THE EFFECTS OF IMPLEMENTING STUDENT-CENTRED LEARNING
ON AT-RISK STUDENTS’ SELF-EFFICACY

by

Stephanie McKean

A thesis submitted in conformity with the requirements
for the degree of Master of Arts
Graduate Department of Curriculum, Teaching and Learning
Ontario Institute for Studies in Education
University of Toronto

© Copyright by Stephanie McKean 2014
The Effects of Implementing Student-Centred Learning on At-Risk Students’ Self-Efficacy

Stephanie McKeen
Master of Arts, 2014

Department of Curriculum, Teaching and Learning
Ontario Institute for Studies in Education of the University of Toronto

Abstract

This study examined the effects of implementing student-centred learning (SCL) in a college at-risk mathematical classroom, and how this teaching strategy affected students’ self-efficacy. A triangulation of methods and data was used to examine these effects in two cohorts of students at a large urban college’s Academic Upgrading program.

The evidence from the study suggests implementing SCL in classrooms for at-risk students is beneficial. The major findings were as followed: (1) both students and teachers experience some level of resistance when SCL is initially implemented; (2) increased levels of self-efficacy lead to better mathematical performance; (3) SCL did not appear to raise achievement; (4) SCL activities improved students’ confidence levels.
Acknowledgements

There are several people that I would like to acknowledge with gratitude for helping me throughout this process. Firstly, I would like to especially thank Dr. Doug McDougall, my supervisor, and Jim Hewitt, my secondary reader, for their guidance and insight.

I cannot express my gratitude enough for the members of the college, who approached this research with so much enthusiasm, professionalism, openness, and sincerity. Matt Foran, Jeffrey Peck, and Brenda Yates, I particularly thank you all for your flexibility, support, and encouragement; without each of you, I cannot imagine the success of the study. Jim Nielson, you are a formatting star.

A very special thank you goes to the participating students who went along with the logistical aspect without fuss and were deeply invested in the activities and learning.

Ahmed Huzayyin, you were the rock. With every uncertainty, you helped to problem solve with endless determination and zest. I thank you for your unwavering support, suggestions, late night phone calls, and everything else imaginable.

Finally, I would like to thank all my friends and family, who never doubted my ability, even when I did, and seemingly never tired of hearing my frustrations and developments.
# Table of Contents

Chapter 1 – Introduction ............................................................................................................................... 1
  Reform mathematics education .......................................................................................................................... 4
  Engagement and Achievement ......................................................................................................................... 6
  Self-efficacy and Achievement ....................................................................................................................... 7
  Purpose of the Study ......................................................................................................................................... 7
  Research Questions ......................................................................................................................................... 8
  Format of the Thesis ........................................................................................................................................ 9

Chapter 2 - Literature Review ..................................................................................................................... 11
  At-Risk ......................................................................................................................................................... 11
    Identity Formation for Students At-Risk .............................................................................................................. 14
    Consequences of Being an At-Risk Student ..................................................................................................... 16
  Self-efficacy .................................................................................................................................................. 17
    Importance of Self-Efficacy .......................................................................................................................... 19
    Higher Education, At-Risk and Self-Efficacy ............................................................................................. 23
  Student-Centred Learning ............................................................................................................................. 24
    Student-Centred Learning and Higher Education ....................................................................................... 28
    Student-Centred Learning with Students At-Risk ....................................................................................... 29
    SCL and Self-efficacy ................................................................................................................................... 30

Chapter 3 - Methods ....................................................................................................................................... 32
  Introduction ................................................................................................................................................... 32
  The Students ................................................................................................................................................ 33
  The Teachers ................................................................................................................................................ 35
  The Program ................................................................................................................................................ 36
  Procedures ................................................................................................................................................... 37
    Preparation ............................................................................................................................................... 37
    Surveys ..................................................................................................................................................... 37
    Observations ........................................................................................................................................... 38
Chapter 1 – Introduction

Students often have a strong opinion of math class. It has almost always been a dichotomy; they either love it, or they hate it. They think it is easy, or next to impossible. They are able to do it, or they are unable to do it. For those who feel they are unable to do it, math class is sheer agony. It often causes anxiety, low self-esteem, and fear of the subject, and commonly these feelings are carried over to other arenas of the students’ lives as well. Most notably, students who have previously failed at mathematics exhibit particularly strong feelings, and have a hard time reversing the effects.

Many educators agree that math education worldwide needs change (Alok, 2012; Dewey, 1902; Global Education Guidelines, 2012; Lederman & Lederman, 2013, Lemelle, 1995; NCTM, 2000; Rich, 1991). Education systems are being scrutinized for their traditional methods, and lack of change over the past 50 years. As other subjects attempt to adapt their teaching methods, few notable changes have been made within classrooms teaching mathematics (Ross, McDougall, & Hogaboam-Gray, 2002). Our traditional classrooms do a particularly poor job at engaging students, and tapping into the creativity that mathematics inherently has. With liberating force, Lockhart (2002) talks about just how damaging mathematics education is:

In fact, if I had to design a mechanism for the express purpose of destroying a child’s natural curiosity and love of pattern-making, I couldn’t possibly do as good a job as is currently being done— I simply wouldn’t have the imagination to come up with the kind of senseless, soul-crushing ideas that constitute contemporary mathematics education. Everyone knows that something is wrong. The politicians say, “We need higher standards.” The schools say, “We need more money and equipment.” Educators say one thing, and teachers say another. They are all wrong. The only people who understand what is going on are the ones most often blamed and least often heard: the students. They say, “Math class is stupid and boring,” and they are right. (p. 2)

Boaler (2002) argues that math is not only is boring for students, but it misrepresents the
subject altogether. “The maths that millions of school children experience is an impoverished version of the subject that bears little resemblance to the mathematics of life or work, or even the mathematics in which mathematicians engage” (p.10).

Despite this, there are some students, usually those who find that math comes “easily” to them, that do experience success with math, who are more willing to complete these ‘senseless’ and ‘soul-crushing’ exercises. These students are often more willing to complete these exercises because the procedures are easily memorized for them, or the importance of mathematics has been instilled in their minds, and they believe they need to do well in math class in order to succeed in their future careers. The variance of hard work is large, with some students getting tutors and doing every practice problem until they can solve similar practices on a test. For others, it seems to come naturally, and little practice is needed.

Unfortunately, success in mathematics classes does not inherently denote high mathematical understanding. Understanding is a complex concept. Michener (1978) argues that:

…to understand a theory, one must explore and manipulate it on many levels, from many angles, with facility and spontaneity. One must be able to travel freely through it, experiment with its items, survey its overall mathematical topography, shift the level of concern from detail to broad overview and vice versa, and be able to ask questions. (p. 373)

As Watson and Mason (2006) caution, understanding does not necessarily take place when students succeed on mathematical assessments as it is possible students simply focus on “surface syntactic structures rather than deeper mathematical meaning - just following a process with different numbers rather than understanding how the sequence of actions produces an answer” (p.93). Consequently, it is argued that specific steps must be taken to promote student engagement and higher order thinking, in order to construct advanced conceptual understanding (see Boaler, 2002; Lai & Murray, 2012). Schoenfeld (1992) argues that:
Mathematically powerful students are quantitatively literate. They are capable of interpreting the vast amounts of quantitative data they encounter on a daily basis, and of making balanced judgments on the basis of those interpretations. They use mathematics in practical ways, from simple applications such as using proportional reasoning for recipes or scale models, to complex budget projections, statistical analyses, and computer modeling. They are flexible thinkers with a broad repertoire of techniques and perspectives for dealing with novel problems and situations. They are analytical, both in thinking issues through themselves and in examining the arguments put forth by others. (p. 4)

Unfortunately, more often than not, mathematics classrooms are more about performing well on assessments, and getting good grades, than they are about the type of mathematical thinking quoted above. Arguably, education is still doing a great disservice to these students, as this type of teaching develops a culture of dependence rather than problem solving, independent thinking or creativity; skills that are commonly referred to some of the most important 21st century skills (Allen & van der Velden, 2012; OECD, 2004; Partnership for 21st Century Skills, 2008).

Still, despite not necessarily having the understanding a mathematics educator would hope, the students who do succeed in current mathematics classes are still the fortunate ones. That is because they are able to continue with more advanced math courses, apply to post-secondary programs that open doors to significantly better jobs, better pay, and often better lifestyles. Referenced time and again, one of the largest concerns with this inequity is that of the students who are not succeeding in math, there is a disproportionately high percentage of women and minority students (Alexander, Burda & Millar, 1997; Good, Rattan & Dweck, 2012; Schoenfeld, 2002; Valla & Williams, 2012). Evidently the effect is that “in our increasingly technological society...women and minorities are disproportionately blocked access to lucrative and productive careers” (Schoenfeld, 1992, p. 7).

In fact, students who regularly experience low success in math class often return to the mathematical dichotomy, creating an identity for themselves as one who is unable to do math,
and therefore will not do math. Dweck (2008) discusses the critical notion of mindset in students, arguing that those who believe that intelligence, or math ability, is a fixed trait, unable to be changed (fixed mindset) are at a significant disadvantage compared to students who instead believe that intelligence can be developed (growth mindset). She shows that these mindsets can lead to adaptive or maladaptive motivational strategies for achievement.

Additionally, the research is showing that these mindsets can play an important role in the relative underachievement of women and minorities in math (and science), as these groups tend to have a more fixed mindset. If students who are regularly underperforming in math class believe they are unable to do math, due to past experiences or self-constructs, they are less likely to succeed. In a cyclic self-fulfilling prophecy, students who are low-achieving often remain low-achieving. This constant failure often leads to levels of disengagement in mathematics, and education in general.

**Reform mathematics education**

In order to combat this disengagement and increase achievement levels, reform education is making ground within institutions. In the past few decades there has been a call to shift from teacher-led instruction to student-centred education (Mascolo, 2009). The idea is that teacher-led instruction simply passes down knowledge and does not allow for students to discover meaning on their own. Dewey (1902) argues that creating a curriculum that has immediate meaning to the student and that allows them to experience learning, will encourage and motivate them, and will develop their reasoning skills along the way. Dewey comments that students are not interested in the ways subject matter is presented but are forced to learn the material through external motivation (by that of discipline and grades). In order to change this notion of external motivation and simple processes and procedures that are memorized, Dewey maintains that the
explicit curriculum content and schools must be relevant and appealing to the children as they are now.

Much like Dewey, Richardson (2003) argues that individuals create new understanding based on their past, and the knowledge they receive. Reform education seems to follow closely with that of Richardson; her belief that pedagogy must be student-centred, facilitate group discussion, provide opportunities for students to determine, challenge, change and/or add to current beliefs and develop students’ “metawareness” (p. 1626). Essentially, reform education is about allowing children to reach their own understanding through guided, meaningful activities.

Unfortunately, despite the talk in education of deep-learning, differentiation and focus on the student, the teaching methods within mathematics classrooms do not vary much, and thus do an inherently poor job at reaching all students (Lesser & Blake, 2007). This is particularly true for students considered at-risk (Vatter, 1992). Perhaps due to inexperience, under-estimating, or students’ already developed fixed mindsets, it seems particularly difficult for educators to engage at-risk learners in challenging, thought-provoking mathematical problems, and to do so with positive outcomes. As Ronis (1999) notes, schools postpone instruction in higher-order thinking skills until basic, low-level skills have been mastered. Unfortunately, students at-risk continuously face dull drill and repetition activities and never seem to grasp the underlying concepts. Not only does this continue at-risk students’ cycle of disengagement, it also lowers their identification with school, and reduces their self-efficacy within mathematics.

Although reform education is discussed in a variety of educational settings, only few post-secondary programs seem to clearly utilize their benefits. Namely, problem-based learning in law and medical schools are particularly common, but also in engineering and business (Hannafin & Land, 2000). However, in the majority of these programs, there is still a heavy
reliance on lecture-based lessons where instructors transmit information (Savin-Baden, 2000). The lecture method is an effective way to disseminate large amounts of information, in the fastest way, however does not consider that students learn through creating cognitive connections, social connections, and experiential connections (Cross, 1990). Not allowing students, and particularly students at-risk, to make these connections, makes it difficult for them to succeed in post-secondary programs, and even more difficult to let them flourish in school when they have a history of low achievement.

**Engagement and Achievement**

Consequently, reform education ideals are important for students, particularly at-risk students, because ultimately, as students become more engaged in their studies, their deep, rather than surface, understanding enhances their learning processes and consequently their achievement levels. When students are interested in the material presented to them, they begin to make connections that they previously may not have seen, they look to understand the material in the bigger picture and see its relevance to their life. Within the literature there are often many forms of engagement, ranging from social (participation in life at the school) to academic (participation in the mandated requirements of school), and more recently intellectual engagement (a cognitive and emotional commitment to learning) (Parsons & Taylor, 2011; Trowler, 2010).

Arguably, all types of engagement are likely to help improve students’ experiences in school on multiple levels that bring a sense of motivation, confidence and pride in school for those who are engaged (Fredricks, Blumenfeld, & Paris, 2004). However, intellectual engagement appears to be especially important in improving achievement levels because it promotes deep cognitive engagement and deep learning (Dunleavy & Milton, 2010).
Self-efficacy and Achievement

Another vital role in understanding students’ learning is self-efficacy (belief in their ability to achieve a goal). Students’ self-efficacy can further engage students and their achievement. As levels of self-efficacy increase, learners are more confident in their abilities, and are encouraged to take on more challenges, be more resilient to failures and to be intrinsically motivated (Bandura, 1994). According to Marsh (1993), when domain-specific self-concept is compared with achievement in the same domain (e.g., math self-concept with math achievement), the relationship is positive and strong. Following from engagement and now this notion of self-efficacy, it appears that students’ achievement levels are likely to greatly improve when students are engaged and have a high belief in their own capabilities.

