Inquiry Based Teaching Methods in a Mathematics Classroom

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Teaching professionals in the area of mathematics have been engaged in colloquial discussion for decades regarding the most effective way to teach students. Teachers, who use a traditional model, practice a top-down, deductive approach. Traditional instruction begins with the teacher introducing principles and theories, models problem solving through examples by applying the principles and theories, then further gives students questions to work on independently (Prince & Felder, 2006). There are also teachers who favor an inquiry-based teaching model. Inquiry-based teaching begins with presenting a problem or question to the students, and then the students analyze and gather data to construct an answer (Kuhn, Black, Keselman, & Kaplan, 2006). Inquiry-based teachers guide their students, encourage when necessary, clarify concepts, mediate when students are working in groups, and sometimes lecture (Prince & Felder, 2006). Albanese and Mitchell (1993) discuss that students are more inclined to learn a concept when it is understood when the concept is going to be applicable.

 Kirschner, Sweller, and Clark (2006) argued that the students require teachers to explicitly teach topics and complete examples in front of the class in order to learn. There is merit to the argument by Kirschner et al. (2006). This idea translates into many of the Alberta curricular outcomes (Alberta Education, 2004). There are some concepts that are best taught traditionally in order to avoid confusion or frustration. The concepts that are best traditionally taught are usually the non-negotiable outcomes of the curriculum. Non-negotiable outcomes are the outcomes that students need to know to be successful at the next level. The next level may be the next grade, post-secondary, or career. An example of a non-negotiable outcome in mathematics would be dividing. Dividing is necessary when understanding how to factor. Furthermore, factoring is necessary when solving rational equations or quadratics. To expect students to problem solve their way through quadratics and rational equations they need to retrieve the process of how to divide numbers from their long-term memory (Kirschner et al., 2006). Therefore, a traditional model would give the instructor the opportunity to explicitly teach the outcomes of the curriculum and possible learning devices that will help students memorize information. A learning device might include a rhyme, song, or mnemonic; any method that a student will be able to relate to in order to make concept meaningful.

 As mentioned earlier, another method to construct knowledge is through inquiry-based instruction. Inquiry-based teaching facilitates learning by providing guidance and extensive scaffolding, because the students have an opportunity to collaborate with each other to answer authentic problems. Through active collaboration, students learn the majority of the content and develop interpersonal and reasoning skills (Hmelo-Silver, Duncan, & Chinn, 2007). Presenting new information in the form of a situation or problem can make the content and experience more relatable to the student, which will increase the chance of the information being stored in long-term memory (Prince & Felder, 2006). Inquiry-based learning encourages deep understanding of content and can increase test results according to Kirschner et al. (2006). Deep understanding is defined as understanding new information based on prior knowledge, thinking critically about new information rather than simply accepting statements, and taking charge of one’s own learning (Felder & Brent, 2004).

 It is important that a teacher does not limit him or herself to only one type of teaching style. There is a non-mutually exclusive relationship between traditional teaching and inquiry-based teaching. Both teaching methods have significance and value. Teaching and learning require some form of traditional instruction and inquiry-based instruction (Prince & Felder, 2006). It is at to the teacher’s discretion as to when to implement a necessary teaching method based on the content and the previous knowledge base of the students.

**Significance**

Alberta’s performance on the Programme International for Student Assessment (PISA) shows mathematics results have declined from being second in the world in 2003 to seventeenth in 2012. PISA is a global organization that assesses 15-year old students from randomly selected schools to complete problems that assess students’ ability to read and complete problems in mathematics and science. Although Alberta remained above the average in 2012 the results are far from impressive in comparison to Alberta’s potential as seen in 2003. In 2003, 7.4% of students in Alberta were considered to be below level 2 in mathematics. Falling below level 2 refers to the students who are innumerate. This statistics more than doubled in 2012 to 15.1% of students being categorized as below level 2. On the opposite end of the spectrum there are the students that are classified as levels 5 and 6, these are the students who are considered to be excellent with numbers. In 2003, 26.8% of Alberta’s students were considered to be level 5 and 6. In 2012, the percentage of students who were considered to be level 5 and 6 dropped to 16.9%. The difference from 2003 to 2012 of level 5 and 6 students in mathematics dropped 9.9%.

The Alberta mathematics curriculum in elementary and middle schools in 2003 was focused on rote memorization of basic facts, and the teacher modeled how to complete mathematics problems. There was a mathematics curriculum change in 2007 that focused more on discovery and constructivist teaching. Students were given the freedom to explore the multiple ways to complete math operations and problems. The purpose of this curriculum change was to allow students to choose the most relevant, best method for the individual student to make math more meaningful. However, without a solid foundation of the basic math facts, the new curriculum caused students to be frustrated, confused, and in some cases innumerate as shown by the statistics. This problem has surfaced at a media level because parents are outraged by their children’s lack of ability to complete basic mathematics. In fact, a small-town physician and mother from Calmar has spoken on CBC Radio and begun a province-wide petition (Staples, 2014). The purpose of the petition was to encourage the Alberta government to emphasize basic math skills in the curriculum. The mother from Calmar found that her daughter’s math skills were not strong enough and the curriculum was too complex. The curriculum at the elementary level especially focuses on students developing personal strategies to solve math problems rather than mastering the basic facts.

