often experienced by students when learning in a course such as Principles of Mathematics 12. The mathematics is at a challenging degree of difficulty, and little time is allotted for applications. In today’s definition, a ‘good’ student would be evaluated based on percentages from prescribed tests rather than on ingenuity. For success in a math class,
rote memorization, and the ability to repeat what is taught seem to be the essential requirements. For me the question becomes, ‘What are educators preparing this next generation for?’ What types of problem solvers will students be and what type of problems have teachers introduced them to? Most importantly, what will students feel they are responsible for as citizens? Questions of this nature have a place in every subject area and should be addressed by curriculum designers, administrators, and teachers.

Analysis

The use of the Constant Comparative Method for analysing the data proved to be a suitable method for categorizing the participants’ responses. This method allowed for coding and analyzing data, as well as for reinterpreting comments as new information became available. This aspect of the analysis of data was necessary since additional statements allowed for a reclassification of students into certain categories.

Journal writing for learners has been promoted by many researchers to further assessment, student understanding, and self-reflection for many years (Countryman, 1992, Dusterhoff, 1995, Elliott, 1996, Mayer & Hillman, 1996, Norwood & Carter, 1994). For several reasons, I have used journals to be the key component for data collection, as opposed to other forms. First, journals allowed me the flexibility to use open-ended prompts, precise answered questions and personal comments. All data was immediately recorded by the students’, in the written journals, and organized by lesson in which I gave the prompt. As well, I felt the students’ were given the opportunity to be honest, and to offer their thoughts and opinions during the writing process. Lastly, the use of the journals was already a common practice within my classroom.
Connections the students' identified

Schools are presenting global issues to their students, but the students are not connecting with the issues. Barnett (1970) concludes in a study, involving participants' opinions of their roles in studying overpopulation, that while a majority of people feel that there is a population problem, very few relate the problem to their own personal family size. The Nisbet study’s findings in Journal Two (Water Conservation) parallel Barnett’s study. After the pupil’s learned to save water by altering their toilet tank, they were prompted to estimate how many in their class would actually partake in this endeavour. Almost every student surveyed provided a low estimate to the question, “What percentage of your classmates, that are capable, do you think will go home and do this alteration?” All the students replied with figures under 30%, and the majority under 15%. Their reasons for low response were mainly apathy, laziness and forgetfulness. Although not asked, no students’ reply noted that they would embark themselves upon the undertaking.

In Journal Six, the students’ were shown the world’s temperature change over the last fifty years. Then they were instructed to determine from the data whether the temperature was increasing arithmetically or geometrically. Since both answers could be argued, no precise answer was correct. The prompt was used to assess the reasons for their choices. Among the 51 participants, many students identified that the numbers were growing geometrically. To have the students understand the implications of the prompt, the teacher announced a 1% increase in the world’s temperature change could cause traumatic effects to the environment. For future implications, the last question in the journal prompt states “that the world’s temperature will increase by 3°C over the next
100 years. Is this consistent with the data." Little discussion occurred in both math classes, but I feel this particular journal prompt has the most potential to be effective in linking the learned mathematics, to a global concern. Furthermore, of all the journal prompts, I believe Journal Six, involving temperature change, would use class time most efficiently.

Teachers are trying to introduce global topics that will cause students to become more aware and hopefully more involved. Dahlberg (2001) advocates the teaching of climate change as an opportunity to empower students to take individual action on this rising problem. In his opinion, Dahlberg notes that classrooms are an excellent place to discuss topics such as bifurcation and chaotic systems. By teaching this relevant topic, students will be given the opportunity to make choices in their lives expanding their global understanding of climate change. As large as the predicament may seem, small contributions to the problem can cause substantial effects that may not be apparent initially. In my opinion, I find that society provides many suggested alternatives as to ‘how’ people can live with a globally aware lifestyle, but not enough educated understanding exists of ‘why’ a single person can be effective on a global level.