For a discipline such as mathematics, this issue of traditional education seems to be amplified as reform methods seem to be unconvincing and confusing for both the teachers and students. Traditional mathematics classroom practices appear to be particularly damaging for students at-risk, while reform practices, done properly could be particularly beneficial for the students’ engagement, self-efficacy and thus, achievement (Pajares & Kranzler, 1995; Vatter, 1992). For this reason, it is the intended hope to determine if student-centred learning activities designed in the interest of students’ intellectual engagement, at the appropriate level can in fact improve at-risk students’ levels of self-efficacy and achievement.

Purpose of the Study

Although this notion that our at-risk students are being particularly disserved in their mathematics education is well documented, few studies have identified whether certain teaching methods can counter some of the damage done to students’ math self-efficacy and self-esteem over the course of their mathematics careers. By exploring this idea of using SCL activities with
students considered at-risk, further research, and practical implementation practice, can lead to better education practices in the future, ultimately increasing the likelihood of success for these students.

The specific objectives are:

- To collaboratively design and deliver a set of activities that promote student-centred learning in a mathematics classroom at a large urban college classroom typically registered with students who are familiar with feelings of low self-efficacy and at-risk status
- Determine how these student-centred learning activities affect this particular group of students’ self-efficacy through measures of surveys and focus group

Research Questions

Student-centred learning (SCL) methods have recently made their way into reform education, arguing for deep-learning and success levels for all students, simply because the students are making their own connections and really learning, rather than regurgitating or imitating. This study is explicitly looking at implementing SCL methods into a large, urban college’s Academic Upgrading program and analyzing the effect of such implementation in mathematics classes. The program is on a 12-week cycle, designed to upgrade students’ math skills prior to them applying to college programs. By nature of the programs, students entering are adults who had previously not completed math in high school, or are coming back to school after an extended period of time and do not yet have the skills required for their program of choice.
Specifically, this study set out to answer a set of questions designed to explore and better understand how implementing student-centred learning approaches would affect the teaching and learning processes in an at-risk college setting. The following questions were specifically being addressed:

1. How do at-risk college students respond to student-centred activities?
2. How will introducing student-centred activities affect students’ self-efficacy?
3. How will professors find implementing student-centred activities, and is it manageable moving forward?
4. How does teaching in a student-centred approach affect students’ achievement levels?
5. What types of challenges did the students confront during the implementation?
6. What types of challenges did the professors confront during the implementation?
7. What additional factors must be considered to better implement student-centred in future?

Format of the Thesis

There are five chapters in my thesis to help organize, and best describe the study.

Chapter One is an introduction of the thesis, describing the research questions, importance of the study and relevant background information.

Chapter Two is a review of the existing literature, examining previous research and the connection to this study. At-Risk is discussed in detail first, bringing attention to the challenges faced by at-risk students, and some of their best learning strategies. Secondly, self-efficacy and its significance to students, particularly at-risk students, are illustrated. Finally, in order to act as a beneficial catalyst for at-risk students, and to improve self-efficacy, Student-Centred Learning is examined.

Methods used to carry out the study are discussed in Chapter Three. The participants, program of study, observations, surveys and interviews are all described, as well as the procedures used. Within this chapter, data collection and analysis methods as well as limitations are discussed.
Chapter Four provides the results and findings of the study. The week’s worth of lessons is described in detail, outlining many of my observations throughout the two weeks of collection. Themes such as resistance, the increase of confidence and the interplay between confidence and achievement are also discussed. Within the chapter, the Student-Centred Learning perspective is described as well.

In the final chapter, conclusions and implications are laid out. This includes the teachers’ experiences -- challenges, overall feelings and buy-in are particularly discussed. Additionally, possible future studies are also considered.
Chapter 2 - Literature Review

At-Risk

Although our mathematics curriculum is in need of redesign across all spectrums (educational levels and academic streams), it is of greatest need with the neediest population - the students considered “at-risk”. Depending on the institutional level of education, at-risk is defined by different measures. The At-Risk Working Group (2003) defined “students at-risk” as one of the following:

- Elementary students who are performing at level 1 or 2, or below grade expectations;
- Secondary students who would have studied at the modified or basic level in the previous curriculum;
- Secondary students who are performing significantly below level 3 (the provincial standard for the EQAO test), earning marks in the 50s and low 60s, and who do not have the foundations to be successful in the current curriculum; or students who are disengaged, with very poor attendance. (As seen in Ministry of Education, 2004).

Sagor and Cox (2004) define at-risk as “any child who is unlikely to graduate, on schedule, with both the skills and self-esteem necessary to exercise meaningful options in the areas of work, leisure, culture, civic affairs, and inter/intra personal relationships” (p.1). Essentially, students can be considered at-risk if they are experiencing difficulty meeting the academic expectations, are disengaged, and/or considering dropping out.

Although difficult to characterize, and even more difficult to generalize (McFeetors & Mason, 2005), Vatter (1992) says students considered at-risk often have any number of the following characteristics:
Poor self-concept;  
Low self-esteem;  
Poor academic performance;  
High absenteeism;  
 Discipline problems;  
Low aspirations;  
Parents or guardians with low expectations;  
Low family socioeconomic status;  
Nontraditional family life, and/or  
Inadequate goals or means of achieving those goals (p.292).

The reasons students may be considered at-risk may be due to their cognitive development, past experiences, factors that influence motivation and attitude, and, important for this study, factors that relate to their confidence in their ability (Augustyniak, Murphy, & Phillips, 2005; Hannula, 2006; Sullivan, Tobias, & McDonough, 2006).

The Ontario Education Ministry is evidently concerned with the number of students who are considered to be at-risk, as initiatives are continuously created in order to rectify the circumstances. Initiatives such as Specialist High Skills Majors, Dual Credits, Expanded Co-op, and Credit Recovery programs are all similar to the No Child Left Behind policy in the US. In their Report of the Expert Panel on Student Success in Ontario, experts quote the research stating that:

At-risk students are not experiencing success in school, exhibit low self-esteem, have a minimal identification with the school, and may have problems that prevent them from participating successfully. As they fall behind their peers, school becomes a negative environment that reinforces their low self-esteem (Bauer, Sapp, & Johnson, 2000; Donnelly, 1987; Vatter, 1992). (Ministry of Education, 2004, p. 37)

Alarmingly, despite recognition and attempted prevention by the ministry, countless students are still underachieving in mathematics across the province. The Education Quality and Accountability Office (EQAO) is an independent agency of the Ontario government that measures student achievement in reading, writing and mathematics in relation to the Ontario elementary and secondary curriculum expectations. The results provide evidence and learning for students in the public schools, and is intended to act as a catalyst for increasing the success of
these students. According to the 2010 results, however, 60% of students in the applied mathematics streams are not meeting provincial standard, and 20% in the academic streams (EQAO, 2010). According to Tibbetts (2008), this trend continues into colleges as well, with 34% of 10,000 math students at six Ontario colleges in “academic trouble”, earning grades of D or F after their first semester. In fact, Rylands and Coady (2009) state that this issue is across the globe, with higher education institutions experiencing increased failure rates in mathematics due to insufficient or inappropriate mathematical background.

This present study focuses on the Academic Upgrading program where students are inherently familiar with characteristics of at-risk. They are attending a program that upgrades their skills because as it stands they do not have the necessary requirements to apply to the post-secondary program of their choice. Many students, following Vatter’s description above, have negative past experiences with math, high absenteeism, low socioeconomic status, and see themselves as failures particularly as learners.

According to Laskey and Hetzel (2011), any student entering college underprepared is often considered at-risk. Beyond the lack of the basic skills necessary, these students often also lack motivation for school and the soft skills required to make them successful, such as attendance, time management, and effective study strategies (Chris, Daigle, & Windy, 2007; Laskey & Hetzel, 2011).

Not academically succeeding in math classes is quite clearly a problem across the educational spectrums. In the remainder of this chapter, I will discuss how the consequences of students’ being at-risk, how raising their self-efficacy could improve these concerns, and how a student-centred teaching method that theoretically would improve their self-efficacy, and hence achievement.
Identity Formation for Students At-Risk

One of the major concerns for students who are considered at-risk is how constant failure in school can affects students’ identities. This is particularly true for mathematics classes where better performance is often seen as directly correlated with the student being intelligent and successful, and vice versa. As Cobb and Hodge (2007) suggest, it is extremely difficult to define who will be successful at math. As definitions and discourse about identity constantly change, it becomes more difficult for one to understand who it is important to be and who it is possible to be, and those understandings may be in conflict with how people view themselves to be. Cobb and Hodge (2007) propose three primary identities that students in mathematics classrooms develop, namely, the normative, core and personal identities. Both the normative identity and personal identity are directly related to the student’s identity within the mathematics classroom, whereas the core identity “is concerned with students more enduring sense of who they are and who they want to become” (p. 167).

Ultimately however, in a variety of ways, the developed sense of self as a doer of mathematics in a particular classroom (normative identity), or the ongoing development of who students are becoming in their mathematics class (personal identity) will affect their core identity. Although Cobb and Hodge recognize four main possibilities in the types of personal identities that students develop in their mathematics classes, the fourth one, regulation through opposition, seems most appropriate for students in at-risk classes. In this development students “…actively resist contributing to the establishment of the normative identity as a doer of mathematics, in the process developing oppositional classroom identities” (p. 169). What is most concerning about this trajectory however is how this personal identity can shape the students’ core identity in the long run.
Since it is so difficult to determine an identity, often people search for essentialism. As Woodward (2002) describes, people want to believe their sexual identity may be embedded in biology, or that there is a shared past or shared national identity that creates belonging for its members. In mathematics classrooms this essentialism exists as those who are able to do mathematics and those who are not. However, as Woodward (2002) points out, the problem with binaries such as these is that they “permit no ambiguity or ambivalence, no middle ground of managing difference, although they are part of the desire for unity and wholeness, which requires clear boundaries” (p. 141). These dichotomies require students to see themselves as either able or unable.

For the at-risk student, this dichotomy often leads to a personal identity in mathematics as incapable. When constantly having bad experiences with math, students find comfort in belonging to a group that is ‘inherently’ less able in math. In fact, students in applied streams almost become accustomed to failure in their everyday life, as well as mathematics and can easily develop low self-esteem. Which, according to Vatter (1992), is “…a primary determining factor in how students perceive, react to, and act in, the world. Once caught up in a cycle of perceived failure, the at-risk student has difficulty breaking out of it” (p.1).

Additionally, Hall (2006), when describing how a national culture is developed, brings two vital aspects applicable to core identity too. He argues that there is a narrative and there are origins. In national culture, the narrative is the stories told in the nation’s history and literatures, and throughout the media and popular culture. The origins are the essentials of the nation that are there from birth and remain unchanged. For the at-risk mathematics learner, the origins are inevitable; they are incapable of becoming a doer of mathematics, regardless of the effort and hard work they put into the subject (related to fixed mindset, which is discussed later). This is
deepened by the narrative in media and popular culture; “too often, society has accepted the stereotype that mathematics is for the few, not the many” (Ministry of Education, 2004, p. 9).

Considering identity is a fluid, ongoing process, it is important to note that students who once had a negative personal identity with mathematics could, in theory, establish a positive one over time. Vygotsky (1935/2011) argues that there is an important difference between actual development and zone of proximal development (ZPD). The former being what the child can do on their own and is determined by functions already developed. The latter is the level of possible development with the help of others determined by functions currently developing. He maintains that although actual development is important, evaluating a child merely on that limits their potential as “what the child is capable of doing today with the help of others, tomorrow he will be doing himself” (p. 205). Clearly, regardless of the reason, students who are struggling to succeed in mathematics, continue to struggle over the years, despite countless initiatives designed to overcome these problems (see Ministry of Education, 2004). Consequently, it is highly unlikely that they develop a positive sense of self in the mathematics classroom, and even more unfortunately, likely in their core identity as well.

Consequences of Being an At-Risk Student

Presumably, educators hope to increase students’ positive sense of self, both in and outside of the classroom. And it is not without good reason; according to Haselden, Sanders and Sturkie (2012) a history of repeated failures in the classroom often leads to a loss of confidence and self-worth and can even hinder these students from becoming contributing members of society. Drago (2011) argues that, in line with other research, self-esteem has an impact on the earnings in the workplace. Waddell (2006) argues too that there are important economic implications for youth with poor attitudes and low self-esteem. Through his longitudinal study,
Waddell shows that these youth attain fewer years of post-secondary education, are less likely to be employed 14 years following high school and, when working, receive lower earnings. The coming sections discuss the concept of self-efficacy and how teaching aimed at increasing it can help at-risk students.

**Self-efficacy**

Students’ belief in themselves has recently received growing attention and is viewed now as of having great importance in education. When someone believes they are incapable of something, like at-risk students, more than likely they will not succeed at the given task. Although there tends to be many different measures of one’s belief in themselves, Bandura’s (1986) self-efficacy is arguably most valuable. Bandura describes self-efficacy as one’s belief in one’s ability to succeed in specific situations. Bandura argues this self-construct is particularly helpful in choices regarding people’s behaviour. When people tend to have low self-efficacy, they usually avoid these tasks, whereas those with high self-efficacy will undertake them. In education, one’s math self-efficacy then is their confidence in completing the math task at hand. Math self-efficacy plays an important role within social cognitive theory, and is particularly significant in student learning (Bandura 1986, 1994; Dinther, Dochy & Segers, 2011; Ramdass & Zimmerman, 2008).