Alberta was not wrong in believing that inquiry-based learning is an effective strategy in mathematics. However, inquiry-based learning can only be implemented when students have mastered the prerequisite skills and stored these skills in their long term memory (Kirschner et al., 2006). Also, there has to be a purpose to why the mathematical skill must be learned. Otherwise the motivation to learn from the student will be lost.

**Purpose**

The purpose of this investigation is to determine how inquiry-based teaching methods affect various ability levels in a grade ten math classroom. Alberta Education has fully adopted and implemented the inquiry-based learning approach. In 2004, Alberta Education issued an extensive teaching guide for implementing inquiry-based learning in all grade and subject levels. The guide argued that inquiry-based learning has the ability for students to have more positive, independent learning experiences that allow them to explore their creativity (Kühne, 1995). Alberta Education (2004) states that in order for inquiry-based learning to change there has to be a culture shift in the classroom and school. Inquiry-based learning has to be made an instructional priority. Through inquiry-based instruction the questions can be enhanced for higher levels of understanding. Silver, Mesa, Morris, Star & Benken (2009) argue that most math pedagogy and tasks are catered to lower levels of thinking such as recalling and memorizing rather than deep understanding of mathematics. Teaching for a deeper understanding requires teachers to encourage students to explain their process in multiple way and creating connections to real-world problems.

The relationship between a students’ mathematical success prior to grade ten and the teaching method given was observed. The effect of traditional and inquiry-based teaching on students who are academically successful and compared to those who are less academic in mathematics was analyzed. An assessment was given at the beginning of the semester to distinguish those who are academically inclined in mathematics. The assessment was composed of questions that students are required to know in order to be successful in the Alberta Education grade ten math curriculum. These prerequisite skills are outlined in the Alberta Education curriculum and are labeled as prior knowledge. In this study a student who is academically successful was a student who can achieve higher than a 60% on an assessment of the prerequisite skills necessary for a grade ten mathematics. A less academically successful student was one who receives less than a 60% on the assessment. Although a mark of 60% seems low, this assessment was administered two days after the students came back from summer vacation. Many of the students had made errors on the test that they probably would not have made if they had practiced their math skills prior to taking the test. If the test was administered to the students at the end of grade nine the standard for a high achieving student would have been greater than 60%.

The grade ten math curriculum in Alberta has been a struggle for many students since it was implemented in 2010. The failure rates in grade ten math have been at an all time high. One of the major changes made to the grade ten math curriculum is that the students are no longer streamed into different math levels as they were in the previous curriculum. All students who pass grade nine are put into the same math class. The name of this course is called Math 10C, where the C stands for combined. This course was developed to ensure that common math standards were met prior to going to the next level of math. Students who perform well in Math 10C (>60%) carry on to Math 20-1. Math 20-1 is more mathematically intense and meant for the students who will eventually need Calculus in order to go onto the next level. Those students who receive a passing mark but also a mark less than 60% will be required to go into Math 20-2. The -2 math is for those students that will not need math as perquisite course into post-secondary but still have plans to eventually acquire some type of post-secondary degree to go into their field of choice. Theoretically, Math 10C made sense. However, teachers struggled to differentiate their lessons to meet all of the needs of their students while still teaching a mathematically intense course. There is a divide between the students who just passed math nine and those who accelerate in math. There is also a disconnect between the math nine curriculum in Alberta and the math ten curriculum. There are outcomes in math nine that are not necessary to know in math ten. There are also prerequisite skills necessary for math ten that are not explored at the necessary depth in math nine for students to be successful given the time frame of a grade ten semester. Many teachers across the province are frustrated with the students’ lack of understanding of the math ten curriculum. Healthy balances of how to effectively teach the math ten outcomes to the student’s varying abilities are needed.

**Summary**

 There is research that supports both traditional and inquiry-based teaching methods. Both methods can be used in a mathematics class depending on the curricular outcome. Some objectives require plenty of teacher guidance while other objectives can be researched by the student. An obstacle when teaching grade tens was their lack of basic mathematical facts as outlined by the PISA results. The missing or lack of prerequisite knowledge for the grade ten curriculum was addressed before teaching the grade ten math outcomes. Determining these holes was accomplished by reviewing the assessment given at the beginning of the year. Considering the effects of the teaching methods on the high and low academic students in the mathematics area was the focus.

**Chapter II - Review of the Literature**

 Determining the most appropriate balance of pedagogical methods in the mathematical classroom is a hot topic. It has caused much debate and drastically different opinions have surfaced as a result of educational conversations and published work.