In the Nisbet study, one of the ‘A’ students in the course arrived at an incorrect response due to her understanding of mathematics. Worth noting is Student 45’s response to Journal Six’s first question prompting if the temperatures were increasing arithmetically or geometrically. Incorrectly reasoning with arithmetic, responding that in the last day’s lesson the teacher had instructed the students’ to check a geometric sequence through its ratio. This ratio is calculated by dividing any number in the sequence, excluding the first, by the number before it. If this division were done again
with any other number in the sequence, and its predecessor, a geometric sequence can be concluded if the ratios matched. The temperature values in the data were not meant to precisely model an arithmetic or a geometric sequence since the numbers were real, as opposed to a precise textbook examples. Student 45 is a typical ‘A’ student who scores in the top ten percent of tests and always does her homework. Of interest is how such an academic student has applied what was taught in class and how her precision led her to an incorrect reason for her decision. In regards to education, I believe schools are criticized when successful students cannot carry their achievements into the real world. Perhaps a shortcoming is in not integrating practical scenarios as a conventional routine within the mathematics classroom.

There exists an inconsistency with the math problems students are able to solve in the classroom when these same problems are brought out into a real scenario. Gerofsky (1996) reveals that students who were efficient mathematical problem-solvers in “real-life” (i.e. Life outside of school) were not necessarily able to solve pencil and paper word problems in school even though the questions appeared to be quite similar to the “real-life” ones. Furthermore, Christiansen (1997) brings in the notions of ‘actual reality’ contexts in mathematics, involving conventions of everyday practices, versus ‘virtual reality,’ which adheres to contexts within school mathematics. In general, mathematics with a “real-life” problem is given with a notion that the problem is understood prior to the mathematical question being taught. In the Nisbet study, the mathematics was taught before the “real-life” problem was introduced. This introduction could be seen in the Population Growth journal prompt where the students’ prior lesson on logarithms was used to calculate how long before the world’s population overtook its resources. The
major difference in the way the Nisbet study exposed the students to mathematics was the open-ended questioning given with certain journal entries. After the learner had determined the length of time that the population would overtake the resources, they were then asked if this raised any questions for them. This new open-ended style of questioning in mathematics merges Christiansen’s ‘actual reality’ with the ‘virtual reality.’ Because of this, the mathematical activity now entails more than just a “real-life” problem, when students’ emerge with “real-life” questions.

The journal responses of two participants were selected as case studies for analysis in more depth. The first, Student 48 an ESL participant changed her opinion towards mathematics and the global issues from the beginning of the unit to the end. By examining her reactions to the prompts, a better understanding of why her views were transformed is possible.

At the beginning of the unit, Student 48 clearly conveyed her sentiments of math not being related to global issues, specifically human population growth. Generally she reasoned that mathematics dealt with exact answers. The opinion based questions within the first journal prompt perhaps led her the belief that math was not related to the subject of global issues. For many ESL students, both a language and cultural barriers exists to the way they learn math in western society. Currently, in countries such as China, math specialists are used to teach pupils at a very young age. This specialization enables a great deal of traditional algebraic mathematical learning to take place. This teaching at a young age accounts for why many North American teachers feel that their Asian ESL students are often further ahead of their fellow classmates. Cultural components are also factored into certain ESL learners need to receive A’s or to be at the top of the class. In
the Nisbet study, I speculated that the ESL students disliked the global issue journal prompts because of the language barrier and the open-ended nature of a response in English. This in turn may have lead to anxiety towards their academic status due to the marking, yet minimal, component of the journal books.

At the end of the unit, Student 48’s transformation indicated success of the Nisbet project. She comments on how she enjoyed not only the unit, but also the relevance of ‘why’ she learned mathematics. Here the reasons for her transformation in making the jump to ‘relevance’ must be examined closely in order to adapt this study to include a positive experience for all ESL participants. Student 48 found the Temperature Increase journal prompt to be the most relevant. A few of the non-ESL participants in the study commented on how they enjoyed the journal books and what was presented, because they perceived it to be a ‘break’ from the math. However, Student 48 found enjoyment in making a direct connection to the math, thereby enhancing its relevance. Relevance will enhance ESL involvement. First, and foremost, ESL learners must understand the prompt. Promoting understanding may entail additional time for translators to be used or may involve partnering of pupils to explain questions to one another. Second, prompts must be connected to the previous days lessons, such as Journal Three (Water Conservation) or Journal Six (Temperature Increase). Connections will ensure greater relevance to not only the math, but to the rationale for the activity in the writing journal. Since the math used to answer the initial prompted questions was taught the day prior, a student would clearly see the reason for the question the following day. Therefore, the related open-ended question that followed seemed more relevant to ESL students when direct links were presented. Finally, ESL learners’ responses within their journal books
were valuable. The concerns of all students who experience difficulty in understanding or responding to prompts must be addressed. Accordingly, instructors must amend their practices for full participation from ESL learners to ensue.

