SPECIALIZED STRATEGIES FOR NON-NUMERATE GRADE SEVEN STUDENTS IN FACILITATING LEARNING NUMBER SENSE

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Abstract

This study offers inputs for enhancing the pedagogic skills of teachers, particularly in the choice of strategies that would appropriately address the needs of the students. Using the pre-experimental design, this undertaking endeavored to extend the work of Xin, et al. (2010) which made a comparison between general heuristic instruction (GHI) approach and conceptual model-based problem solving (COMPS) approach to improve students' number sense skills. In the present study, the technology-supported instruction (TSI) was added to the GHI and COMPS to determine the extent of the three strategies' contribution in improving the numeracy levels of the 69 non-numerate students who were randomly distributed into three groups, with each group receiving one of the three interventions. Standardized pre-test and posttest were used to evaluate students' numeracy levels before and after the intervention. Each teaching strategy as intervention was implemented for two weeks (10 sessions). Data show that of the 69, nine (9) had achieved the numerates' level; one (1) remained in the non-numerate category; and the majority (59) were classified as nearly numerates. This study concludes that the improvement in the students' performance may be attributed to the use of specialized teaching strategies. Utilization of such strategies to help non-numerates is thus recommended.

Keywords: Conceptual model-based problem solving (COMPS) approach, general heuristic instruction (GHI) approach, specialized strategies in mathematics, technology-supported instruction (TSI), number sense, pre-experimental design, teaching Mathematics, non-numerate

INTRODUCTION

In this day and age, the standards of Math, Science, and Technology drive the educational system on their importance in the current classroom settings (Duncan, 2011). In America, for example, Mathematics is preferred by all students from the elementary up to the secondary levels (Lach & Sakshaug, 2005). One of the obvious reasons for such preference is that Mathematics is regarded as a foundation to people's decisions in their lives. The teaching of Mathematics is the heart of educational system as it can be linked to everyday living and in the students' planning of their future career (Ontario Ministry of Education, 2005). Through Mathematics, learners solve problems using critical thinking and making connections, investigation, representation, and communication of concepts and ideas.

Every rational person has common sense and a number sense as well. Number sense is a developing concept that refers to a person's fluidity and flexibility with numbers (Gersten & Chard, 1999). In an educational context, the student has the sense of what numbers means and an ability to perform mental mathematics, to look at the world and to make comparisons and distinctions.

The K to 12 Mathematics curriculum in the Philippines (Department of Education, 2012) and the Mathematics standard of the United States of America (National Council of Teachers of Mathematics, 2000) put importance on developing the number sense competency of students. This competency generally refers to the learner's ability to apply one's understanding of the meaning of number and its properties, to make reasonable estimates, to perform both mental and written computation, and to determine the reasonableness of one's calculations. There is an evident, spiral approach to achieving this goal in elementary. Hence, it is hoped that a student should have developed such competency upon entrance in high school.

As a multi-grade teacher in high school Mathematics, the researcher has observed that a number of her high school students from freshman to senior years have difficulty in performing operations in whole numbers, fractions, decimals and in judging the reasonableness of their answers despite exposure to learning experiences aimed at honing these skills. Since the pressing problem of learners nowadays involves lack of understanding in number sense, it is suggested that the teacher utilizes specialized strategies for the low numerates especially the incoming Grade Seven students. Understanding the learner is the core of teaching number sense. Fennell and Landis (1994) defined number sense as an awareness and understanding about what numbers are, their relationships as well as their magnitude, the relative effect of operating numbers including the use of mental mathematics and estimation.

Kaminski (2002) articulated that the understanding and the use of Mathematics can be promoted and assisted by the development of number sense. The findings in Kaminski's study showed that students developed and utilized various relationships among the numbers, investigated the sense of Mathematics and provided the explanations for the results achieved.

Mohamed and Johnny (2010) emphasized that number sense is an essential skill to be mastered by all learners to enable them solve real-life problems. They further described number sense as good intuition about numbers and their relationships. The study also investigated the components of number sense that the students are weak in performing mathematical computations. Students who perform well in number sense exhibit the following characteristics: ability to do sense-making approach, planning, and controlling, having flexibility and sense of reasonableness.

The study of Lock and Gurganus (2004) revealed that number sense is developed throughout a student's mathematics education and applies to a wide range of concepts. The study offered different strategies for promoting number sense development: structure, numerical understanding, and more complex numbers and number relationship. As highlighted in NCTM (2000), the study set forth the importance of number sense as an intuition about numbers that are drawn from all various meaning of numbers.

In his study, Dehaenae (1999) explored how the mind creates mathematics. He believed that number sense is an enlightening of the mathematical mind. The study offered an intriguing tour on how the structure of the brain shapes the mathematical abilities, and how mathematics opens up a window on the human mind. He also suggested that this sense is as basic as the perception of color and it is wired into the brain.

Halberda, Wilmer, Naiman, and Germine (2012) explored on the number sense across the lifespan as revealed by a massive internet sample. The results indicated a huge difference in the precision of number sense among adolescents and adults of same age. Moreover, number sense in terms of nonverbal has been correlated with the abilities of children and adults in mathematics. On the other hand, no direct evidence had been found in infant's numerical abilities to their mathematical abilities during their childhood.