**Three Strikes Against Only Discovery-Based Learning**

In the 1960s Bruner (1961) performed an experiment with three comparison groups: pure discovery (no teacher guidance or help), guided discovery (teacher provides hints, feedback, coaching, etc.), and an expository group (where the teacher provides the answer and problem at the same time). Of the three groups the completely discovery group performed the worst. Students require some form of guidance when discovery-based learning to ensure that they meet the curricular outcome (Shulman & Keisler, 1966). Determining how much guidance to provide to students is a difficult to determine (Mayer, 2004).

 Students need to make sense of the material by sifting through all information to determine what is important, organizing the relevant information, and make sense of it based on the students’ cognitive architecture (Mayer, 2003). Reed (2006) defines cognitive architectures as cognitive operations and memory stores and codes. Therefore, conversations providing students with feedback are insignificant without full student understanding of the task (Mayer, 2004). For an average fifteen-year old in a grade ten math class there is little understanding of why or how the math is significant. They are capable of grasping the basics of the curriculum the concepts in the Math 10C curriculum have little to no connection to real-word situations. This is a challenge for math teachers at the grade ten level to enhance and apply understanding of the concepts.

 When Clements and Merriman (1988) investigated teaching methods in computer programming courses (computer programming has a strong relation to math language and understanding) the pure discovery method showed the weakest results establishing that students will not have an understanding of programming language with the absence of prerequisite skills necessary for computer programming. To master a mathematical concept, it is necessary to have a solid understanding of the prerequisite knowledge. This is an obstacle when all students have different educational experiences coming into high school. Trying to encourage a student to discover a mathematical concept without a solid understanding of the previous skills necessary is difficult.

**Social Networks Meet Inquiry-Based Learning**

Kong and Song (2014) studied a school in Hong Kong and explored the effects of inquiry-based learning in a primary school setting. They identified the importance of teachers needing the necessary knowledge and training to execute proper inquiry-based learning effectively by having effective training in order to have a seamless learning experience for the students. There are three types of inquiry-based learning: structured, guided, and open inquiry. Structured inquiry has the most teacher involvement and open inquiry has the least (Colburn, 2000). Structured inquiry is best for the young learner or a learner who is most familiar with traditional methods.

To balance the two inquiry approaches, Kong and Song (2014) developed a 5E inquiry-based pedagogical model as follows: (a) “engage” in inquiry topics and questions, (b) “explore” the inquiry methods and processes, (c) “explain” the inquiry analyses and outcomes, (d) “evaluate” the inquiry processes and outcomes and (e) “extend” the inquiry topics and questions. The process is cyclic and progressive but not linear, and may not involve all of the components in each learning cycle. (p.129)

 The students completed the explain stage of the 5E process by posting discoveries and asking questions though the Edmodo website. This form of social media allowed students to get teacher responses quickly and encouraged peer collaboration (Kong & Song, 2014). Edmodo is a safe, educational social networking site. Edmodo allows teachers to create classes where students can post their findings safely and the teacher can award the students badges based on their posts and participation. By using Edmodo students are also able to reflect and provide pictures of their recently acquired knowledge or findings. Metacognitive skills are best developed by students who have the opportunity to monitor and reflect on their learning and inquiry strategies (Lin & Lehman, 1999).

Song and Kong (2014) had students submit knowledge onto the Edmodo website that was copied and pasted from another website and identify from where the source came. Very similar to other teaching styles and methods it is necessary to equip students with the skills necessary to complete projects to avoid plagiarism or missing the learning outcome altogether.

Kong and Song’s (2014) found significant learning gains for the unit for which they gathered data. The pre-average score of the unit was 11.65 while the post-average score was 22.50, p<0.05. They argued that the students did have a strong knowledge of the content area and most of the marks docked were due to not using the proper Chinese characters when writing their work. They also point out that the advantage of using social media throughout an inquiry-based project is that students can work at their own pace on projects where the difficulty can change based on the individual student.

**Teaching Methods in a Rural Setting**

 It has been shown that the USA is not at the same level of education in comparison to other countries on a global scale in the field of mathematics. The USA was ranked 36th internationally on the 2012 mathematics PISA results with an average score of 481. The overall average of the PISA scores for those countries that participated was 494. One the 2012 PISA results document, the USA was categorized as a country with a mean share of top performers that was below the Organization for Co-Operation and Development (OECD) average and had a share of low achievers above the OECD average. The USA has also been under scrutiny because the curriculum is not providing students with the skills to be successful and competitive after grade school. In response to these criticisms Grady, Watkins, & Montalvo (2012) completed a seven year study to compare and contrast three different teaching methods in rural schools in Illinois, USA. Three different school districts were included in the study. Each school district taught the mathematics curriculum by three different types of pedagogical approaches. One district taught the curriculum traditionally, another taught the curriculum using constructivist instruction, while the last district taught the curriculum using both constructivist and traditional teaching methods. Constructivist teaching is one way to achieve inquiry based learning. Grady, et al. (2012) defined constructivist learning as an active process where both teachers and students are constantly learning. Furthermore, constructivism can be defined as the teachers and students interacting through words an actions to create meaningful connections (Cobb, 1988).