The other case study with interesting insights on mathematics involved Student 44, a person who was already quite globally aware. Referring back to her journal book, Journal Three prompted students to calculate when human population would overtake available resources, given the current rate of consumption. A following question asked, ‘is there anything that you personally can do to address this issue? Explain.’ While other pupils were making suggestions that researchers devise ways of increasing resource production or limiting population growth, Student 44 made the connection that society must reduce the current rate of consumption.

After more data on Student 44 had been collected, her opinions became more controversial. Some of them implied that better use of extra time in math should be devoted to “more math related topics.” If the question remains that a global issue is not a very ‘math related topic,’ then perhaps the purposes for educating learners in mathematics must be examined to determine how to better convey the goals of math. Is the intention to better understand mathematics in and of itself, is it to develop the mind, or to apply concepts to mathematical occupations such as engineering. What entails mathematical literacy? To function in society do students need to be mathematically literate? Must people be mathematically literate? These answers to these questions should be agreed upon before designing mathematical practices in schools.

One could view Student 44 as a high achieving mathematics student who is interested in global issues yet would rather study more curriculum specific topics. When
looking for reasons why such a student would not want to further explore global issues in
the math class, perhaps educators should debate whether these topics belong in the senior
math class.

Re-evaluating Curriculum Design

The Principles of Math 12 IRP, produced by the Ministry of BC, is comprised of
two basic components: Prescribed Learning Outcomes (PLO) and Suggested Instructional
Strategies (SIS). When searching for a curriculum that even remotely resembles ‘global
issues,’ very little is suggested. Under ‘Patterns and Relations,’ the SIS quotes, “Many
real-world problems (e.g., in navigation, engineering, surveying, chemistry) require the
application of exponential, logarithmic, or trigonometric equations... Present examples
illustrate the need for radian measure when modelling real-world situations”(p.178).
From the entire Principles of Math 12 Curriculum, this section was the only place where
even a remote connection was made involving logarithms and real-world situations. As
can be seen, the connection is far from constructive. With respect to “Series and
Sequences,” the SIS suggests, “Have students find examples and describe the type of
pattern of geometric sequences and series occurring in real-world tools and scales (e.g.,
the f-stops on a camera lens, rule of five).... Encourage students to use a variety of media
and to refer to a range of real-life examples to show patterns (e.g., in history, fine arts,
science, economics)” (p.176). Clearly the Nisbet topics and the way they were presented
fall under the IRP sphere of recommendations, but the vagueness of the IRP is a poor
compass to direct an educator. The applications the ministry recommends seem extremely
linear (i.e. Direct applications to the mathematics with numbers that will fall in place
accordingly). Referring back to the journal prompts, the Temperature Increase journal prompt used numbers that were not perfectly geometric, but the implications were more far reaching for the participants than f-stops on a camera lens.

Evidently the Principles of Math 12 Curriculum makers have not incorporated global issues in the IRP. Possible reasons may include time constraints, lack of resources, lack of instructor knowledge about the global topics, or simply a low priority topic. Whatever the case may be, teachers will not implement global topics into their senior class without the proper instructional strategies or resources. Until curriculum makers put value on the idea of teaching global responsibility through a mathematical lens, and until documents are produced to provide teachers with the necessities for implementation, I cannot envision successful education of global responsibility at this senior level in the mathematics class.

Analysing Concerns/Advice to Teachers

Even though the majority of the students liked and found greater relevance with the mathematics being taught under the global issues umbrella, some students expressed concerns about 'better use of time.' Referring back to the participants, Student 50 who enjoyed the prompts responded to the post-unit question, “Do you believe the issues addressed in this unit belong in a math class?” with “Yes, I believe it does, but not if it takes up too much time.” The fact remains that ‘time’ is an issue for Student 50, and the value put on the issues is less than that of the regular mathematics. Curriculum designers and teachers alike can both see the importance of why cross-curricular topics should be taught in all subject areas. However, before teachers put them into practice,
perhaps they must explain their worth to the learners, since the students are the ones who must ‘buy into’ why they are working so hard to learn what is being taught.