According to Bandura (1986), there are four main sources through which one’s self-efficacy can be developed. The first is enactive mastery experience, which, within education, refers to students’ experiences with success at the task at hand, as it provides evidence that the student is able to succeed. The second is through observational experiences where students judge their capability by observing others such as their classmates or peers. Verbal persuasion is the third source of self-efficacy, referring to the encouragement students receive from teachers and
other role models. The fourth key source is the students’ physiological, emotional and mood states, which inherently affect students’ views of their ability.

In order to fully understand it, self-efficacy needs to be differentiated from various other self-constructs that play active roles in learning as well, and affect students’ belief in themselves. The construct most closely related to self-efficacy and often incorrectly used synonymously is self-concept. Self-concept is defined as “one’s perception of the self that is continually evaluated and reinforced by personal inferences about oneself” (Bong and Clark, 1999, as cited in Lee, 2009, p. 355). Self-efficacy is more narrowly defined and is directly related to successful outcomes. Pajares and Miller (1994) describe this difference in association with self-concept’s inclusion of self-worth, and self-efficacy’s commitment to context-specificity.

One’s self-concept judgments are not task specific. However, self-efficacy judgments are. Zimmerman (2000) echoes these differences, stating that self-concept involves self-evaluative questions, where self-efficacy focuses on performance expectations. When looking to measure these constructs, Bandura (1994) argues one should be asking questions about how confident students are in completing a math task for self-efficacy, and overall how good of a math student they think they are, for self-concept.

Another fundamental self-construct that receives a lot of attention in math education, is math anxiety. Since there is a high reportage of math anxiety in classrooms (Sherard, 1981; Cates & Rhymer, 2003; Geist, 2010), it is important to distinguish differences among one’s math self-efficacy and their math anxiety. Smith (1997) defines math anxiety as “students’ restlessness during mathematical operations and their fear thereof, fright of failing exams and experience of physical stress rather than as negative attitudes or dislike for mathematics” (as seen in Akin, Kurbanoglu 2011, p. 263). Bandura (1994) argued that math anxiety is generally determined by
one’s self-efficacy for a given task (Pajares & Miller, 1994), and Akin and Kurbanoglu (2011) agreed with that argument stating that students with low self-efficacy were found to have higher levels of anxiety.

In their study, Lee (2009) took the PISA results across 41 countries as well as the PISA questionnaires to determine if math self-concept, math anxiety and math self-efficacy were distinguishable self-constructs. In the study, it was concluded that the constructs were, in fact, distinguishable. They also found that the constructs were “…inevitably related to the societal and educational environment of the country” (p. 363). That is, certain countries were inherently more likely to have high levels of math anxiety and low self-efficacy (generally speaking Asian countries) for example, whereas others had low math anxiety and high self-efficacy (like in Western European countries). Canada seems to be relatively high for all three constructs, making top ten highest levels of all three constructs, indicating the importance for Canadian educators to be aware of these self-concepts.

**Importance of Self-Efficacy**

It is of utmost importance to differentiate these constructs and to use them within education to better students. Math self-efficacy, math self-concept and math anxiety despite having overlapping dimensions, are distinct and measurably different constructs. Interestingly, numerous studies have proven that math self-efficacy is a better predictor of math performance than either of the other two constructs (Akin & Kurbanoglu, 2011; Lee, 2009; Llabre & Suarez, 1985; Marsh, Roche, Pajares, and Miller, 1997; Meece et al., 1990; Pajares & Kranzler, 1995; Pajares & Miller 1994; Pietsch et al 2003; Zimmerman 2000).

This is one of the major reasons self-efficacy is being looked at within education; it is something to pay attention to, if educators can improve academic performance by increasing
self-efficacy. According to Pajares (1996), self-efficacy is a good predictor of academic
performance because:

Self-efficacy beliefs act as determinants of behaviour by influencing the choices that
individuals make, the effort they expend, the perseverance they exert in the face of
difficulties, and the thought patterns and emotional reactions they experience. It is for
these reasons that high self-efficacy is likely to promote stronger academic performance
whereas low self-efficacy is likely to undermine them. (p. 325)

Zimmerman (2000) argued similarly, maintaining that efficacious students “…were better at
monitoring their working time, more persistent, less likely to reject correct hypothesis
prematurely, and better at solving conceptual problems than inefficacious students of equal
ability” (p. 87).

Pajares and Miller (1994) note that Bandura argues self-efficacy is a better predictor of
performance because he believes one’s confidence in approaching a task, and their self-concept,
perceived usefulness and anxiety are all mostly the result of self-efficacy judgements. Bong and
Skaalvik (2003) argue that self-efficacy is one cognitive basis for the development of self-
concept. Consequently, improving one’s self-efficacy can lead to the increase in feelings of self-
worth. This is particularly important for students considered at-risk as their self-worth tends to be
centred around the fact that they are not very capable when it comes to academics, and in
particular, mathematics. Additionally, as Cobb and Hodge (2007) note in discussing identity,
being able to improve students’ normative and personal identities, should also improve their core
identity. Improving their math self-efficacy could likely mediate some of the self-worth issues
they have been battling much of their lives. Furthermore, these indirect benefits of improving
students’ self-efficacy are without doubt cyclic; as one’s self-efficacy increase, so too does their
persistence, effort and self-worth, leading to more improvements in their self-efficacy, and so
forth.
Although, not being examined within this study, it is important to recognize some of the additional potential benefits of improving self-efficacy. Besides improving academic performance, self-efficacy is said to have a strong direct effect on career interest and choices, as people tend to pursue fields they believe they are capable of doing well in (Cordero, Porter, Israel & Brown, 2010; Hackett, 1985; Zimmerman, 2000). In Cordero et al’s (2010) study, they demonstrated with gender analysis that female participants reported significantly less math self-efficacy than their male counterparts. This is unsurprising as females have consistently showed lower levels of math self-efficacy (Amelink, 2012).

Despite women superseding men in college, the U.S Department of Commerce demonstrate that there is still a significant underrepresentation of women in Science, Technology, Engineering and Math (STEM) careers. “According to the Census Bureau’s 2009 American Community Survey (ACS), women comprise 48 percent of the U.S. workforce but just 24 percent of STEM workers” (US Department of Commerce, 2011, p. 2). The study also shows that women hold a disproportionately low share of STEM undergraduate degrees, and even those who do hold these degrees, tend to go into education or healthcare, rather than occupations more directly associated with STEM fields such as analyst, engineer, or scientist. Increasing college students’ math self-efficacy could positively promote these careers for women and begin to close the gender wage gap as well as gender stereotyping.

Furthering this notion of gender differences, Dweck (2008) has been a big advocate in the growing body of research discussing mindset. She argues that students who believe their math and science ability is fixed (fixed mindset), are at a significant disadvantage compared to those who believe their ability can be developed (growth mindset). Interestingly, she has also found that women and minorities are more susceptible to having a fixed mindset.
Women’s representation in math and science is far lower than their past grades and achievement test scores would warrant. An eroding sense of belonging may be a key factor in women’s decision to go elsewhere. Our research shows that a fixed mindset contributes to this eroding sense of belonging, whereas a growth mindset protects women’s belief that they are full and accepted members of the math community. (p. 5)

Dweck (2008) extends this notion to minorities arguing that “negative stereotypes about ability are fixed mindset beliefs. They embody the belief that ability is fixed and that certain groups do not have it” (p.6). It seems likely that students who are less efficacious than others, also hold a fixed mindset mentality about their ability to do math tasks. To counter students’ beliefs about fixed mindset, Dweck (2008) argues that one of the best ways to do this is by portraying challenges, effort and mistakes as highly valuable. This is inline with much of Bandura’s arguments about self-efficacy as well. Since it is already proven that increasing students’ self-efficacy improves students’ persistence and effort (Bandura, 2001), it seems likely that improving these skills could also play a vital role in changing their mindset as well.

Overall, according to the research, improvements in self-efficacy lead to increased achievement scores (Akin & Kurbanoglup, 2011; Lee, 2009; Llabre & Suarez, 1985; Marsh, Roche, Pajares & Miller, 1997; Meece et al., 1990; Pajares & Kranzler, 1995; Pajares & Miller 1994; Pietsch et al 2003; Zimmerman 2000), improve self-esteem (Bong & Skaalvik, 2003; Pajares & Miller, 1994;) and likely mediate negative identification with mathematics and consequently school (Cobb & Hodge, 2007; Cordero, Porter, Israel & Brown, 2010; Hackett, 1985; Zimmerman, 2000), and change their mindset (Dweck, 2008). If fostering environments that promote higher levels of self-efficacy could also mediate all the factors listed above, it seems that it could also mediate stereotypes and inequities for women, minorities and students considered at-risk, potentially improving equity.
Higher Education, At-Risk and Self-Efficacy

Improving self-efficacy is important in all levels of education and should be considered in all classrooms. Specifically in higher education, Fletcher (2005) argues that documenting relationships between self-efficacy and performances should also enable practical evaluations of higher education programs intended to support individual learners towards successful higher learning. Jerusalem and Schwarzer (1992) believe stronger academic self-efficacy expectations result in better outcomes for students in higher education institutions because those more efficacious perceive failure as challenges rather than threats, and as Bandura (1986) stressed, persist through the challenges. Additionally, higher self-efficacy also lowers academic stress and helps to maintain mental and emotional health (Solberg et al. 1998). In their review, van Dinther, Dochy, and Segers (2011) found that it is possible to influence students’ self-efficacy in higher educational settings. Eighty percent of the intervention studies, done across several types of study and across several domains, demonstrated a significant relation between an intervention programme and students’ self-efficacy.

Self-efficacy seems to have numerous positive contributions to the well-being and improvement of students’ math ability. Pajares and Miller (1994) say it best when maintaining the importance of addressing self-efficacy in education:

We dare not go so far, but it seems clear that assessing students’ self-efficacy can provide classroom teachers with additional insights about their students’ subsequent performance – insights beyond those obtainable by simply assessing prior knowledge. If self-efficacy is an important predictor of performance and is a primary cause of feelings of self-worth and perceived usefulness, then efforts to identify, understand, and alter inaccurate judgements should prove beneficial. (p. 201)

Being that students’ in at-risk classrooms have low self-efficacy, and often lower self-worth because of it, it is particularly important to attempt to alter these inaccurate judgements in math
ability for these students. The next section will discuss student-centred learning as a method that could do just this.

**Student-Centred Learning**

Pajares (1996) suggested designing interventions that allow students to experience academic success through authentic mastery experiences. Little research has been conducted in this area detailing the results of specific strategies that have been suggested to improve the self-efficacy of struggling students (Haselden, Sanders & Sturkie, 2012). For years, reform education has been attempting to make education across the board more student-centred and problem-solving based for the benefit of students. Although the term often means many different things to different people, Cannon and Newble (2000) suggest that student-centred learning (SCL) emphasize student agency and engagement in learning. Lea, Stephenson and Troy (2003) insist that SCL involves active, rather than passive, learning, requires deep understanding, has increased responsibility and involvement of the student in their learning, involves respectful and sound relationships between the teacher and student, and requires both the learner and teacher to be reflective throughout the process. SCL approaches come from a constructivist epistemology where knowledge and context remain connected and learners develop meaning by solving problems that develops their understanding. It is about constructing knowledge rather than passively receiving it, as is often the case in SCL’s contrast, the more conventional didactic teaching.

Unfortunately, as SCL begins to make way within education, there appears to be confusion about the application of these methods. Despite many institutions and educators believing they are using SCL approaches, most are not (Biggs, 1999). In Farrington’s (1991) study, he found that, although educators in the In-Service Certificate in Further Education
thought they were using student-centred approaches, teacher-led instruction was still at the forefront of teaching. In other cases, educators use SCL tactics but for seemingly unimportant, non-curriculum based activities that simply interest the students. Page (1999) found that teachers created a ‘muddled’ curriculum by combining conventional biology with lessons that were meant to be relevant to a diverse group of students, but had little to do with biology, defeating the purpose of SCL altogether. Barr and Tagg (1995) argue that despite reform paradigms attempting to be adopted into education institutions, few of them have succeeded.

The reason is that they have been applied piecemeal within the structures of a dominant paradigm that rejects or distorts them. Indeed, for two decades the response to calls for reform from national commissions and task forces generally has been an attempt to address the issues within the framework of the Instruction Paradigm. The movements thus generated have most often failed, undone by the contradictions within the traditional paradigm. (Barr & Tagg, 1995, p. 14)

As student-centred learning requires a significant amount of time and effort, and a lot of resources (at least initially), it has proven difficult for these teaching methods to be properly adopted. Nonetheless, studies have found that SCL is a highly valuable teaching approach that if implemented fully could have great benefits for students.

Prior to the use of the Internet, having a vast amount of knowledge was seen as an extremely vital asset in work and in life. Since Google and similar search engines have joined the mass interconnected computer network, being able to recall information is superseded by being able to understand relationships, synthesize information, make connections, and create (Gardner, 2006; Robinson, 1999). Peacock (2008, as cited in Boaler 2009) says, “Lots of people think knowledge is what we want, and I don’t believe that, because knowledge is astonishingly transitory. We don’t employ people as knowledge bases, we employ people to actually do things or solve things” (p. 4). Student-centred learning is more focused on developing these skills rather
than on transmitting knowledge, and utilized correctly in mathematics courses could encourage independent thinking (Polya, 1971, as cited in Boaler, 2008, p 10).

Furthermore, students in learning-centred courses achieve learning outcomes more frequently and to a higher standard than those in instructor-centred courses (Boaler, 2006; Fink, 2003; Nelson, 2010). Lea et al. (2003) reviewed several studies on student-centred learning and found that overall it was an effective approach. A six-year study in Helsinki, which compared traditional and activating instruction, found that the activating group developed better study skills and understanding, but were slower in their study initially (Lonka & Ahola 1995).