 No statistical difference was shown between the three methods. The district that used both traditional and constructivist teaching did have the highest results for students who had individualized educational plans.

The statistical analysis was based on the Illinois Standards Achievement Test scores. Kohn (2000, p. 5) argues that a single achievement test is not the best indicator of a student’s knowledge and whether deep understanding was accomplished. A student can randomly guess answers or the student might not have an interest in doing well on the test. Having the students complete a performance task as well as the achievement test would be a better determiner of the best method of instruction. Essentially, the researchers were expecting the constructivist learner to be more successful on a traditional style of exam but those results did not appear.

 The researchers encouraged future researchers to analyze other grade levels for different teaching methods. They also pointed out that teachers using the constructivist teaching styles were not closely monitored. Whether the execution of the constructivist lessons was given properly was not confirmed. Much of the information researched by Grady, et al(2012) can be translated to a rural Alberta setting.

**All Hands on Deck**

 In order to close the grade discrepancy between the United States of America and similar countries in the math and science fields effective instructional leadership is necessary (Leithwood, Louis, Anderson, & Wahlstrom, 2004). This requires principals to make the shift from a building administrator to a leader of learning. Principals are involved in the development, implementation, and data analysis of student results on formative and summative assessments (Brookhart & Moss, 2012). Instructional leaders help teachers define what adequate content is and how to teach the key content at each grade level (Lochmiller, Huggins, & Acker-Hocevar). Instructional leaders also need to encourage exploration through inquiry-based learning and project based learning (van Zee, 2010). Authentic inquiry-based learning can be created within professional learning communities (Stoll & Louis, 2007). Professional learning communities encourage collaboration and collective responsibility which in turn maximizes the value of the lessons and projects created to encourage inquiry-based learning.

 Promoting professional development and networking among staff can enhance lesson creation by sharing resources and engaging in professional conversations (Lochmiller, Huggins, & Acker-Hocevar). To create meaningful learning experiences instructional leaders can provide opportunities for teachers to connect with local businesses to gain resources and up to date information in the field (Lochmiller, Huggins, & Acker-Hocevar). Although the options are all viable and make sense when discussing ways to increase how to incorporate inquiry-based learning in the classroom by involving administration to be instructional leaders there are many implications to consider. The expectations of principals are high and their agendas are full. However, teaching content should be made a priority. All of the other administrative duties that need to be accomplished in a school need to be spread throughout the entire school to shift the focus on meaningful and original learning experiences. Ultimately, this shift will increase student achievement and engagement when inquiry learning is the focus by all members of a school. (Lochmiller, Huggins, & Acker-Hocevar).

 Wagner & Kegan, 2006 suggest that one way to achieve successful academic results for a school is for school leaders and teachers to focus on relationships, relevance, and rigor in the classroom. To have rigor in the deliver the curricular content in an organized fashion where all students are challenged and relationships between complex ideas are created. Incorporating rigor into the classroom requires the teacher to have a strong knowledge base of the content and is comfortable challenging and holding students accountable. Moreover, creating lessons and situations that are relevant to the students is necessary for clear and deep understanding of the curriculum. Creating relevant lessons means that students are able to answer the question, *Why is this concept important and useful?* Lastly, creating solid relationships with students should be a teacher’s main objective. When a respectful relationship between students and teachers is created it is easier for a teacher to motivate his or her students (Wagner & Kegan, 2006). Also, when teachers make connections with their students it means that teachers can create problems that are appropriate for student’s interests and ability level (Silver et al., 2009) Silver et al. also argued that respectful relationships among students in a classroom should be promoted. When students interact and communicate about the content it creates an environment where students can work through complex and discovery tasks cooperatively.

**Summary**

 Inquiry-based learning and traditional teaching methods have been explored and compared by multiple researchers. There has yet to be a distinct decision regarding which is the best method to date. However, it is clear that if executed correctly by implementing inquiry-based learning has the potential to increase student learning by creating authentic learning experiences and being mindful of student engagement. The creation and implementation cannot be created by a single teacher. A professional learning community has to be involved. Teaching is not a singular profession and this has to be understood by students, teachers, and administration. Throughout most of the research there has been a common theme that if the students are engaged in problems that interest them will be more motivation to engage in the activity or lesson. Relating the content to the students is key.

**Chapter III - Methodology**

The following section discusses the methodology used to conduct the study. The purpose of this investigation is to determine how inquiry-based teaching methods affect various ability levels in a grade ten math classroom. These data were reviewed both qualitatively and quantitatively. Field notes and student assessment data were examined to determine if inquiry-based teaching is an effective way to teach math ten students. Furthermore, the research question and hypothesis, the role of the researcher, the participants and the setting, rationale, limitations and delimitations, materials, design and procedure, and the instruments used will be explored in this chapter.