Student 20 and Student 49 both expressed concerns surrounding the difficulty they were having with the Logarithms unit. Neither commented on disliking the way the journal was being used, but they were definitely concerned about the need for more practise. A point of concern, Student 49 explicitly says, “For the last couple of days we started three different topics, which is confusing. When I start understanding the logarithms you give us graphing and compound interest, which is a lot in 2 or 3 days. I think we should spend more time reviewing.” A teacher must identify with this concern but not by dismissing the activity. Further explanation as to why the activity is necessary, in the short term and the long term, should be given, and ample time within the lesson should be allotted to go over any pending questions from the homework. A great deal of resentment will occur if the previous lesson was misunderstood by many students, and the teacher refuses to review the lesson, instead spending time on a journal prompt. As noted in my personal journal on Day 10 and 11, I did not give a journal prompt on review days when many questions regarding logarithms were sure to arise. Instructors must be able to communicate openly with students before introducing journal activities. Similarly, they must be flexible and adaptable to the students’ concerns, daily events, and class atmosphere.

Participants taking Geography 12 concurrently expressed concern about certain topics saying that these were already being discussed in their Geography class. Student 50 responds to the final journal prompt’s questions asking, “Would you like to study one of these topics within our math class in more depth, perhaps as a project? Why or why
not?" with "No, because I am studying the same stuff in geography. (It) gets boring."
Among the total ten participants who concurrently took Geography 12 and Math 12, several of them had similar comments. My recommendation would be for instructors to investigate what is being taught in other courses that may overlap. With this knowledge, a math classroom can work to complement, as opposed to reiterate, the global topics being covered in the other courses.

The majority of queries left unanswered, for certain journal prompts, were given by ESL students who admitted to not understanding the questions. This issue will play a challenging role for instructors who wish to employ activities such as those presented in this study. Crandall (1987) reminds educators that mathematical activities involving language should be designed simplistically for ESL learners. The language to be used can be given to ESL teachers ahead of time and incorporated into their ESL course. This preliminary exposure will allow for ample comprehension when the material is presented in math class: "If such activities are tailored to the language and mathematics proficiencies of the students, they will have numerous opportunities to experience success in completing both language and mathematics tasks, and they will be able to do so in a less threatening atmosphere than the mathematics classroom" (p.31). Furthermore, Crandall emphasizes the need for ESL learners to have ample opportunity to respond to language based instructional tasks. This opportunity can be generalized as a necessity for all mathematics learners when dealing with such thought provoking, open-ended questioning. In general, reflective time, consisting of the period in which to collect a student’s thoughts based off the ideas presented, does have a place on a daily basis in a math class if time is used efficiently.
Certain conditions will cause success for the integration of global issues in the classroom. Swan (1974) describes two preconditions for effective implementation of global issues to occur in a school setting. First the students' should have a certain concern or emotional feeling for the problem, and second, the student should have a personal feeling that they can resolve the problem. If both conditions are present, a sense of concern may provoke proactive involvement. For example, if students do not have strong and informed opinion towards a global issue, such as water as a resource, they will not pass judgement on what occurs to the water around them. No moral dilemma will arise in the student when they notice the toilet being used as a garbage disposal or the shower being used for extended periods of time. When purchasing a showerhead, people apathetic to the subject will not care whether or not the device saves water. People will not consider the amount of water used to create such consumer products as tin cans unless they recycle. Equally disturbing is the notion that these people pass on their uninformed value system to their own children, the world's next generation.

Limitations

The purpose of the study was to evaluate the increase in global concern through the mathematics, and the global issues relevance within the course, from Nisbet’s Principles of Math 12 students from their responses to journal prompts given during the Logarithms unit. Using the Constant Comparative Method to collect and analyze the data, conclusions were arrived at in determining the measure of the intended goals for the study. However, limitations towards the study must be addressed in order to justify the extent to which the validity of the results can be supported. The researchers, the
participants, and the format that was used to collect the data need to be considered in analyzing the limitations of the study.