Additionally, Hall and Saunders (1997) found that students had increased participation, motivation and grades in a first year information technology course. In addition, 94% of the students would recommend it to others over the more conventional approach (Hall & Saunders, 1997). Students in a UK University elaborated on the impact of student-centred learning on them, i.e. they felt there was more respect for the student in this approach, that it was more interesting, exciting, and it boosted their confidence (Lea et al., 2003).

Overall, it is claimed that a student-centred approach has the potential to enhance “motivation to learn, retention of knowledge, depth of understanding, and appreciation of the subject being taught” (Felder & Brent, 1996, p. 43).

Additionally, SCL seems to be able to mediate the negative formation that often students considered at-risk develop within math class. As described by Hall (2006), Nasir (2007), Woodward (2002) and various others, identity is not simply created by oneself. It is a way of locating ourselves and others, formed by an interaction between the self and society. Interestingly, these interactions, or narratives, need not even be explicit. Often what is ‘told’ to students is actually understood by them based on various actions, expectations and assumptions.
They see themselves as the ‘other’, in this case, as the one not capable in mathematics. Society reinforces it by suggesting there are those unable. Worse yet, however, is that the school’s ‘hidden curriculum’ (Apple, 1983) yet continues to support this idea. The hidden curriculum is not openly discussed, and often, in fact, is not even what the school intends to teach. However, it is so ingrained in the education system that many educators act according to it. Often, lower-achieving schools tend to teach students in a more procedural way and have worse views of education in general (Anyon, 1980).

Even teachers’ attitudes for students in lower-achieving streams, often have different expectations for their students compared to their more academic counterparts. This reveals how a school environment favouring teacher-led and not student-centred instruction can subtly teach those students that they must be told how to do everything, ultimately limiting their potential. Those students, and other learners considered at-risk, became self-fulfilling prophecies – perpetuated by the hidden curriculum and attitudes within education, these students often believe they are unable to succeed and consequently, do not succeed, exhibit low self-esteem and have minimal identification with school.

Teachers tend to teach low-ability students, or students at-risk, as if they are unable to explore, investigate, be inquisitive, ask questions, find patterns, discover or learn (Anyon, 1980). They find it easier to merely tell the students what they need to be told and expect them to sit still, do their work, memorize and repeat. This teacher-led method to education is what Freire (2009) calls the banking concept in education. Here the knowledge is passed down by the ‘all knowing’ teacher to empty vessels who will regurgitate the knowledge. These types of skills are what Bruner (1965) calls training; skills that are able to be applied to a very similar task, but not necessarily to new
situations. The whole concept greatly limits the students and indirectly teaches the at-risk students that they are not capable of other forms of learning, nor valued enough to try.

**Student-Centred Learning and Higher Education**

If students have better understanding, motivation and retention of knowledge it seems apparent that educators should be using SCL as much as possible. A number of studies demonstrate the growth of interest in student-centred learning in higher education discourse and the translation of the new paradigm into specific practices (Edwards & Thatcher, 2004; Kinchin, De-Leij & Hay, 2005; Livingstone & Lynch, 2000; Montgomery, 2008; Prendergast, 1994; Rust, 2002). Although certain disciplines have done this better than others, mathematics still seems to be behind the curve. In higher education too there seems to be a large delay. Although some professional programs have undertaken types of SCL such as Problem-Based Learning (Savery & Duffy, 1996), case-based reasoning (Kolodner & Guzdial, 2000), computer simulations (de Jong & van Joolingen, 1998), design projects (Perkins, 1986), and computer supported collaborative learning (Koschmann, 1996), the majority of higher education programs remain instructor-centred. Wright (2011) argues that college and university level institutions “are extremely instructor-centred and that this situation works against students becoming successful, mature learners” (p. 92). Further, Noyes (2007), reporting on trends in attitudes in mathematics from the International Mathematics and Science Survey, found that there was a correlation between positive attitudes and student-centred learning. Berry and Sharp (1999) study found that prior to their student-centred learning module for mathematics at the university level, students had a dependency on the lecturer through a transmission model of learning, but afterwards they realized the advantages of cooperation and discussion in that learning process.
According to Biggs (1999), “When university classes contained highly selected students, the traditional methods of teaching, lecture followed by a tutorial, gave the appearance of working well enough” (p. 2). Referencing a fictional student who is academically motivated and committed, Biggs argues it is unsurprising that traditional methods of teaching could prove successful for certain students. It is, however, the type of educational circumstance that reform educators object to (Brandes & Ginnis, 1984; Dewey, 1938; Knowles, 1970; Lindeman, 1926; Richardson, 2003; Rogers, 1951). Biggs (1999) urges these traditional approaches to be adapted and for higher education institutions to look into ‘fresh’ approaches. Cannon and Newble (2000) agree, arguing that traditional methods encourage surface learning among the students.

However, the process moving to SCL is not always easy for adult learners, who may originally resist. Being unfamiliar with this teaching style, adult learners may find it difficult adjusting to the expectations involved. Many have become accustomed to learning in a teacher-led approach, and may find student-centred learning approaches as frightening and difficult (Prosser & Trigwell, 2002; Stevenson & Sander, 2002). In order to mediate this notion, it is important to explain to students the purpose of student-centred learning and its benefits.

**Student-Centred Learning with Students At-Risk**

This teaching approach is supposed to be particularly beneficial for students considered at-risk (Marchesi, 1998; Vatter, 1992). These students are often not engaged and have a low self-efficacy, and, unsurprisingly, by definition, low achievement. It seems evident that trying something different than the traditional method may, in fact, better engage, motivate and encourage these learners. Although this has not gone untried, Kajander, Zuke and Walter (2008) found that, despite most teachers wanting to help their students at-risk, they ended up falling
back to familiar practices, namely, teacher-led instructor and individual homework help, not knowing what else to do. This is unsurprising, as Pajares (1992) shows that when people are confronted by new situations, they fall back on their beliefs to help guide them. According to Pedersen and Liu (2003), this is especially true in teaching because there are so many factors. In the situation when teachers are uncertain of how to teach SCL activities, they often instead go back to what they know.

In order to break this cycle of disengagement and failure, these students need to be given opportunities to raise their engagement and self-efficacy. Studies have shown that students considered at-risk have a better chance at succeeding when the work is more hands-on, is applied to work in the real world and when students’ feel their work or accomplishments are valued. Students are encouraged to find their own solutions to problems, and students at-risk need to be particularly involved in engaging learning experiences (Fleener, Westbrook, & Rogers, 1995; Huhn, Huhn, & Lamb, 2006; Van de Walle & Folk, 2005; Vatter, 1992). Essentially, students considered at-risk are in need of methods of reform education such as those of student-centred learning. In their study, Balfanz, Mac Iver and Byrnes (2006) found that the at-risk students receiving reform education outperformed students from control schools on multiple measures of achievement. In Boaler’s (2006) study of a school that had a diverse population and was traditionally seen as at-risk, she found that students excelled when taught in student-centred approaches.

**SCL and Self-efficacy**

There can be further value added should SCL increase students’ self-efficacy. If educators are able to create a space where students are further engaged, coming to their own
conclusions, and constructing knowledge rather than receiving it, it seems likely their self-efficacy would increase as well. This study is intended to better explore this notion in particular for student at-risk, where enhancing self-efficacy is needed the most.
Chapter 3 - Methods

Introduction

The intention of this chapter is to discuss the methods used to complete the study. Amongst these are the procedures used for collecting and analyzing survey data, observational data as well as interview data. Additionally, this section will better describe the specifics of the students within the program, and the program itself.

The aim of this mixed methods study was to determine the effects of student-centred learning approaches on students’ math self-efficacy, particularly for low-achieving students at the college level. A triangulation of methods and data was utilized in the study. This triangulation is often used within education research in order to strengthen the results and conclusions that would normally be based exclusively on one viewpoint, and allow the researcher to overcome certain biases. According to Cohen and Manion (1986), triangulation is an “attempt to map out, or explain more fully, the richness and complexity of human behaviour by studying it from more than one standpoint” (p. 256). Turner and Turner (2009) argue that, while triangulation cannot establish any objective truths, it can provide a fuller picture, and when careful application is applied, triangulation “...remains valuable in the verification of conclusions and in compensating for the lacunae and partiality of single techniques, data sources, or researcher analyses” (p. 172).

Consequently, both data and methodological triangulation have been attempted in this study, in order to receive as full of a picture as possible regarding students’ self-efficacy in a student-centred learning environment. In order to have a variety of data sources, this study was completed with two different cohort of students, and also used both teachers as sources.
Methodologically, information was gathered using researcher observations, student survey collections, and student and teacher interviews.

By observing the lessons, instances of clarity or difficulty that the students and/or teacher may have had that often goes missed in a classroom setting were noted. By having students do self-efficacy questionnaires throughout the activities, quantitative changes in self-efficacy were identified, and by looking at performance tasks, accuracy of those self-efficacy questionnaires was determined. Lastly, by having student and teacher interviews, voice was given to both stakeholders in case the observations and surveys did not quite touch upon all aspects of their views. With this focus in mind, this triangulation was designed in order to get a full picture of how student-centred learning could affect students’ self-efficacy.

In a final attempt to understand the variety of factors for increasing students’ self-efficacy, a control group was formed for one of the cohorts taught by one of the teachers. Observations took place to ensure no level of student-centred learning took place, and to get an idea of how comfortable students were learning the same material in a teacher-led environment. It was intended that if there was an explicit difference the student-centred teaching approaches made for students’ self-efficacy, it could be measured.

The Students

The two cohorts of students were chosen because they were enrolled in a course designed for at-risk students. By nature of the Academic Upgrading program, all students have had difficulty with math in the past, were coming back as adult learners to upgrade their mathematical skills in order to apply for a post-secondary program upon completion. Although the students come in with different backgrounds in math, some feel more able than others, many
students have been out of school for a significant period of time, and all did not complete the level of math required for a post-secondary program.

In the first cohort, there were 22 students, and in the second 12, for a total of 34 students in the experimental groups. In the control group there were 13 students, for a total of 47 students. All students were attending the Academic Upgrading (AU) program at a large urban college.

Below is a descriptions table of the participants, providing information on gender, ages, amount of schooling before AU, number of math courses in High School, and number of math courses in College, all obtained from the initial background surveys students were asked to complete.

Table 1  Student Background Information

<table>
<thead>
<tr>
<th>Category</th>
<th>Subcategory</th>
<th>Control</th>
<th>Experimental</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Number of</td>
<td></td>
<td>13</td>
<td>34</td>
</tr>
<tr>
<td>Participants</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gender</td>
<td>Males</td>
<td>38.46%</td>
<td>42.42%</td>
</tr>
<tr>
<td></td>
<td>Females</td>
<td>61.54%</td>
<td>57.58%</td>
</tr>
<tr>
<td>Ages</td>
<td>18-24:</td>
<td>58.33%</td>
<td>36.36%</td>
</tr>
<tr>
<td></td>
<td>25-31:</td>
<td>0.00%</td>
<td>24.24%</td>
</tr>
<tr>
<td></td>
<td>32-39:</td>
<td>8.33%</td>
<td>12.12%</td>
</tr>
<tr>
<td></td>
<td>40-46:</td>
<td>25.00%</td>
<td>3.03%</td>
</tr>
<tr>
<td></td>
<td>47-53:</td>
<td>8.33%</td>
<td>21.21%</td>
</tr>
<tr>
<td></td>
<td>54-60:</td>
<td>0.00%</td>
<td>0.00%</td>
</tr>
<tr>
<td></td>
<td>60+:</td>
<td>0.00%</td>
<td>3.03%</td>
</tr>
<tr>
<td>School Before AU</td>
<td>Elementary Only</td>
<td>0.00%</td>
<td>0.00%</td>
</tr>
<tr>
<td></td>
<td>End of High School</td>
<td>33.33%</td>
<td>50.00%</td>
</tr>
<tr>
<td></td>
<td>Including Some College</td>
<td>66.67%</td>
<td>50.00%</td>
</tr>
<tr>
<td>Math Courses in High School</td>
<td>Zero:</td>
<td>11.11%</td>
<td>4.55%</td>
</tr>
<tr>
<td></td>
<td>1 or 2:</td>
<td>22.22%</td>
<td>31.82%</td>
</tr>
<tr>
<td></td>
<td>3 or 4:</td>
<td>44.44%</td>
<td>45.45%</td>
</tr>
<tr>
<td></td>
<td>More than 4:</td>
<td>22.22%</td>
<td>18.18%</td>
</tr>
<tr>
<td>Math Courses in College</td>
<td>Zero:</td>
<td>77.78%</td>
<td>34.78%</td>
</tr>
<tr>
<td></td>
<td>1 or 2:</td>
<td>11.11%</td>
<td>39.13%</td>
</tr>
<tr>
<td></td>
<td>3 or 4:</td>
<td>0.00%</td>
<td>17.39%</td>
</tr>
<tr>
<td></td>
<td>More than 4:</td>
<td>11.11%</td>
<td>8.70%</td>
</tr>
</tbody>
</table>
** Note: Percentages were based on the total number of participants subtracted by the number of participants who did not declare a response, in any of the given categories.

The students were asked to take an adapted version of the Mathematics Attitude Inventory (MAI) (see Appendix A), as well as complete a background survey in order to get a clearer picture of the students in these groups. The MAI was a multidimensional inventory created in 1980 by Richard Sandman. The inventory measures mathematics perceptions in six constructs: anxiety, self-concept, enjoyment, motivation, value, and instructor. The original inventory is forty-eight Likert-type items were based on a four-point scale ranging from (1) strongly agree to (4) strongly disagree. This adapted version is twenty-four Likert-type items, again based on a four-point scale. Adaptations to the test were mostly to more exclusively focus on the anxiety, self-concept and value of mathematics indices, not so much on the enjoyment, motivation and instructor as they were not factors analyzed in the data. Scores were totaled using the scoring template for the inventory to give each student a composite test score for the indicated constructs. If an item was not scored by the student, an average score was put in its place, based on the guidelines from the MAI manual (Sandman, 1979).