**Research Questions and Statement of Hypothesis**

There has been a push from Alberta Education to teach mathematics through inquiry-based teaching methods. The question that this study sought to answer is to determine how inquiry-based teaching methods affect various ability levels in a grade ten math classroom. It is predicted that all students should learn best from the inquiry-based teaching methods and have a more in depth knowledge of the content.

**Participants and Setting**

The research was conducted at Notre Dame High School in Red Deer, Alberta. Notre Dame High School is in the East side of Red Deer and has a population of 98, 585. Notre Dame is the only Catholic High School in Red Deer; drawing its students from all neighborhoods in the city. The school has 1560 students from grade ten to twelve and there are 96 staff members at the school in total. The participants of this study included 15% of the students to be English language learners. One of the participants of this study had mosaic-down syndrome and was a mature student. This student was a participant in the inquiry-based learning class.

**Rationale**

To conduct this research I used a pre- and post- test method in order to track students’ of various abilities progress. Multiple versions of the exams were made to avoid students looking off of another student for answers. Although the versions were different, the level of difficulty was equal for all versions.

**Design and Procedure**

 The study was conducted over a four month period in two grade ten math classes. During the first week, students were given a formative assessment to determine how much of the prerequisite knowledge is understood prior to beginning the grade ten math curriculum. Students’ misunderstanding and lack of understanding was addressed and retaught before teaching the grade ten outcomes. Once the curriculum commences students were taught the unit of exponents and radicals as presented in the grade ten curriculum from Alberta Education. The method of instruction was different in both classes. One class was solely traditional in its instruction for the exponents and radical unit. The teacher taught lessons on the Alberta Education curriculum and students completed textbook and worksheet assignments based on these lessons. The other class was a mix of traditional and inquiry-based teaching. There was some traditional teaching for the new and essential outcomes that student must master in order to be successful the grade eleven math level. However, the assignments and outcomes that students explored on their own were completed through inquiry-based learning. Students used technology, projects, and Edmodo in order to demonstrate their findings, knowledge, and understanding.

Both classes received common summative assessment at the end of the exponents and radicals unit. Both classes results were compared based on pre and posttest assessments. Furthermore the high academic and low academic results of the students in both classes were analyzed in order to determine what is the best instruction for the various levels of academic ability in a mathematics classroom.

**Instruments**

 These classes were taught grade ten math in the first semester of the 2014 to 2015 school year. One class received only traditional instruction while the other received inquiry-based instruction. The inquiry-based class received traditional instruction for the content that cannot be explored. Both classes received the same summative assessment throughout the semester. This showed the difference in how traditional students perform on traditional pen and paper exams in comparison to projects. The results were then compared with the inquiry-based learning class. The pretest at the beginning of the semester was a formative assessment of the content knowledge that students have learnt in previous grades and are necessary to be successful at the grade ten level in mathematics. Both classes received the same chapter four final exam. This exam was a comprehensive assessment of number systems, exponents, and radicals. The results among the high and low academic students were monitored and analyzed by a *t*-test of the pretest and posttest data. Furthermore, recognizing whether traditional or inquiry-based learning is most beneficial for the various levels of students is the objective of this research.

**Institutional Review Board**

 The Institutional Review Board granted permission to conduct this research study on July 4, 2014. The research was performed during the second and fourth block of a four block schedule at Notre Dame High School. Parental or legal guardian consent was not necessary for this research as the instruction of the grade ten math class was not be beyond the normal scope of regular duties and responsibilities of a teacher. No class was disadvantaged in any way by completing this research.

**Role of the Researcher**

From September 2014 to January 2015, I taught four math classes and I administered my research in the two grade ten math classes that I had. While conducting this research I was a University of Portland student in the Masters of Education program. I am expected to graduate from the University of Portland in July 2015. Prior to enrolling in the Masters of Education program, I received my Bachelor of Education degree from the University of Alberta with a major in mathematics and a minor in physical education. Throughout this research, I was in my fourth year of teaching high school math. I had experience teaching all grades and levels of math at the high school level prior to completing this research. With my genuine passion for teaching and solid background in mathematics, it allows me to be prepared for the research component of this study.

**Summary**

 Through the data obtained from the pre and post assessments, this study measured how inquiry-based teaching methods affect various ability levels in a grade ten math classroom. The pretest used for this study was a beginning of the year assessment that specifically assessed the students prerequisite knowledge for the Math 10C curriculum. The posttest was the chapter four unit exam after the two classes learnt the curriculum. One class received inquiry-based teaching while the other class received traditional teaching. Specifically, this study used paired *t*-tests to measure the statistical significance of the affect of both the inquiry-based and traditional teaching methods.

**Chapter IV – Results**

 To determine the affect of inquiry-based teaching practices in a math classroom; this study implemented a quantitative study to determine if inquiry-based teaching methods were more effective than traditional teaching methods. More specifically, did inquiry-based teaching methods work best for both the stronger and weaker math students compared to traditional methods? To achieve this, the researcher collected quantitative data from the pretest and posttest. EZAnalyze was used by the researcher to complete paired *t*-tests.