The relationship between myself, the teacher, and students may have affected the results. I could be seen as having an exceptionally good relationship with the students, especially the Principles of Math 12 group. I started at the school three years prior and had taught a few of the participants for those three years. Several had requested me specifically to teach them the Principles of Math 12 course, and this positive attribute could possibly have influenced other students within the grade level. I was known to do journal work, which at times veered away from mathematics, but always remained in the realm of an interesting educational production. In course evaluations from previous courses, many students commented that they enjoyed the teacher’s teaching style and his use of the journal books. This good relationship may be viewed as a severe limitation in replicating the study in another Math 12 classroom. The positive results at the end of the study may have been biased, even subconsciously, by the students’ convivial association with their teacher.

By having a known teacher, the participants of my study were already preconditioned to doing journal work in mathematics, since the work had been a regular occurrence from the beginning of the semester. For some students, journaling has been a routine practice from the time they were in Principles of Math 10. A positive attitude towards the journal books and the tangent topics had already been established within the classroom. Unfortunately, this qualification may not be present in all Principles of Math 12 classrooms intending to use global topics. When viewing the Nisbet study’s results, the relationship between the teacher and students must be taken into account.
John Nisbet Secondary offered four classes of Principles of Math 12 in the first semester, when the study was conducted. I used my math classes exclusively to collect data, which comprised only two of the four classes. This selection of classes may have limited the study by confining the responses to only one teacher and therefore only one teaching style. The results may have been more valid if a consistency between the teacher’s results and another teacher’s could have been compared. As well, the Principles course is a prerequisite for taking Calculus, and it is recommended that a minimum of 67% be achieved in Math 12. Calculus 12 is only offered in the second semester, comprising of two classes. These two blocks of Calculus are comprised solely from the four Principles of Math 12 courses offered in the first semester. Under these circumstances a greater number of higher achieving math students took the Principles of Math 12 course in the first semester. To put more legitimacy towards the results of the study, both semesters of math classes may have had to be studied.

When viewing the nature of the results from the Nisbet study, understanding the context in which the data were collected is important. Journal books had been used in all of my math classes. Since I had started teaching at Nisbet, these books were the pre-established place within the class where the teacher would introduce interesting questions, fun activities, and thought provoking concepts, some of which surpassed the realm of mathematics. In regards to the journal use in my classes, Nisbet students of past, and present, seemed to enjoy this aspect of the class mainly because of the freedom aspect to explore, make mistakes, and offer personal opinions. In the Nisbet study, the data collection stayed within this realm of these past attributes of the journal use, where no transition or ‘selling’ was required to use the journals.
Even though very few mathematics teachers use journal books, I did not evaluate any participants who were not accustomed to the use of journal books as a regular practise in their Principles of Math 12 class. These implications may be far reaching for teachers trying to implement the study of global issues in their math classes in the same manner as in my study. For classes that do not use journal books, the students may resent a sudden introduction of journals. Although, it should be noted that incorporation of a global issues program similar to the Nisbet study without the journals may cause the unity of the lessons to collapse, and only limited benefits may be reached. The journal as a component of this study was important because it allowed the students’ to express written general opinions and address open-ended questions.

Implications for the Global Senior math classroom

Three issues need to be considered when discussing the Nisbet study’s impact on future endeavours research. First, time constraints, due to the rigid Principles of the Math 12 Curriculum, may encourage a ‘stick to the textbook’ mentality that limits math teachers from implementing additional activities. Second, relevance of the topics, since most math teachers may have little or no experience, or interest, with global issues. If teachers have time to implement activities not directly in the curriculum, they may want to do a higher order mathematical concept as opposed to a global issue. Third, teachers and students may resist exploration of global issues beyond simply the mathematics, noting that the discussion belongs in another course.

Expansions on these three constraints are as follows:
1. Time constraints due to a rigid curriculum can be seen as a hindrance in any high school course, but this factor cannot excuse teachers from trying new and exciting ideas. By incorporating relevant topics in mathematics, a cyclic domino effect can take place where students' interests increase towards the subject, and in turn student motivation for the subject causes a more efficient use of class time. The following are suggested strategies to successfully address the issue of time constraints:

   a. As described in the study, as little as five to ten minutes at the beginning of class was used in the introduction and evaluation of the global issues presented. Teachers can implement such issues if they are well organized, and manage the students efficiently at the beginning of the lesson. In many ways, journal use can be seen as a way to bring the class together as a daily practise.

   b. Time will not be a decisive issue if instructors use their resources wisely. Many global issues can be linked directly to the mathematics being taught, through questions similar to those I used in the Nisbet study. Placing global mathematical calculations strategically throughout a unit will allow for a theme to develop, which can be addressed at the end as a form of summary towards the unit. This line of reasoning is where the relevancy of math to global issues can arise and possibly the new found enlightenment towards the state of the world.