The Teachers

The teachers are both experienced math professors at the college working within the Academic Upgrading Department. JP has been at the college for over 6 years and also is the faculty coordinator within the department. BY has been with the college for 2 years, and is an integral part of the department. Both were excited and comfortable being a part of the research, giving feedback along the way.
The Program

The Academic Upgrading program runs on a 12-week cycle. Each week focuses on a new topic running from Whole Numbers to Solving Algebraic Equations. Both cohorts were approximately 6 weeks into their 12 week cycle, working through the Signed Numbers and Scientific Notation unit. The experimental unit ran for one week, two hours a day, every day. In order to test SCL activities effects on students’ self-efficacy, a week’s worth of lessons were collaboratively created that allowed students to come to their own conclusions about the rules for adding, subtracting, multiplying and dividing integers, as well as understanding absolute value and scientific notation. See Appendix B for full lesson plans.

These topics are usually taught within Academic Upgrading with a high level of teacher instructed learning techniques and numerous practice problems. In order to ensure all topics and main ideas were still being met, online material and practice sets were diligently worked through and ensured to be included in all lessons to be learned, as well as gathered information from the department teachers about the notions they always teach in this unit. From there, important questions the teachers clearly wanted their students to gain were discussed before beginning to look at how these might be approached in a student-centred learning method.

AU was a particularly good fit for the study because it already had in place a number of the sources Bandura (1986) argues are so important for developing students’ self-efficacy. The study’s activities were intended to act as enactive mastery experiences for the students, providing evidence of success throughout. The classes within AU are also very diverse and will offer students with more opportunities for observational experiences. Additionally, the department as a whole is completely committed to ensuring their classrooms are positive learning environments, and spend a large amount of time encouraging students, hitting both the third and fourth sources
of self-efficacy development, namely verbal persuasion and students’ physiological, emotional and mood states. For these reasons, it seemed like a great place to attempt to develop self-efficacy.

**Procedures**

**Preparation**

The week prior to the administration of student-centred learning activities, students received a letter informing them of the research study, explaining the purpose and the procedures. These letters were distributed and a quick introduction to the study was given. Students were asked if there were any questions and urged to take the information letter home, have a thorough read through and come back with any uncertainties. The day before the experimental week, students were asked to sign a consent form as well. See Appendix C and D.

During the experimental week, students first completed a background survey including their gender, age, prior schooling experience, the number of math courses they have taken, and how they best learn mathematics. Included in this background survey was the MAI, in order to get an idea of students’ math self-concept, math anxiety, and motivation.

**Surveys**

Self-efficacy surveys were used to gauge how confident students were feeling about the tasks required of them in math class. They were intended as a glimpse into students’ perceptions, but would be incomplete without the observations and interviews. According to Bandura (1986), the surveys should be specific as possible, and done as closely to the task itself. Consequently, the surveys were given to every student prior to the main student-centred learning task, and then after completion as well. One reason surveys were administered pre and post the activities is that many of the students in these groups are coming from a variety of backgrounds, and may have
seen the material at hand before. Therefore, the pre- and post- surveys could determine any changes in students’ self-efficacy due to the student-centred learning activity.

Students were asked to simply rate their confidence on a 4 point scale (between “not confident at all” to “completely confident”) on specific questions similar to that of the assessment, but not to actually solve those problems. For example, they would be asked, “How confident are you in solving: (-3) x 4?”, though they were not expected to actually solve this question. The administrator proctored carefully to ensure that students did not solve the problems. Students were also reminded of the importance and value of these surveys, before they were asked to answer them. After the first day of administering the surveys, there was a slight change in order to measure students’ competencies on questions similar to what was being asked on the self-efficacy questionnaire. These skill competency tests were done immediately after both the pre- and post- self-efficacy questionnaires. This was to enable measuring any over-, or under-confidence that was occurring. The changes in self-efficacy responses pre and post SCL activities were measured, as well as between the first day and the last day, in order to determine whether the activities had any effect on self-efficacy. Additionally, changes in competencies were measured.

Observations

Unlike respondents’ answers to questions about objective measures (e.g. age, education), answers to questions in the self-efficacy questionnaires about how one feels can be affected by transitory and situational factors (see also Bertrand & Mullainathan, 2001 for a discussion of the critical issues in using subjective survey data). In order to counter some of these factors, observations took place to try to capture them. The observations acted as context. Having watched how the students faced this new teaching approach, and hearing their comments gave an
idea as to how these types of activities made them think, feel and react. These observations also helped identify other factors that would affect students’ responses to the questionnaires or to the tasks themselves. For example when one student was completing a self-efficacy survey, he was visibly agitated crumpled up the questionnaire, and walked out. Initially it was believed that this may have been due to the questionnaire itself, however once the learner returned to the class it was apparent that it was due to unrelated personal problems, and he asked for another questionnaire.

**Interviews**

In order to fill in any remaining gaps and to ensure all voices were heard as much as possible, formal interviews with each of the teachers present in the study, and any students who volunteered were also conducted. Unfortunately, no students volunteered. It was intended to get students’ opinions after they had spent some time with these types of activities, and could discuss some of the things they felt about them. The primary focus of these interviews was going to be how their confidence was affected by the activities they did in class, but was not able to be completed.

The interviews with the teachers were done informally after each lesson to get an idea of how they felt the lesson went, how their students’ learned, engaged, and if these methods were overall better or worse for them as teachers and their learners. These interviews simply took place after the lesson, and notes were taken. The teacher was also able to review and revise the notes, if they felt they were not representative of their comments. More formal interviews were done at the end of the week to probe how they felt, their students’ self-efficacy was affected, and what factors they think may have affected those feelings. These interviews were videotaped, in
order to better compare and contrast the two teachers’ feelings. The specific interview questions can be found in the appendix.

These qualitative aspects to the study allow a deeper understanding of the participants’ experiences, and their responses to self-efficacy surveys.

**Data Analysis**

A series of t-tests and correlation tests were run, to better understand the self-efficacy improvements, and achievement levels. Difficulties were encountered regarding having a consistent, complete set of data for any given student, given the nature of the program, as well as the group of students. In general, there was a high level of absenteeism, and the program was very flexible accommodating to individual needs.

**Limitations**

This study was conducted with a small sample size. The nature of the AU program, did not allow for a great number of students. Additionally, within the program, there was high variance in students’ attendance, making complete data sets even more difficult to obtain. Another limitation was that there were many additional factors that could affect students’ self-efficacy not directly addressed in this study.
Chapter 4 - Results and Findings

This chapter will present the results and findings of the study. First I will describe the lessons and then I will discuss some of the quantitative results and their meanings. Secondly I will identify some themes that evolved more from the qualitative data.

The Lessons

According to Jones (2007), Student-centred Learning approaches should include features such as:

- Asking and not telling
- Focusing on the students’ experiences
- Communication rather than accuracy
- Learning by doing
- Open-ended questions

The activities were designed in order to incorporate as many of these features as possible with the tight time frame and specific curriculum demands.

In order to best do this, the teachers were asked what they saw as the most valuable for the lessons. With that in mind, lesson plans were created, reviewed, and revised. It is important to note the amount of time and collaboration creating these lesson plans (found in the Appendix) took. As Pendersen and Liu (2003) emphasizes, preparing SCL activities takes a lot of preparation and thought, in order to do it properly.

Lesson 1

In lesson 1, the objective was to have students investigate adding and subtracting integers with counters and to attempt to come up with their own, general, rules about how to add a negative to a positive, for example. Although typically taught by using the number line, we asked students to use the red poker chips as negative numbers and the blue ones as positive numbers. Before setting the students off to do work in groups, the teacher put four sets of drawn counters
on the board, each one representing the same overall value, expressed differently. For example, in one set there would be four positive counters, in another group five positive counters and one negative counter, and in another eight positive integers and five negative integers. The teacher asked the students to do a think, pair, share, with a person next to them to try to work out why all those sets were on the board together. Working as a whole group, they determined that the overall value for each of these sets of counters was the same. With this they were guided through a series of problems, beginning with questions they already knew the answers to, such as $4 + 3$, or $7 - 2$, and eventually moving to newer, more complex questions such as $4 + (-3)$, and $(-5) - (-3)$. Eventually, from seeing enough questions with the counters, the students were able to start to generalize some of the patterns they were seeing. It is during the group presentations that the teacher was able to specifically address any misconceptions, questions, and to make any clarifications. This was designed to enforce...which aspects relate to which aspects of SCL (depending could be done as a summary at the end of the all the lessons)

**Lesson 2**

In lesson 2, the objective was to master the skill of multiplying and dividing integers. Now that students were more comfortable with using the counters, it was felt this lesson would be less time consuming and overall more successful. When asked, the teachers said they would usually teach this lesson by beginning the lesson with the point that two positive numbers being multiplied together (as they know from the Whole Numbers unit) gives a positive answer, as does two negative numbers being multiplied together, and multiplying two numbers with different signs, would give a negative number. From there they would expect students to practice before going into order of operations questions, exponents and even absolute value, depending on how long their group needed to complete these tasks. Instead of giving that information to the
students from the beginning, they again placed the students in groups of 4 by counting them off, and had them work with the counters to represent how the multiplication was done. In order to scaffold the problems, learners were first asked to begin with multiplication questions they were able to do such as 4 times 6, and to represent that with the counters. There was a quick discussion about recalling that multiplication is a faster way of doing addition, and 4 times 6 can be thought of as 4 groups of 6.

Once they were comfortable with that idea, they did a similar activity with questions that were a positive multiplied by a negative. After this there was a pause, and the teachers gathered from their classes any rules the students had generated thus far. They then do a quick demonstration, and discussion, on the board about how (-2) time 3 can be thought of as taking away 2 groups of 3 from zero. Initially concerned this would be difficult for the students to grasp, it was observed that this actually allowed an “aha” moment in many of the students eyes, and they eagerly attempted the next set of questions involving multiplying two negatives together, using that rationale. When debriefing with the teachers after this lesson, both agreed that they found students to really enjoy this new way of thinking of this problem.

Lesson 3

It was evident that the teachers were becoming more comfortable with teaching in a student-centred way, even getting excited about some of the activities. This was particularly true in lesson 3 for one of the teachers. He later mentioned that this was because teaching absolute value was never one of his favourite topics to teach, and that these student-centred learning activities made it more exciting. After doing some work on exponents, the teacher gave each student one or two sticky notes with a number or an expression in absolute value bars, and asked
the students to place that sticky note on the appropriate number on the number line in the front of the class. Some students had not seen the absolute value sign and were confused to start.

After all the sticky notes were on the board, the teachers went through a couple of the placements, saying which ones they agreed with, and which they did not. In this fashion, it was expected that students would then realize themselves that the absolute value bars means you take the positive result. It took a bit of time, but once students caught on, students went back to the board voluntarily to change any ones that they thought were incorrect. More absolute value ideas were consolidated with word problems. They also discussed the situations in real life when they may, and probably already have, experienced this mathematical concept of absolute value.

**Lesson 4**

In the final lesson prior to their assessment, students were expected to learn how to change numbers in scientific notation to standard form and vice versa. Knowing that this is often a concept students merely memorize, we tried to develop a set of activities that made them understand why they move the decimal in the direction they do, without knowing what a negative exponent is. The teacher set up a comparison table on the board, with a mix of scientific notation and standard form of large numbers all on the left side, and small numbers on the right. It was intended that students would see some patterns that were emerging; the numbers in standard form on the left were all big, and the exponents in scientific notation on the left were positive, for example. It seemed to be just challenging enough of a question, as all the students had to think about it, and work together to come up with these patterns. After they did, in pairs, they were asked to look specifically at some of the large numbers in scientific notation, and asked why, with their knowledge of exponents and multiplication of powers of 10, these numbers would be large. Could they see the shorthand rule of just moving the decimal over to the right the
number of spaces in the exponent? After they had these rules, the students worked in groups on a Tarsia puzzle that allowed them to practice their newfound discoveries, matching the numbers in scientific notation to the numbers in standard form.

**Unit Assessment**

On the final lesson of the week -- the unit assessment -- no student-centred activities were done, however a self-efficacy survey was still administered before the test. Additionally, unit tests within the program always work such that students work independently, closed-booked for the first hour into the assessment, marking the questions they liked with a checkmark. Later they are allowed to look through their notes and encouraged to put an “N” next to the questions they received help from the notes, and in the final twenty minutes allowed to collaborate with their classmates. This is typical in the AU math department, a philosophy they began two years ago arguing it creates a better learning environment when test days would normally foster high anxiety for their students. For a successful completion of the test, students must receive a grade of 70% or higher.

**Quantitative Results**

Self-efficacy surveys were completed both pre- and post-lesson each day. There were 33 students in the experimental groups and 13 in the control group, for a total of 46 participants. Due to a small space size, a stricter significance level of p < 0.01 was used. It was concluded that the at-risk group of students taught in a student-centred approach experienced a greater change in their self-efficacy, than those who were taught in a more traditional teacher-led approach. See Table 2 for the particular t-test scores of the change in self-efficacy prior to the lesson being taught, and afterwards, for each of the four days. Sample sizes vary depending on attendance for
that given day. A complete version of the data, including the particular sample sizes, can be found in the appendix.