**General Data Analysis**

It was hypothesized that teaching mathematics through inquiry-based teaching would be most beneficial for all students at varying ability levels in comparison to traditional teaching methods. However, these data show that the impact of inquiry-based teaching methods did not create a statistically significant (*p*=0.294) difference for the low achieving students or a statistically significant (*p*=0.168) difference for the high achieving students. The impact of traditional teaching methods for the low achieving students was statistically significant (*p*=0.001). Conversely, the traditional teaching methods were not statistically significant (*p*=0.137) for the high achieving students. Therefore, these data suggest that teaching students using inquiry-based teaching methods had little to no effect on increasing student achievement at varying level of abilities knowledge in the Math 10C classroom.

**Quantitative Data Analysis**

These data show that the inquiry-based teaching methods did not increase student success at the various ability levels in the Math 10C classroom. There was no statistical significance between inquiry-based teaching and increased math scores for both the low and high ability. These data were based on a unit about number systems, exponents, and radicals. Although the students had experience with both of these concepts before many of the students struggled when the base and radicands of the problems were variables. Also, there is very little relevancy between exponent laws and simplifying radicals in the real world context. Thus it was difficult for students to engage in the inquiry-based lessons. The data implies that students did not respond well to the inquiry-based teaching methods. The students who were categorized as low on the beginning of the year assessment (*M*=35.8, *SD*=7.7) in the inquiry-based class continued to score low on the summative chapter four exam (*M*=40.2, *SD*=17.3) (Table 1). The remaining students in the inquiry-based class who were categorized as high from the beginning of the year assessment (*M*=64.3, *SD*=11.2) maintained an average above 60% on the summative chapter four practice exam (*M*=72.5, *SD*=19.7) (Table 2). Although the averages increased by at least 4% for both groups the t-test for the low ability (*p*=0.294) and the t-test for the high ability (*p*=0.168) students implied that the learning gains were not statistically significant.

The data also indicate that the low group students responded better to the traditional teaching methods in comparison to the higher ability students. The students who were categorized as low on the beginning of the year assessment (*M*=31.1, *SD*=12.2) in the traditional class scored much better on chapter four exam (*M*=50.1, *SD*=19.4) (Table 1). The low ability group’s learning gains in the traditional class was a result of the teaching methods used (*p*<0.005). The high ability students in the traditional class had learning gains; however, the learning gains were not as statistically significant (*p*=0.137) as the low ability students in the same class.

One of the reasons that neither of the high ability groups from the inquiry-based and traditional classes did not have statistically significant gains could have been a result of a ceiling effect. It is unlikely that both of the high achieving groups did not learn any content from the either teaching methods. The pretest averages for the high achieving groups were high at the beginning of the study; therefore, making it challenging to increase the learning gains significantly over the course of the unit.

 Overall, the data implies that students did not respond very well to the inquiry-based teaching approaches. Additionally, it appears as though students are not achieving statistically significant learning gains for chapter four. Although, when comparing t-tests among the four different groups these data show that the traditional method is more favorable for the students who scored below 60% on the beginning of the year formative assessment. This learning gain statistically was more significant than the low ability students in the inquiry-based class.

Table 1

*Paired* t*-test - Pretest vs. Posttest Scores for Low Ability Students*

|  |  |  |  |
| --- | --- | --- | --- |
|  | Pretest Scores*N*=24 | Posttest Scores*N*=24 |  |
|  |  |  |  |  |
| Subscale | Mean | SD | Mean | SD | *t* |  *df* |
| Inquiry | 35.8 | 7.7 | 40.2 | 17.3 | 1.114 | 23 |
| Traditional | 31.1 | 12.4 | 50.1 | 19.4 | 4.121 | 23 |

*Inquiry*: p = 0.294; *Traditional: p* < 0.05

Table 2

*Paired* t*-test - Pretest vs. Posttest Scores for High Ability Students*

|  |  |  |  |
| --- | --- | --- | --- |
|  | Pretest Scores*N*=17 | Posttest Scores*N*=17 |  |
|  |  |  |  |  |
| Subscale | Mean | SD | Mean | SD | *t* |  *df* |
| Inquiry-based Teaching | 64.3 | 11.2 | 72.5 | 19.7 | 1.539 | 16 |
| Traditional | 70.6 | 11.1 | 78.7 | 13.1 | 1.652 | 16 |

*Inquiry*: p = 0.168; *Traditional: p* = 0.137

**Summary of Results**

To determine the effect of inquiry-based teaching in a grade ten mathematics class, the study utilized a quantitative approach to test which type of teaching method was more effective for students at varying ability levels. It was hypothesized that after students received inquiry-based teaching methods that they would have more learning gains than the students who received a more traditional pedagogy. The researcher collected quantitative data in the form of a pretest and posttest and determined statistical significance by using EZAnalyze to perform paired *t*-tests. These data indicate that opposed to the proposed hypothesis, there was no significant difference between the learning gains of the students in either the low or high ability groups in the inquiry-based classroom in comparison to the traditional classroom data. However, the data did indicate that traditional teaching in a grade ten math class did have significant difference for the low ability students. The data is contrary to the government arguing that inquiry-based learning is beneficial in the mathematics program and classroom. These data indicates that students do not respond well to inquiry-based methods in the mathematics classroom. The data for the high ability students remains questionable as the low probability values were most likely a result of a ceiling effect.