2. A teacher has many roles in education. For secondary instructors within their specialty area, topics may arise that are less than enjoyable for them to teach. As
well, elementary educators share this position when they are asked to be
generalists, teaching a variety of disciplines outside their preferred areas of
expertise. Nevertheless, they are professionals who see this responsibility and
convey the information accordingly. For me, I believe educators must embrace
the global problems of today not only as a personal responsibility for themselves
as citizens, but also as their duty as civil servants to contribute to the awareness of
future generations.

a. Teaching about issues that you as a teacher are not passionate about, or
even interested in is very difficult. Since so many global issues exist,
educators can do a little research after picking an issue of personal interest
through the library, internet, newspaper, or possibly the social studies text.
Once an issue has been established, teachers should assess the course to
see where this issue would be most mathematically applicable. They could
then devise mathematical questions to link the global topics and provoke
personal responses from the students. These responses would not be
evaluated for their correctness, but would serve as activities for the
students to reflect upon issues that they may have never considered before.

b. Students are more motivated to learn about topics that they are interested
in or concern their lives, the school, or the community at the present time.
Personally, my use of global issues in the classroom relies heavily on
activities that students are capable of participating in. Issues can range
anywhere from racism in the community to the depletion of the rainforest
in the Amazon. If issues are not immediately apparent to teachers, they
can use journals to prompt the student inquiries into which issues that they would most like to explore. In that way, teachers have determined not only what topics are of greatest interest, but also what types of learning students can expect.

3. In the history of education, cross-curricular topics have been integrated across subject areas enhancing student learning. For example, chemistry classes require scientific notation learned from math, math classes involve journal writing entailing written self-expression learned in English, and art classes learn to evaluate the art being expressed in a poem. No course is ‘an island’ so to speak, because education should not compartmentalize its learning. If courses existed in isolation, future occupations, higher understanding, and social advances could never be developed. Global issues have a place not only in math and social studies, but also in all subject areas. I believe education’s underlying theme should be one of responsibility.

a. If teachers feel strongly enough to want to keep their math class purely mathematical, they could still identify the cross-curricular components to be taught. By sharing the mathematics to be learned with the other teachers, mathematics will be promoted in more disciplines, helping to bridge the gap between math and the social sciences.

b. Many schools are developing clubs with social interests, such as Respect for Life, Social Justice, Environment, or the Global Awareness Club. A responsible mathematics teacher can facilitate or provide global information necessary to better realize the world’s problems. As well, by
doing so, the students will be able to comprehend the global issues from a
different perspective and incorporate mathematics as a tool for
understanding.

In order for global issues to be incorporated in mathematics or in any other
subject area, value must be placed on their importance. I believe that this has already
taken place in upper levels of government, as can be seen by UNESCO’s (1976)
Recommendation Concerning Education for International Understanding, Cooperation
and Peace. More so, this value could be addressed in all instructional areas of education
from all teachers. Teachers must look holistically at the curriculum on a macro level to
define what ‘education’ should entail. Whether the problems in setting goals for
education seem too intricate or the basic teachings to the students too trivial are
unimportant. What is of consequence is the bleak future that lies ahead if young learners
are not educated about the state of the world today, and tomorrow.

Implications for further research

Much research has been done on the use of global issues across all levels in many
subject fields, such as science and social studies. I feel very little investigation has taken
place in the area of senior mathematics. A few suggestions have already been given for
furthering necessary research, but other situations to be discussed merit consideration.
The considerations rely heavily on the key players of education including students,
teachers, and curriculum designers.
The Students

Students need a reason why they are learning subjects such as mathematics. Frankl (1985) says a person with a why to live can bear any what. I feel students today are lacking the crucial reason why they are learning certain mathematical concepts. In this study, I chose ‘global responsibility’ to address their why, and I feel students will always react to learning better when this gap has been filled. Further, filling this gap is a necessity for all students, including ESL learners.