Table 2

Changes in Self-efficacy

<table>
<thead>
<tr>
<th></th>
<th>Experimental Group</th>
<th>Control Group</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Self-efficacy Change Day 1</strong></td>
<td>p = 0.015626053</td>
<td>p = 0.011727452</td>
</tr>
<tr>
<td><strong>Self-efficacy Change Day 2</strong></td>
<td>p = 0.000000545634</td>
<td>p = 0.369894551</td>
</tr>
<tr>
<td><strong>Self-efficacy Change Day 3</strong></td>
<td>p = 0.001454661</td>
<td>p = 0.006552663</td>
</tr>
<tr>
<td><strong>Self-efficacy Change Day 4</strong></td>
<td>p = 0.000000553837</td>
<td>p = 0.022258552</td>
</tr>
</tbody>
</table>

The data shows that there was no significant change in the first day for either the experimental or the control group. However, the experimental group shows a significant change in self-efficacy for the following three days, whereas the control group only has one day of significant change. Even on that day, the experimental group has a greater significance than the control. These results suggest that allowing the students to come to their own conclusions about the rules of integers and scientific notation does in fact also boost their confidence in completing these types of problems.

Although few quantitative studies have looked directly at the link between student-centred learning and self-efficacy, this result is in line with what is suggested by Bandura (1986, 1994), and Pajares (1996), who argue that mastery experiences (in this case SCL activities) improve self-efficacy. Although Bandura and Pajares have not specifically looked at implementing mastery experiences for students at-risk, it appears it will be particularly desirable
to implement engaging SCL activities for these students who have previously not experienced success and likely have lower self-efficacy as a result. Dinther, Dochy and Segers (2011) suggest that self-efficacy is a vital component of student learning because it affects their motivation, and according to Lea, Stephenson and Troy’s (2003) definition, SCL encourages more student involvement in their learning. For these reasons, it seems important to further examine this relationship. As the data above suggests and as echoed in the interviews (discussed in details later), it seems that the effect of SCL on self-efficacy requires time to become more significant as students get used to the unfamiliar SCL approach.

**Interplay of Confidence and Achievement**

In this section, I will explore the changes of student achievement as well as any changes in confidence.

**Self-efficacy View**

The research demonstrates that greater levels of self-efficacy improve math performance as well (see Akin & Kurbanoglu, 2011; Lee, 2009; Llabre & Suarez, 1985; Meece et al., 1990; Marsh, Roche, Pajares, & Miller, 1997; Pajares & Kranzler, 1995; Pajares & Miller 1994; Pietsch et al 2003; Zimmerman 2000). In order to explore this within the study, students’ achievement levels on the final unit test were compared to their average self-efficacy over the week. A correlation test was run between the students average self-efficacy score over the week and their grade on the integer unit test, however no significant correlation was found (r = 0.119).

To gain further insight on whether or not students’ with higher self-efficacy did in fact have better grades, a quick count of students with high self-efficacy and who scored above the average test score was completed. Those who reported having an overall average self-efficacy score of 3 or higher were considered to have a high level of self-efficacy, while those with a
score of less than 3 were considered to have a low level of self-efficacy. The average grade of
the 34 participants in the experimental group was 84.7%. Of those 34, 14 were considered to
have a high self-efficacy. Of those 14, 12 received a grade above the average, resulting in almost
86% of the students with high self-efficacy receiving a grade better than average. Of the
remaining 20 students, 7 did not write the assessment and therefore will be excluded. Of the 13
students who had a low reported self-efficacy, 5 achieved a grade higher than the average,
resulting in just over 38%. It seems based on this anecdotal information that, as research
suggests, having higher self-efficacy may also lead to better performance.

**SCL View**

Achievement levels were also analyzed from the perspective of implementing student-
centred learning activities. A t-test was conducted between the students’ average grade before the
experimental unit and their grade on the integer unit test. There was no significant change in the
experimental group’s grades (p > 0.01), indicating that perhaps SCL activities did not help
students improve their achievement levels. However, there was no significant change in the
control group’s grades either (p > 0.01). Some of the qualitative data collected suggests why this
may be true. During their interviews, both teachers noted that although the activities challenged
the students thinking, there was not much time for them to individually master the types of
questions they would see on the assessment. In fact, this was one of the concerns the teachers
stressed. In his interview, JP states:

During the week I was worried that doing the activities, using things like the chips the
positives and negatives and putting them together, I was pretty sure they were
understanding what they were doing, but if I was going to give them a slightly harder
question on it that they were not going to be able to figure it out, because we hadn’t done
a lot of theoretical examples on the board like we normally do. So that was my worry. It
seemed to be okay by the time the test came around, the test scores I’d say were pretty
much average. Scientific Notation was lower than usual, and I think that was just because
of, just because we did not spend as much time as we normally would have, right? There
were time constraints. I think having more time in that specific section would have changed everything.

BY reiterates that argument saying that there was “not as much time to have the students practice on their own. While they are able to practice during the activities, I think it’s really important for people to be able to sit on their own and do the questions themselves.”

Prosser and Trigwell (1991) argue that improving the quality of learning outcomes, rather than rote practice, results from the establishment of an academic environment which encourage deep learning. They found in their studies that students who had higher quality learning outcomes adopted deeper learning (Prosser & Trigwell, 1991). So although practice is important, it is imperative to note that creating an environment focused on deep understanding is also necessary in the classroom and perhaps, in doing so, there is a reduction in the amount of in-class practice time.

Additionally, it is likely, that had there been more time for students to adapt to the types of activities, there would have also been more success, as well as additional time for practice. This is particularly true because of the noticed resistance from students, discussed further in the next section and indicated by SCL increasing self-efficacy more with time, as discussed in the previous section.

Confidence

Despite the lack of significant change in students’ achievement, it is important to emphasize the improvements in self-efficacy that were discussed above. Through observations, it was clear that, as the week went along, students became more comfortable with the SCL activities, and with finding the patterns themselves. Day 1, for example, was noticeably difficult for students as they got used to the counters, whereas when for Day 2 students needed to work
with the counters, they were much more willing and engaged in the activity. Most students were looking for patterns prior to the teacher even emphasizing the need for this.

Another important aspect of the increase in confidence is in the increase of confidence in some of the softer skills such as working in groups and communicating their ideas. BY describes one of her students who fits this description well:

With that class, in particular, there seemed to be a lot of people who like to learn as individuals. And to see them start to...come out of their shell, and were working well in groups. I am thinking of a few students in particular, one...she works hard and knows her stuff, and I think sometimes is not confident in sharing it, and to see her share it with the group, that was a great moment.

These skills are extremely important for the 21st century (Partnership for 21st Century Skills, 2008) and improving students self-worth (Drago, 2011; Haselden, Sanders & Sturkie, 2012; Waddell, 2006), and should therefore not be undermined.

**Resistance**

A theme that was reflected in both the qualitative and quantitative data was one of resistance. Students had a particularly difficult time on the first day to fully succumb to the activities. In my observations, I noticed that the students would say things such as "I cannot do this", "I do not understand" and "why can't you just tell me how to answer this question". As BY noted, it was often the students who already felt they knew the material, that saw little point in the activities; "Of course there were a few people resistant to that kind of learning, and it seemed to be the people who already knew the rules. For them, it was hard to get out of their comfort zone...Everyone is afraid of change." JP argues similarly stating that the first day was the hardest as students got used to the student-centred teaching approach, which is in agreement with Prosser and Trigwell (2002) and Stevenson and Sander (2002).
This resistance is evident in the survey data as well, as Day 1’s overall self-efficacy was the only day to not have a significant change between the survey before the lesson and the survey after it. This suggests that students were still trying to get used to the unfamiliar way they were being taught, and having many of the expectations of the learning to be on them creating that understanding, rather than being told.

However, it was not just the students who were resistant to the new approach. Both teachers had changed how they taught the material. Despite not seeing it as resistance, BY mentions her two biggest concerns were the students not having as much practice time as they usually get, as well as them not having a comprehensive set of notes. She thinks both of these activities are very important for student success. In fact, this resistance extended so far into the week that the teacher adapted some of the lesson plans in order to create more time for these things. JP acknowledged himself that he was not used to teaching in this way and sometimes found himself "having to go back to the 'chalk and talk' either because of me or the students not being used to it, I am not sure". It is expected that, over time, as both teachers and students become more comfortable with this new teaching approach, and adaptation are made to the curriculum, there will be more time for practice. This was unfortunately difficult in the limited time frame for the study.
Chapter 5 - Conclusions and Implications

The results indicate that SCL activities increase at-risk students’ levels of self-efficacy. However, it appears that this is not the only benefit of implementing SCL activities, as qualitative data suggests that overall students were more excited about their learning, more engaged (Fleener, Huhn, Huhn, & Lamb, 2006; Westbrook, & Rogers, 1995; Van de Walle & Folk, 2005; Vatter, 1992), and had their confidence in presenting and working in groups increase as well. Despite some expected difficulties the professors faced (Prosser & Trigwell, 2002; Stevenson & Sander, 2002), the study demonstrates the importance of fostering a positive learning environment for students considered at-risk, and leads future studies to dig deeper into understanding student learning, identity, and pedagogical strategies that can be taken to help improve or enhance these important aspects of the student experience, and ensure student success.

The Teacher Experience

As one of the major stakeholders of the study, it was important to explore how the professors would be affected by the implementation of student-centred learning activities. There seemed to be a number of patterns or observations that arose from the teachers’ perspective and this section will further examine them.

Overall Feelings

As a starting point in the formal interview, teachers were asked of their overall opinion of the week in order to address the research question that focuses on the professors’ experience implementing SCL. Both teachers commented about how the week was a positive one. Despite the main challenges discussed in detail below, the teachers felt that the week brought a lot of excitement and engagement to the classroom. JP said his
favourite part was the "overall energy level of the class". BY echoes these thoughts saying the "best part of the week was seeing some of the students who are not normally engaged, become engaged". This finding is in line with much of the SCL research that argues this type of teaching increases levels of engagement and motivation (Felder & Brent, 1996; Berry & Sharp, 1999; Biggs, 2003; Meece, 2003). Based on this then, it seems vital to create a positive learning environment, incorporating some of these activities, in order to engage at-risk students who are often disengaged.

Challenges

Implementing SCL activities was not without its challenges as expected and suggested within the literature (Biggs, 1999; Farrington, 1991; Barr & Tagg, 1995). The main challenge for teachers was a lack of time. In the quick chats after each lesson, as well as their formal interviews, the teachers constantly brought up the fact that they felt they were short on time. When observing, particularly on the first day, it was obvious that students did not have enough time to process and completely understand the material. JP noted that in general using concrete materials, organizing them into groups, and allowing that time to discover all takes more time, ultimately leading to less practice time. However, as students got more used to the idea of student-centred activities, it appeared that less time was needed. Both teachers noted how Day 2 was significantly smoother, and faster than Day 1, for example.

Another component to the time issue was that both teachers too were learning to teach in this new way. They had to adapt to teaching in a way they had not done before, and introducing activities that they did not come up with themselves. "Because I didn't do the lesson plans myself, I think I'd be more comfortable a second time through" (BY, interview). JP too felt this way, saying that although he was "debriefed, I have never done
this before”. Furthermore, the teachers had to largely step outside their comfort zones, attempting not to revert back to the more traditional teaching styles they were accustomed to.

**Lessons Learned**

Beyond the challenges, the week brought many lessons to the teachers as well regarding the implementation of SCL activities. Particularly important for students considered at-risk, it was noted often that these activities reached more learning styles than a more traditional approach might. Attesting to that, JP said:

> It really worked for certain people. I noticed the artist in the classroom…was really tuned into the visual stuff...so I think there were improvements for certain types of learners. Students who already know what they are doing, it doesn’t matter what you do with them, right?

BY thought it was especially helpful for some of her students as well, giving the following example; “One of the students tends to more of a kinesthetic learner, and for him I thought it was really good. The activity actually helped him to focus”. Throughout the week, she also noted that this was a “very inclusive way of getting everyone involved”.

Since it was evident to the teachers that certain types of learners did better in the student-centred lessons than they did in more teacher-led approaches, both teachers also said it made them realize the importance of including more of these activities throughout other units as well, and to continue to use these activities in the future.

> Seeing, as I said before, some of the students...who really want to learn in groups, and talk with their peers, and really hash something out, to see them excel in that environment was a reminder to me that I really want and need to get more variety, more variety of styles in my teaching. (BY, interview)

JP felt that most of the activities were successful and well appreciated by the students, but was most excited about Day 3, the lesson on absolute value. He commented that he has always
had a hard time bringing excitement to this topic, but the discovery number line activity was a
great fit for the students; it was at the right level of difficulty, but was also fun and engaging.
Consequently he believed that in his five years teaching in the program that was his “most
successful absolute value lesson I have had yet” and overall felt that the absolute value questions,
along with word problems were done best within the week.

Moving forward, the teachers agreed that they would want a more balanced approach to
their teaching. Integrating more of these student-centred learning activities with some of the
traditional methods in order to get students thinking critically about the math they are learning,
but also preparing them for inevitable assessments and college entrance exams.