**Chapter V - Conclusions and Discussion of Findings**

The purpose of this investigation is to determine how inquiry-based teaching methods affect various ability levels in a grade ten math classroom. More specifically, did the results of a grade ten math class that received inquiry-based teaching methods surpass the results of a grade ten math class that received traditional teaching methods? The study took place in two Math 10C classroom composed of grade ten students, a few grade eleven students, and one mature student at Notre Dame High School in Red Deer, Alberta.

 Overall, most research suggests positive leaning gains are a result of inquiry teaching (Anderson, 2002). Furthermore, Flick (1995) implies that learning is enriched when students are engaged and curious about novel situations as seen in inquiry-based classrooms. Students should be aware of their metacognitive abilities and value depth of content knowledge rather than breadth.

 The quantitative data collected in this study show that, contrary to the hypothesis; inquiry based teaching does not improved learning in a grade ten classroom for varying student ability levels. The class that received their lessons via inquiry-based teaching did have a better average from pretest to posttest; however, the *t*-test levels for both the low and high ability students was greater than 0.05. When the data from the inquiry-based teaching classroom was compared with the data from the traditional classroom it can be concluded that the traditional teaching methods were more beneficial. The averages for the low ability students in the traditional classroom from posttest to pretest were statistically significant and the overall average for the same posttest was 9.9% higher. The average for the posttest for the high ability students in the traditional classroom were 6.9% higher the results from pretest to posttest for the high ability students in the traditional classroom were not statistically significant. The high ability data from both the inquiry-based and traditional classroom was most likely a result of high pretest scrores which is referred to as the ceiling effect. These varying data results when comparing the traditional based classroom was largely a result of students in the inquiry-based classroom not learning the most efficient of effective way to complete a problem. Often the students in the inquiry-based classroom would forget what they had discovered or learnt a method that was difficult to communicate and there was a greater chance for error when demonstrating their knowledge on the posttest. The ensuing chapter will comprise a discussion of the results and how they relate to prior research, the implications for the field of education and suggestions for future research.

**Limitations and Delimitations**

The study used convenience sampling; therefore, there are some limitations and biases of the study. As such a small sample size was available (*N*=41), the only two math classes taught during the first semester was purposefully selected to complete the pre- and post-assessments, and no randomization of the treatment occurred. This study was conducted with two grade ten math classes at Notre Dame High School, in Red Deer, Alberta. Two grade ten math classes were dedicated to this study to compare and contrast traditional teaching methods to inquiry-based teaching methods. The size of the sample was small; therefore, the results of this study cannot be generalized to a larger sample size. All students participated in the pre- and post-assessments, no randomization of the participants occurred. Students did not have access to the pretest or posttests prior to the study being conducted. The same teacher taught both the students in the traditional teaching setting and the class receiving their instruction through inquiry-based lessons. Students did not know that they were a part of the study to avoid observer bias. The results were focused on the affects of the pedagogy based on the students’ previous academic achievement. The previous academic achievement was the average of pretest marks. Minorities, socioeconomic status, and other student achievement data were not be taken into consideration. Both the traditional-based learning class and the inquiry-based class received the same common assessment for the unit. The common assessment for the math department at Notre Dame High School is a paper and pen based exam with multiple choice, numerical response, and written response questions.

Notre Dame High School uses a Response to Intervention (RTI) and High School Flexibility (FLEX) model. The additional RTI and FLEX time throughout the day allows students to seek extra math help from other teachers within the school at this time. During this time, the students in the inquiry-based classrooms could have received traditional teaching style methods from colleagues. Also, the students in the traditional classes could have had access to math help via inquiry instruction. Students choosing to attend these RTI and FLEX math help sessions were beyond the control of the researcher. Secondly, two participants from the traditional classroom were getting homework help from tutors. Tutoring would have given these students an advantage to having assistance while working on the chapter four homework. Also, one of the participants from the inquiry-based classroom was away from the classroom for a week due to being ill. These eternal factors were beyond the control of the researcher. The time frame of the study certainly presented its own limitations. The study was completed over a period of five weeks and was not enough to show definitive results. Additionally, the data did not include the students’ final exam marks to identify if the students retained more knowledge from the inquiry-based classroom in comparison to the traditional classroom. These data begin to suggest some quantifiable results; however, a longitudinal study with more participants is needed.