Mathematics students will become better problem solvers if they are interested in the problem. Crandall (1987) refers to ‘good problem-solvers’ as pupils who can “discover the discourse properties of word problems that provide them with both a real-world context and a mathematics context in which to approach the problem” (p.23). Later she states in her study, that ESL students to become good problem solvers must acquire the skills to integrate mathematical processes with complex linguistic skills. Crandall continues to discuss the process of mathematical thinking in relation to the student’s interest towards the topic. She furthers, “students’ mathematical thinking and metacognition must be driven by a curiosity and a willingness to investigate the unknown” (p.26). Higher success will be found in curious math students.

I believe my ESL learners were less motivated to want to understand and explore the ideas presented because they lacked curiosity. This curiosity was absent for them because of the written language barriers they dealt with. If the same concepts and global issues were being introduced to the ESL learners in their own language, the same outcome experienced by the native English speakers may have been observed. However, this outcome is speculation because no evidence was obtained to suggest this
phenomenon either way. Nevertheless, for teachers who choose to effectively involve their ESL learners in global issues, I recommend group discussions in peer groups to assure clarification of words, phrases, or entire concepts. This recommendation agrees with Crandall’s suggestion that all “instructional activities should promote second language development through a natural, subconscious process in which the focus is not on language per se but on communicating the concepts, processes, and applications of mathematics” (p.29). Naturally these concepts, processes and application to be communicated must first be understood.

I have found the use of the journal books to be very beneficial in receiving feedback from ESL learners. Many ESL students are very shy to voice their opinion in class, but have many things to say about the way in which they are learning. If a problem in learning is occurring, a teacher should use every means possible to determine where the difficulty lies. In the Nisbet study, students were asked mid-way through the unit to comment on the way in which they were being taught. Because of this mid-way journal prompt, I was able to discover that a high proportion of ESL learners were not enjoying the journal prompts for this unit. Once informed, I was able to take the time to further explain the importance of learning the ‘whys,’ and not just the ‘what’s.’

The Teachers

As a teacher, I have chosen this profession, in part, to better the next generation, and I feel many other teachers have similar intentions. When the ‘dust clears,’ so to speak, after the first few years of teaching, classroom lessons soon become routine. Routine is good, if dynamic and relevant undertakings are occurring. In subject areas
such as social studies, keeping up to date is commonplace with requirements such as current events in the curriculum. In mathematics, however, teachers must look to other applications to keep courses meaningful. Here, continuous re-education is necessary. A ‘good’ teacher is always a good learner who should be willing to advocate for reform and to try new practices.

Even though teachers are interested in global issues, many are lacking in knowledge. Fortner’s (2001) research indicates how teachers place a high value on global issues, such as climate change, but reveals that their own knowledge is inadequate for teaching the subject. A major study with students, ranging from elementary to college level, found that numerous students misunderstood the environmental problems and their corresponding solutions. The need and enthusiasm for teaching global education may be present, but resources and teacher training programs are lacking.

If the Nisbet study were to be continued, teachers would have to be flexible with time allotments towards certain issues. In some instances, I experienced frustration when students were eager to further discuss an interesting journal prompt, but the day’s lesson plan did not allow time. In ways, I felt the participants were left ‘hanging’ after I had ignited an idea that needed to be further explored. An additional study of global issues allowing for more open-ended discussions after prompts might garner more positive reactions from students.

Many students enjoyed global topics such as Water Conservation even though it was not directly related to the current mathematics being taught. However, some felt a sense of confusion about why they were learning the topics at that time. To avoid this uncertainty, teachers should create the most relevant prompts possible to coincide with
what is presently being taught. For example in the Nisbet study, the Population Growth and Temperature Increase journal prompts perfectly coincide with the logarithms and numerical growth. This concurrence will eliminate opponents of the journal who seek direct relevance for all classroom content.

Curriculum Designers

In order for change to occur in any aspect of education, consistency is a necessity. As mentioned, teachers must re-examine the goals of mathematics and of schooling in general, to benefit students. I feel that education over the past century has evolved to improve students and community well being. This progress can be seen with the introduction of such classes as Career and Personal Planning and Physical Education’s Community Recreation Program. Similarly the school’s core subjects should be constantly changing to provide students with the tools not only to function in society but also to better society.