Eventually over time, we still teach the fundamentals, we still really spend a lot of time
on the skills and allow people to get really comfortable with numbers, but they’re going
to have activities that really bring it to life, and allow it to sink in. (JP, interview)

**Importance of Buy-in**

It is often talked about in the literature that teachers and students alike, need to really
believe in the activities they are doing (Turnbell, 2002; Mahoney, 2009). Observations from this
study would suggest this to be true too. Over the course of the week, it was evident that one of
the teachers felt uncertain about how the students would handle being asked to come to their own
conclusions based on the activities they were encouraged to do. In fact, there was enough of a
lack of buy-in from this teacher, that some of the lesson plans were adapted in order to maintain
some level of their traditional teaching style. Unfortunately, students can often sense this
uncertainty and they themselves won’t buy-into the activities either. JP strongly believes that a
good amount of its success is based on the delivery:

It's a lot what you make of it. It's how you set it up. It's how you present it -- 'guys, we are
going to have fun doing it. This is really exciting week. We get to try something
different.' versus 'okay if you don't like it, its okay we'll do something different.'
Developing his argument, JP says that “If [the students] aren’t buying into what they are doing, and believe it is legitimate, it’s not going to work out, I don’t think”. For this reason, it is extremely important the teacher believes in the activities and the teaching approach, as well as having a set of activities that themselves are ‘legitimate’ to the students, are interesting and not too childish. Often this is a difficult task, particularly with adult learners, who, at least initially, may find frightening and pointless (Prosser & Trigwell, 2002; Stevenson & Sander, 2002). Buy-in is expected to increase when SCL approach is consistently implemented throughout the whole course and within multiple courses, a goal to move toward.

**Future Study**

In order to better understand the relationship between student-centred learning and self-efficacy further research needs to be done. In this future research, it is suggested that the time issue expressed by the teachers is more fully addressed, by including perhaps giving teachers more professional development on teaching in a SCL approach prior to delivery, as well as by introducing these types of activities in smaller doses to start, increasing in increments as time went on. Additionally, should curriculum time frames allow for it, enabling teachers to have more flexible time for such activities, could prove to be helpful as well.

Another area for future work would be in deepening the understanding of the relationship between self-efficacy and student-centred learning. Based on self-efficacy improvements made over just 4 days, it seems imperative that future studies more closely examine that relationship. They may also want to include a look at whether or not SCL activities foster a deeper understanding than traditional teacher-led approaches and whether or not this would affect students’ self-efficacy.
References


Stevenson, K. & Sander, P. (2002). Medical students are from Mars-business and psychology students are from Venus-University teachers are from Pluto? *Medical Teacher 24*(1), 27-31.


Trowler, V. (2010). Student Engagement Literature Review. Lancaster University. Available at: [http://www.heacademy.ac.uk/assets/documents/studentengagement/StudentEngagementLiteratureReview.pdf](http://www.heacademy.ac.uk/assets/documents/studentengagement/StudentEngagementLiteratureReview.pdf)


Appendices

Appendix A

Questionnaire

<table>
<thead>
<tr>
<th>Statement</th>
<th>Strongly Agree</th>
<th>Agree</th>
<th>Disagree</th>
<th>Strongly Disagree</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mathematics is useful for the problems of everyday life.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>Mathematics is something which I enjoy very much.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>I like the easy mathematics problems the best.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>4. I don’t do very well in mathematics.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>5. My mathematics teacher shows little interest in the students.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>6. Working mathematics problems is fun.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>7. I feel at ease in a mathematics class.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>I would like to do some outside reading in mathematics.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>9. There is little need for mathematics in most jobs.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>10. Mathematics is easy for me.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>11. When I hear the word mathematics, I have a feeling of dislike.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>12. Most people should study some mathematics.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>13. I would like to spend less time in school doing mathematics.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>14. Sometimes I read ahead in our mathematics book.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>15. Mathematics is helpful in understanding today’s world.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>16. I usually understand what we are talking about in mathematics class.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>17. My mathematics teacher makes mathematics interesting.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>18. I don’t like anything about mathematics.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
</tbody>
</table>
19. No matter how hard I try, I cannot understand mathematics. | 1 | 2 | 3 | 4 |
---|---|---|---|---|
20. I feel tense when someone talks to me about mathematics. | 1 | 2 | 3 | 4 |
21. My mathematics teacher presents material in a clear way. | 1 | 2 | 3 | 4 |
22. I often think, “I can’t do it,” when a mathematics problem seems hard. | 1 | 2 | 3 | 4 |
23. Mathematics is of great importance to a country’s development. | 1 | 2 | 3 | 4 |
24. It is important to know mathematics in order to get a good job. | 1 | 2 | 3 | 4 |
### Lesson 1

#### Adding and Subtracting Signed Numbers

<table>
<thead>
<tr>
<th>Minds On: 10 Min.</th>
<th>Math Learning Goals</th>
<th>Action: 60 Min.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Determine through investigations and group work the rules for adding and subtracting integers</td>
<td>• Determine through investigations and group work the rules for adding and subtracting integers</td>
</tr>
<tr>
<td></td>
<td>Solve problems involving addition and subtraction of signed numbers</td>
<td>• Solve problems involving addition and subtraction of signed numbers</td>
</tr>
<tr>
<td></td>
<td>Use manipulatives in groups to investigate and communicate their understanding of adding and subtracting integers</td>
<td>• Use manipulatives in groups to investigate and communicate their understanding of adding and subtracting integers</td>
</tr>
</tbody>
</table>

| Consolidate/Debrief: 50 Min | |
|-----------------------------| |
| Total = 120 Min.            | |

#### The Big Picture

- Students must have previous knowledge on whole numbers including add/subtract and BEDMAS
- The lessons will begin with an introduction of an integer on a number line
- The first day students will learn the fundamentals of adding and subtracting integers, before moving to multiplying and dividing, absolute value and scientific notation
- Students will learn mostly from student centered approaches, with the teacher as a guide, and peers to help

#### Minds On...

### Whole Class ➔ Teacher led Introduction

- Teacher will introduce the term “integer” using a number a line and asking students to think of real life applications of negative numbers
- Teacher will then led introduction on how counters can be used to represent numbers
- [http://nrich.maths.org/5947](http://nrich.maths.org/5947) helpful link
- Use a table to show different ways to represent the same number with counters (*see Table one in the attached page*). Explain that this representation will help with their next task.

#### Action!

### Small Groups ➔ Inquiry

<table>
<thead>
<tr>
<th>Assessment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time</td>
</tr>
<tr>
<td>Opportunities</td>
</tr>
</tbody>
</table>
- **Hand out self-efficacy questionnaire** *See attached page*
- Have students get into groups. Each group will be given a handout of 10 questions in which they are required to complete together, using provided counters and Bristol board. *See Attached page.*
- Questions are each intended to make the students think about adding and subtracting integers
- Once the groups have worked out solutions they are required to put one question on chart paper and prepare for a brief presentation

<table>
<thead>
<tr>
<th><strong>CONSOLIDATE</strong>&lt;br&gt;DEBRIEF</th>
<th><strong>Whole Class ➔ Presentations</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Each group is required to present one of their questions and to fully describe how they determined using the counters (or number line) why it was true</td>
</tr>
<tr>
<td></td>
<td>Questions from the remainder of the class are encouraged</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Whole Class ➔ Teacher led Debrief</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Teacher will debrief understanding by using the hot air balloon, or happiness explanation and pulling out the rules of add/sub</td>
</tr>
<tr>
<td><strong>Hand out self-efficacy questionnaire</strong> <em>See attached page</em></td>
</tr>
<tr>
<td>Ask students to answer 8 quick adding/subtracting questions to check understanding. <em>See attached page: Debrief Questions</em></td>
</tr>
<tr>
<td>If time, play card game where black cards are positive, red negative</td>
</tr>
</tbody>
</table>
Attached Pages

Table 1

Created on board, having students guess why each column is grouped the way it is

<table>
<thead>
<tr>
<th>All represent the Number 4</th>
<th>All represent the Number -2</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image1.png" alt="Image of groups of numbers representing 4 and -2" /></td>
<td><img src="image2.png" alt="Image of groups of numbers representing 4 and -2" /></td>
</tr>
</tbody>
</table>
Student Handout

Use your counters, rough paper and some problem solving to answer the following questions.

a) $8 - 6 =$

b) $3 - 5 =$

c) $3 + (-5) =$

d) $(-4) + 7 =$

e) $7 + (-4) =$

f) $7 + (-10) =$

g) $-4 - 3 =$

h) $4 - (-3) =$

Be sure to be thinking of the general understanding too; for example, how would you add a negative.
i) \( 4 - (-9) = \)  

j) \( -8 - (-3) = \)  

k) \( -5 + 3 + (-7) = \)  

Self-efficacy Questionnaire

ID: 1 - _____________________   Date: ___________________

Do not mathematically try to answer these questions. Simply answer how confident you are to answer the given question, if you did have to answer it.

<table>
<thead>
<tr>
<th>My confidence in answering this question:</th>
<th>Not confident at all</th>
<th>A little confident</th>
<th>Quite confident</th>
<th>Completely confident</th>
</tr>
</thead>
<tbody>
<tr>
<td>Subtracting for example: 6 - 4</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>Subtracting for example: 7 - 9</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>Adding a negative number: 3 + (-4)</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>Adding a positive number to a negative number: (-4) + 7</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>Subtracting a negative number from a positive: 5 - (-2)</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
</tbody>
</table>
Do not mathematically try to answer these questions. Simply answer how confident you are to answer the given question, if you did have to answer it.

<table>
<thead>
<tr>
<th>My confidence in answering this question:</th>
<th>Not confident at all</th>
<th>A little confident</th>
<th>Quite confident</th>
<th>Completely confident</th>
</tr>
</thead>
<tbody>
<tr>
<td>Subtracting for example: 6 - 4</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>Subtracting for example: 7 - 9</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>Adding a negative number: 3 + (-4)</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>Adding a positive number to a negative number: (-4) + 7</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>Subtracting a negative number from a positive: 5 - (-2)</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>Subtracting a negative from a negative: -4 - (-1)</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
</tbody>
</table>

Debrief Questions

Have the students write the answers to these 6 questions individually. After they are taken up, ask the students how many did as well as they expected, how many did worse, and how many did better.

a) -8+3
b) 9 - (+2)
c) 12 – (-8)
d) -11 – 2
e) 5 – 8
f) -7 – (-3)
Lesson 2

### Multiply and Divide Signed Numbers

<table>
<thead>
<tr>
<th>Minds On: 10 Min.</th>
<th>Math Learning Goals</th>
<th>Academic Upgrading</th>
</tr>
</thead>
<tbody>
<tr>
<td>Action: 60 Min.</td>
<td>• Determine through investigations and group work the rules for multiplying and dividing integers</td>
<td></td>
</tr>
<tr>
<td>Consolidate/Debrief: 20 Min</td>
<td>• Solve problems involving multiplication and division of signed numbers</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Use manipulatives in groups to investigate and communicate their understanding of multiplying and dividing integers</td>
<td></td>
</tr>
<tr>
<td>Total = 120 Min.</td>
<td>Materials</td>
<td>Red and Blue counters</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Bristle board</td>
</tr>
</tbody>
</table>

#### The Big Picture

- Students must have previous knowledge on whole numbers including multiply/divide and exponents
- The lessons will begin with a check for understanding of the lesson on add/subtract integers
- Students will learn the fundamentals of multiplying and dividing, before moving onto absolute value and scientific notation
- Students will learn mostly from student centered approaches, with the teacher as a guide, and peers to help

#### Assessment

<table>
<thead>
<tr>
<th>Time</th>
<th>Opportunities</th>
</tr>
</thead>
<tbody>
<tr>
<td>10 min</td>
<td>Questions allow students to individually see if they understand</td>
</tr>
</tbody>
</table>

#### Minds On...

**Whole Class ➔ Teacher led Introduction**

- Teacher will give 6 quick questions on adding/subtracting integers as a check for understanding
- Have students do a quick Think, Pair, Share answering: “is there anything I am still unsure of” and take up as a class

#### Action!

**Small Groups ➔ Inquiry**
Have students get into groups of approximately 4. Each group will be given a handout of 4 questions in which they are required to complete together, using provided counters and bristle board. *See Attached page: Student handout #1.*

Questions are each intended to make the students think about multiplying and dividing integers.

Once the groups have worked out solutions, students will be asked what they have found about multiplying a negative and a positive together.

### Teacher Led → Demonstration

- Have someone demonstrate on the board how $3 \times -2$ is equal to $-6$
- Then show how $-2 \times 3$ can be thought of as *taking away* 2 groups of 3 from zero, and that it still equals $-6$. *See attached: Explanation*
- Ask why it makes sense that $-2 \times 3 = 3 \times -2$

### Small Groups → Inquiry

- Ask students to use the logic from above demonstration to work out what a negative times a negative could be. *See attached: Student Handout #2.*

### Whole Class → Presentations

- Each group is required to present one of their questions and to fully describe how they determined using the counters that a negative multiplied by a negative is a positive, or a negative multiplied by a positive is a negative.
- Questions from the remainder of the class are encouraged.

### Whole Class → Teacher led Debrief

- Teacher will debrief understanding by giving the basic rules that two numbers with the same sign being multiplied or divided gives a positive, and two numbers with opposite signs being multiplied or divided gives a negative result.
- Ask students to answer 8 quick adding/subtracting questions to check understanding.
Explain to students that you can write zero like this:

\[
\begin{array}{cccccc}
  + & + & + & + & + & + \\
- & - & - & - & - & - \\
\end{array}
\]

And if you are taking away 2 groups of 3, then:

\[
\begin{array}{cccccc}
  + & + & + & + & + & + \\
  \times & \times & \times & \times & \times & \times \\
- & - & - & - & - & - \\
\end{array}
\]

And you are left with:

\[
\begin{array}{cccccc}
- & - & - & - & - & - \\
\text{or } -6 \\
\end{array}
\]

Which is just like 3 groups of -2:

\[
\begin{array}{cccc}
- & - & - & - \\
\text{or } -6 \\
\end{array}
\]

**Student Handout #1**

Use your counters, rough paper and some problem solving to answer the following questions. Once you have a good understanding, answer these questions formally, drawing counters to explain how to answer these questions on the bristle board.