**Implications for the Field of Education**

Despite the many limitations involved in this study, the results provided an insight into the how to best teach new concepts in a grade ten math class. Specifically, whether teaching mathematics via inquiry-based teaching methods is superior to traditional teaching methods for varying ability levels in a math classroom. Anderson (2002) argues that inquiry is the heart of all learning and that teachers who embrace inquiry teaching will allow students to fully develop knowledge and understanding. However, inquiry learning and teaching did not create statistically significant gains that would encourage a math teacher in a Math 10C classroom to drastically change pedagogical practices. It is important to invest time into inquiry-based learning for students to create memorable and strong learning experiences (Alberta Education, 2004). According to Anderson (2002) there are three barriers that are inhibiting inquiry learning to have strong results in the classroom: technical dimension, political dimension, and cultural dimension. The technical dimension includes teachers struggling with students participating in group work, assessment changes, and lack of in-service opportunities to learn about inquiry teaching. The political dimension refers to teachers not collaborating effectively, parents resisting change, and a lack of resources. Finally, the cultural dimension focuses of teachers feeling as though trying a new style of teaching might not prepares students for the next level; therefore, continue to teach with the textbook is safe. After conducting this study, two other barriers in addition to Anderson’s barriers for the context of Alberta: knowledge dimension and content dimension. Many of the students in the Math 10C class came from many different middle schools; which resulted in their math knowledge base to differ from school to school. Although the students had all received the same curriculum in grade nine, the strengths of students ranged from students who could not multiply to students who could learn complex content in two days. Implementing inquiry learning while differentiating instruction became an obstacle throughout this study.

Many of the studies regarding inquiry teaching were from science classrooms. There were few studies conducted from mathematics classrooms. Some mathematics concepts are quite theoretical and are difficult for students to apply to a real-world example or visualize; thus making it challenging to discover the content. Therefore, it was not an unexpected result of this study when students who struggle with math having more learning gain to the traditional teaching styles. Furthermore, it was also interesting hearing the dialogue of the struggling math students in the inquiry-based teaching method who found it challenging to understand the concept and find motivation to learn the material. The results of this study would have been more favorable to inquiry learning at the content been easier to visualize and apply. The measurement unit from the Math 10C curriculum might have been a unit where the inquiry-based teaching could have been had more successful results.

**Future Research**

To improve this study for future research, there are a few recommended changes. Firstly, the participants should be more than 100 students from a variety of high schools within a region. Secondly, a longitudinal study would benefit this research greatly. One such opportunity would be to collect data throughout the course of an entire semester. These data could identify which units the inquiry-based learning was more effective. Also, the researcher could identify the information retained from the beginning of the semester to the end of the semester to determine which teaching method is the best for the cumulative Math 10C.

The study could have also been improved by teaching the same group of students science and math using inquiry-based teaching strategies in both classes. Teaching the students using inquiry-based methods in both classes would help the researcher identify if the same students responded better to science, math, both or neither using inquiry-based methods. Also, this study should be conducted at multiple grade levels to determine whether the inquiry-based teaching methods are more beneficial at one grade level than in comparison to another.

When a students are first introduced to inquiry-based teaching methods the teacher has to spend a large amount of time introducing how to collaborate with peers and find quality information from a variety of sources Kirschner et al. (2006). Another improvement to this study would be teaching students via inquiry-based methods for an entire high school career to determine if the students can continue their inquiry learning skills from year to year.

Furthermore, the results of the high achieving students having insignificant results in both classrooms are questionable. Further research could also consider how the affects of inquiry-based teaching methods in an advanced classroom to narrow the focus of the study.

Lastly, this study could have improved by analyzing the results of more than one teacher at a school attempting inquiry-based learning. Anderson (2002) argues that when more than one teacher is teaching the same course there is an opportunity for collegial conversation. This increased collaboration can often encourage the generation of more authentic ideas and increased knowledge of improved pedagogical practices.

**Summary**

The purpose of this investigation was to determine how inquiry-based teaching methods affect various ability levels in a grade ten math classroom. The results of the study indicate that inquiry-based teaching methods did not have a significant effect on either low or high ability levels. Throughout this study it was determined however that low ability students did have a statistically significant learning gains from traditional teaching methods. These results were likely a result of students not having a foundation of strong math ability who needed explicit instruction that is not given through inquiry teaching.

 Despite its limitations, the study presented important data for the field of education. By determining that lower ability students learn best from traditional methods, it will hopefully be useful data for the province to consider when analyzing PISA data. The students who were performing below a level 2 are not going to learn best from inquiry-based teaching methods. The important piece is to give students the necessary knowledge to be successful at the next level. It is the teachers’ responsibility to prepare the students using the best pedagogical practices based on the grade level, subject, and level of the students in the class. Further research may support inquiry-based learning to be a better way to teach math once more professional development opportunities and increased collaboration time are available in schools. Overall, these data suggest that teaching mathematics via inquiry is did not produce statistically significant results at the Math 10C level.

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