The Nisbet study has taken place in the Principles of Math 12 course, exclusively. To complement the study, a variety of possible other subject areas should be visited. As well, courses such as Principles of Math 10 & 11 may accommodate more effectively the time demands of a global issues program than the Principles of Math 12 course. If inspiration occurred at these lower levels, students should be more accepting of new approaches to global awareness in the Principles of Math 12 program. Perhaps, the Applications of Math stream may be the best place for the mathematical study of global issues. The course is centred on applying more relevant mathematics to a learner’s
education. Regardless which course is used, more research at various levels is required before a global issues program can be fully implemented in a school’s math curriculum.

Implementing global issues into the mathematics curriculum, beyond mere suggestions in the IRP, could cause a top-down effect towards change. Instructors teach what is in the curriculum, and textbooks are written in accordance to those curriculums. Resources are developed when there is a need for them, and school budgets are designed around the needs of the courses. This circular effect will generate change through society, but an initial push is necessary for the wheel to be put into motion. Only at the curriculum level can this move forward occur to create genuine reform.

Conclusion

A comparison can be made to summarize how we should be educating students. In Hare’s study (as cited in Chazan & Soltis, 1973), a distinction between education and indoctrination is made stating, “the educator is trying to turn children into adults; the indoctrinator is trying to make them into perpetual children.... The educator is waiting and hoping all the time for those who he (or she) is educating to start thinking; and none of the thoughts that may occur to them are labelled ‘dangerous’ a prior.” (p.123-124).

Educators cannot make assumptions about what students find relevant or irrelevant in mathematics. In curriculum, ‘schooling’ and ‘teaching responsibility’ should become synonymous in educators stance to redesign what should be emphasized in education. Teachers must look to adolescents not only as future adults but also as citizens of our future. A need for relevance is growing among young learners, and a greater need for responsibility is looming in an aging human race. If society cannot teach pupils to live
conscientiously, when encountering global problems, their disconnection from these matters will increase in their adult years. Then the cycle continues with another generation reared by a new breed of apathetic educators that we ourselves have miseducated.
CONCLUSION

"Show me where to stand, and I shall move the world"

- Archimedes (in reference to his discovery of the lever)

Educators cannot assume that by exposing our students to global concerns that they will immediately change their way of thinking towards the problems or the mathematical context in which the problems were exposed. What teachers must realize is that students construct meaning from their own personal experiences, and our intentions cannot be forced upon any learners. At present, “we can avoid indoctrinating, coercing or leading students if we (teachers) acknowledge that our (educators’) goal is to encourage an open-minded critique and analysis of both facts and values” (Hart et al 1999, p.112). By introducing future global citizens to the issues they will face, teachers are increasing the mathematical relevancy in the curriculum and promoting the need to further their studies in both arenas. If we view the role of education as preparation for responsible citizenry, intentions such as those in the Nisbet study would serve in the forefront, rather than as the bi-product of society’s curricular practises. A classroom will become more effective as a learning environment by adapting to the concerns of the participants. As a global community, students can identify with the problems of society, but as observed in the Nisbet study, often struggle with their role in society. What students are lacking as they become more mature is the teachings of ‘responsibility.’

More value must be placed on the lenses that teachers choose to have students learn mathematics through. In the classroom, teachers must be careful how they present topics, such as global issues. The learner’s needs must be accounted for by receiving their
input and reactions about teachings in their math class. The ‘value’ for the Nisbet study was based on global issues pertinent to our environment. For student success to occur, ESL participants, geography students, students’ familiar with global issues, and academically weaker (and stronger) learner’s needs must be considered.

Worthwhile mathematical tasks must readily stimulate and cultivate higher order thinking. At present, little time is allotted for students to develop processes of thinking that could be optimally effective in resolving complex world problems. Today learners are consistently being pushed to obtain the greatest amount of information in the least amount of time. For education to progress, teachers must aim to have the greatest amount of relevancy occur in any given amount of time. Reflecting back to the maximized spherical bubble, the question might ask - has the Nisbet study reshaped the ‘bubble’? Perhaps the answer is no, but by identifying a starting place for our students, and teachers, to stand, maybe the world has moved into a slightly better position.
REFERENCES