1. 3 x 5
2. 4 x 2
Student Handout #2

Use your counters, rough paper and some problem solving to answer the following questions. Once you have a good understanding, answer these questions formally, drawing counters to explain how to answer these questions on the bristle board.

1. \(-2 \times -3\)
2. \(-5 \times -4\)
3. \(-6 \times -1\)
4. \(6 ÷ 2\)
5. \(-6 ÷ 2\)
## Lesson 3

### Exponents of Negative Numbers and Absolute Value

<table>
<thead>
<tr>
<th>Minds On: 10 Min.</th>
<th>Math Learning Goals</th>
</tr>
</thead>
<tbody>
<tr>
<td>Action: 60 Min.</td>
<td>- Determine through investigations and group work the rules for negative numbers that have exponents (positive exponents only)</td>
</tr>
<tr>
<td>Consolidate/</td>
<td>- Communicate their understanding of absolute value through real life examples</td>
</tr>
<tr>
<td>Debrief: 20 Min.</td>
<td></td>
</tr>
<tr>
<td>Total = 120 Min.</td>
<td></td>
</tr>
</tbody>
</table>

### The Big Picture

- Students must have previous knowledge on whole numbers including multiply/divide and exponents
- The lessons will begin with a check for understanding of exponents
- Students will learn the fundamentals of exponents, before moving onto absolute value and scientific notation
- Students will learn mostly from student centered approaches, with the teacher as a guide, and peers to help

### Assessment

#### Time Opportunities

- **Whole Class ➔ Teacher led Introduction**
  - Teacher will introduce how to input negatives, exponents and brackets into the calculator
  - Teacher will revise what an exponent is, and what it means, and quickly go over the rules for multiplying integers
  - Questions allow students to individually see if they understand
  - 10 min

- **Individual ➔ Inquiry**
<table>
<thead>
<tr>
<th>Activity</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Think, Pair, Share → Discuss</strong></td>
<td>Teacher will ask students to think, pair and then share why some of the answers come out negative and others positive. See if they can come up with an overall rule for when they will come out negative, and when positive.</td>
</tr>
<tr>
<td><strong>Individual → Inquiry</strong></td>
<td>Have students individually find the answers to 5-10 questions with negatives outside of the brackets. See Attached Page: Student handout #2</td>
</tr>
<tr>
<td><strong>Think, Pair, Share → Understand</strong></td>
<td>Have the students discuss why none of those answers are positive</td>
</tr>
<tr>
<td><strong>Whole Class → Discuss</strong></td>
<td>What is the difference between (-3^2) and ((-3)^2) then?</td>
</tr>
<tr>
<td><strong>Small Groups → Inquiry</strong></td>
<td>Have students do some real life absolute value questions, understanding that the sign is sometimes irrelevant</td>
</tr>
<tr>
<td></td>
<td>*Note this should be done after the break and teacher should explain we are switching gears a little bit, doing something a little new</td>
</tr>
<tr>
<td></td>
<td>Once questions are answered, have students put up their answers on the number line on the board</td>
</tr>
<tr>
<td><strong>Teacher Led → Inquiry</strong></td>
<td>Teacher will have pieces of paper with absolute value questions on them, and will place them in the appropriate place on the number line. The idea is that they will learn it is the result of what is in the absolute value that is positive. See attached page: Teacher Demonstration</td>
</tr>
<tr>
<td></td>
<td><strong>Think, Pair, Share →</strong> in pairs students will be asked to try to figure out why each question is in the correct place.</td>
</tr>
<tr>
<td><strong>Consolidate Debrief</strong></td>
<td><strong>Individual → Plenary</strong></td>
</tr>
<tr>
<td>------------------------</td>
<td>--------------------------</td>
</tr>
<tr>
<td></td>
<td>Students will be asked to complete an exit card on their learning done for the day, and hand it in to the teacher. <em>See attached page: Exit Card</em></td>
</tr>
</tbody>
</table>
Attached Pages

Student Handout #1

Use your knowledge about exponents and multiplying integers to determine these questions by hand.

5. \((-3)^2\)
6. \((-2)^3\)
7. \((-1)^5\)
8. \((-7)^2\)

Now use your calculator to finish the remaining questions.

9. \((-16)^4\)
10. \((-22)^6\)
11. \((-15)^3\)
12. \((-5)^8\)
13. \((-6)^9\)
14. \((-1)^{100}\)
15. \((-1)^{103}\)

Student Handout #2

Use your calculator to work out the following answers. Remember to type it into the calculator exactly as you see it.

1. \(-4^7\)
2. \(-5^3\)
3. \(-15^3\)
4. \(-20^6\)
5. \(-11^5\)

Student Handout #3

1. A submarine and an airplane are both trying to get to the surface of the ocean. Interestingly, they are both moving at the same speed as well. If the submarine is -45m from the ocean, and the airplane 42m, who will reach the surface first?
2. You are in a race, with the finish line as “zero” You are 50 ft behind the finish line, your friend Sameer is 30 ft behind you, and your all-star friend Sasha is 100 ft into their victory lap. How far are you from the finish line? How far is Sasha from Sameer
3. The temperature on December 12th last year was -14°C. If it is -3°C how much change was there?
4. Tiger Woods is at -18, and Phil Michelson is -16. How many strokes behind is Phil from Tiger?
5. Brad Marchad is -20 on the year and Mark Fraser is +14. What is the difference in their rating?

Teacher Demonstration

1. $|-5 + 7|$
2. $|4 - 6|$
3. Etc

Exit Card

Recall three important ideas from today’s class

1. N
2. N
3. N

What confused you about today’s lesson?

When would you ever use absolute value?

Answer the following:

1. $(-4)^3$
2. $(-1)^{10000}$
3. $|{-9}|$
4. $-|{-7}|$
5. $|-8 - 3|$
### Lesson 4

**Scientific Notation + Review**

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Math Learning Goals</td>
<td>Math Learning Goals</td>
<td>Math Learning Goals</td>
<td>Math Learning Goals</td>
</tr>
<tr>
<td>• Determine through investigations and group work the rules for multiplying and dividing integers</td>
<td>• Solve problems involving multiplication and division of signed numbers</td>
<td>• Use manipulatives in groups to investigate and communicate their understanding of multiplying and dividing integers</td>
<td></td>
</tr>
<tr>
<td>Materials</td>
<td>Materials</td>
<td>Materials</td>
<td>Materials</td>
</tr>
<tr>
<td>Tarsia</td>
<td>Tarsia</td>
<td>Tarsia</td>
<td>Tarsia</td>
</tr>
<tr>
<td>Always/Sometimes/Never</td>
<td>Always/Sometimes/Never</td>
<td>Always/Sometimes/Never</td>
<td>Always/Sometimes/Never</td>
</tr>
</tbody>
</table>

**The Big Picture**

- Students must have previous knowledge on whole numbers including multiply/divide and exponents
- The lessons will begin with a check for understanding of the lesson on add/subtract integers
- Students will learn the fundamentals of multiplying and dividing, before moving onto absolute value and scientific notation
- Students will learn mostly from student centered approaches, with the teacher as a guide, and peers to help

**Assessment**

**Minds On...**

**Whole Class ➔ Teacher led Introduction**

- Explain that there are more than one way to write numbers. Teacher will put a table on the board and start placing certain numbers (both in scientific notation and regular notation) on either the right or left hand side. Idea is to have Large Numbers on one side and Small Numbers on the other
- Keep adding numbers until the students are able to classify the left and right hand side as Large and Small Numbers.

**Action!**

**Small Groups ➔ Inquiry**

- Group and students ability
<table>
<thead>
<tr>
<th>Consolidate Debrief</th>
<th>Whole Class ➔ Discussion</th>
</tr>
</thead>
<tbody>
<tr>
<td>− Have students in groups look specifically at $4.9 \times 10^5$ and get them to work out using what they know about exponents and multiplying, why this is a large number</td>
<td></td>
</tr>
<tr>
<td>− What could the short hand “rule” be (move the decimal)</td>
<td></td>
</tr>
<tr>
<td>− What kinds of conclusions can be made about $4.9 \times 10^5$ given the table and your new rule</td>
<td></td>
</tr>
<tr>
<td>− Students to complete a Scientific Notation Tarsia. See attached page: Tarsia</td>
<td></td>
</tr>
<tr>
<td>60 min</td>
<td>to solve the questions will be observed to check understanding</td>
</tr>
<tr>
<td>Discussion questions will help to check understanding</td>
<td></td>
</tr>
</tbody>
</table>

Teacher leads review discussion and has the signs “Never/Sometimes/Always” up on the board. Student will be given statements they must decide are Never true, Sometime true, or Always true. See attached page: Never/Sometimes/Always | 50 min |
Appendix C

Research Study: The Effects of Student-Centred Learning on Students’ Self-Efficacy in College Level Classrooms Considered At-Risk

[May __, 2013]

Dear Student,

You are being invited to participate in a research study entitled: “The Effects of Student-Centred Learning on Students’ Self-Efficacy in College Level Classrooms Considered At-Risk.” This research is being conducted by Stephanie McKean and supervised by Dr. Doug McDougall, of the University of Toronto.

The purpose of this study is to determine the affects of teaching mathematics to students, using teaching approaches more focused on providing meaningful activities that allow students to better understand the material. We are inviting students enrolled in the academic upgrading mathematics courses at George Brown College (GBC) to participate.

You were not placed in this section of math because you were selected as an individual. Instead your whole section was selected, in order to better understand how students in these sections learn. Both the researcher and your teacher will work collaboratively on creating activities that will help you learn the material necessary for the course in ways that are less directed by the teacher and encourage you to be more engaged. The goal is simply to measure the benefits of using these teaching methods in your and your classmates’ belief in your own abilities.

Participation in this study involves the completion of an initial questionnaire, a math attitude inventory, and a math test, which will take approximately 60 minutes total, and will take place at the start your classes. You will also be invited to complete a second math test at the end of the math course a week before your final exam. Completion of the first questionnaire and the pre-tests does not obligate you to complete the post-test.

Your class will also be observed wherein the primary researcher attends your class and makes note of the activities that take place over the two hour period. The researcher will not identify you, or your class in any way.

Participation in any aspect of this study is completely voluntary and confidential. You are free not to respond to any questions you choose, and to not participate in any of the pre-test/post-test activities. The goal of the project is to assess the changes in students’ belief of their abilities based on the particular form of instruction you will be receiving, not to evaluate your abilities in mathematics. The pre and post-tests will not be graded until after your course is complete, and will not affect your course mark in any way. Refusal to participate in this study will involve no penalties of any kind. You can also withdraw from the study at any time without fear of repercussions. Any data collected at the point of withdrawal will be destroyed and not included in the study. If you consent to participate in the study,
any information concerning you will be kept confidential by the Principal Investigator, and your name will not appear in any reports of the study. To ensure confidentiality, only the Principal Investigator will have the link between your names and the ID numbers that appear on the materials you hand in. The name of the participants and any other information which could specifically identify a particular individual will be removed from all transcripts; therefore it will not be possible to identify any individual respondents.

As per the University of Toronto and George Brown College policies, all data will be kept in a locked cabinet in the Principal Investigator’s office for five years after which all surveys and tests will be destroyed in accordance with the policy. Only the researcher will have direct access to the information and grouped responses will be used and reported in a format that will not identify you in any way.

If you choose to participate in this study, you will be assigned a unique number that will be stamped on all material you complete. This is in order to ensure your confidentiality within the study. If you complete the starting package, along with consent form it is implied that you have consented to all aspects of the research study. To reiterate, this study is completely voluntary and you are able to withdraw at any point with no consequences to you.

It is believed that you will directly benefit from this study since the activities being used within your classroom will be collaboratively designed in your interest in order to better your learning. Additionally, your participation may have relevance for future students at George Brown College and beyond. Findings from this study may be used for future program planning and course development, and publication within the field of education.

This study has been approved by the George Brown College Research and Ethics Board (REB) and the University of Toronto Research and Ethics Board. Results of the study will be available via the researcher upon request, once the study report has been completed. If you have any questions regarding your rights as a participant in the study, you may contact Sarah Evans, Chair of GBC’s Research and Ethics Board.

In the event that you have any questions about this research, now or in the future, you may contact Stephanie McKean, Principal Investigator, at stephanie.mckean@mail.utoronto.ca or (416) 415-5000 ext 3103.

Thank you for your time and consideration to participate

Sincerely,

___________________
Stephanie McKean
Principal Investigator
Appendix D

For further information:
Stephanie McKean
Graduate Student
Faculty of Curriculum, Teaching and Learning
University of Toronto
416-415-5000 x 3103
Email: stephanie.mckean@mail.utoronto.ca

Supervised by Dr. Doug McDougall

Nov 2, 2013

The Effects of Student-Centred Learning (SCL) on Students' Self-Efficacy in College Level Classrooms Considered At-Risk

I, (please print)__________________________________________ have read and understood the information on the research project “The Effects of Student-Centred Learning (SCL) on Students' Self-Efficacy in College Level Classrooms Considered At-Risk.” which is to be conducted by Stephanie McKean and all questions have been answered to my satisfaction.

I understand that participation in this research is voluntary. I understand that the project will be conducted in accordance with the Information Letter, a copy of which I have retained for my records.

I understand I can withdraw from the project at any time, without penalty, having all data collected at that point destroyed and not included in the study, and do not have to give any reason for withdrawal.

I consent to:

- The completion of an initial questionnaire, a math attitude inventory, and the CAAT math test
- On-going brief self-efficacy assessments
- The completion of a second CAAT math test
- Being observed by the researcher during class periods where the teaching methods at hand are implemented

Print Name: _____________________________________

Signature: _______________________________________

Date: _________________________________________