In support of the aforesaid idea, several studies have demonstrated that nonverbal number sense is correlated with the mathematical abilities in children and adults. However, there had been no direct evidence that infant numerical abilities are related to mathematical abilities later in childhood. Starr (2013) asserted that preverbal number sense may serve as a developmental building block for the uniquely human capacity for Mathematics. In the study, it was seen that infants in the first year of life process already have an intuitive sense of number. More importantly, the study validated that number sense in infancy predicts mathematical abilities in childhood.

In primary education, Jordan, Glutting, and Ramineni (2010) discovered the importance of number sense to mathematical achievement in first and third grades. Number sense has been strongly related to solving applied problems in mathematics. Hence, number sense should always be considered in early mathematics' development, assessment, and intervention. The same study explained the importance of addressing math difficulties early on in a child's education in order to prevent future failure. It noted the common characteristics among struggling students, including weak computational fluency and deficient number sense. It was recommended further that school screening for numeracy problems in kindergarten be made within the same extent for literacy problem screening. The study also includes a description of the number-sense screening test which covered areas including counting skills, number knowledge, and story problems.

Several types of research provided comparisons between low numerates and the high numerates. Keller (2011) conducted experimental research which provided evidence that a familiar risk comparison within a risk ladder is understood by low– and high–numerate individuals. It especially helps low numerates to better evaluate risk. In the study, an eye tracker was used to capture individuals' visual attention to a familiar risk comparison. It was found that there is no correlation between numeracy and perceived risk.

In a continuum, Keller (2014) explored the use of numeric and graphic risk information processing of high and low numerates in the intuitive and deliberative decision modes. The data indicated that the use of pictographs attracted the attention of low numerates in the first, intuitive, and phase of numeric information processing. Pictographs thus ensure low numerates' further elaboration on numeric risk information, which is an important precondition of risk understanding and decision-making.

According to Reyna Nelson, Han and Dieckmann, (2009) as cited in Keller (2014), to address low numerates' difficulties in understanding numeric risk information, the use of graphics format and particularly pictographs had been recommended. Further, it is likewise necessary to take into account the processing approach of information to numeracy (Lipkus & Peters, 2009). Liptus and Peters (2007) also examined the extent of the attractiveness of pictorial and numeric forms to low numerates' intuitive attention by making them process information for comprehension of relevant risky information.

One of the parameters that define quality teaching is the use of strategies. Ingram (2011) defines strategy as "a strategy is a clear decision and statement about a chosen course of action for obtaining a specific goal or result" (p. 1). Many effective instructional techniques and interventions have resulted from research aimed at reading needs, but schools lack sufficient recommendations for students who struggle in mathematics (Sundling, 2012).

Hulac, Dejong and Benson (2012) cited that in recent studies, many effective interventions and instructional techniques such as the Response to Intervention (RTI) process has been introduced for reading needs of the students. Teachers generally encounter difficulty in figuring out students' areas of weaknesses in mathematics. Most often, teachers' time had been overstretched due to figuring out such weaknesses and engaging in different interventions to make students learn.

Assessments had become an important part of a teachers' activity and the results act as telling signs of the extent on how much learning is progressing. Even though teachers' advice is taken into consideration, test information is important to screen the development of all students (Lembke, Hampton & Beyers, 2012). If a student experiences difficulties in mathematics, assessments need to be accomplished to assist them and perceive the troubles and cause of the problems (Burns et al., 2010).

Students want to clear up troubles rapidly (McCallum et al., 2006). Proofs suggest that students who can grasp simple facts mechanically may possess extra cognitive ability for studying more complex computation concepts. The more students can easily grasp entire basic mathematical information, the greater speed they can receive new complicated tasks. Similarly, students who lack understanding, knowledge and abilities on basic concepts of mathematics are probable to keep struggling and perhaps fail in higher mathematics courses (Grafman & Cates, 2010).

Coaching teachers, psychologists, and some other school educational experts regarding effective academic techniques may assist in finding solutions for ability-deficit students (Grafman & Cates, 2010). A good number of meta-analyses have been carried out on the features of mathematical instruction for low-reaching students (Baker, Gersten & Lee, 2002) and students with disabilities in learning (Gersten et al., 2006). Six academic techniques were regarded to be consistently effective in coaching mathematics to students with problems. The techniques consist of visual and image depictions, systematic and specific coaching, student suppose-aloud, peer-assisted studying, formative assessment records furnished to teachers, and formative assessment statistics furnished directly to college students.

The use of a graduated instructional sequence that proceeds from the concrete to representational to abstract (CRA) is usually recommended. Concrete education is learning through hands-on manipulation of using standards or approaches. After students analyze concretely, getting to know takes place with pictorial representations. Eventually, students' research and guidance ought to focus on summary symbols. Those scaffolding strategies are additives of effective mathematical instruction (Ketterlin-Geller, Chard & Fien, 2008). The techniques listed above are considered since they activate student engagement. The greater a pupil responds to the system the more learning takes place.

At present, teachers are continuously trained on using research-based techniques in inclusive classrooms (Martel, 2009). Impetuous and unfavorable teaching techniques result in teacher frustration and may cause the teachers to withdraw from their position as an educator (Baker, 2005). However, instructors who were trained to master skills that can be effectively applied to the teaching and learning process, both academic and behavioral, are better prepared for educating diverse learning encounters (Baker, 2005).

The accurate use of every approach enhances scholarly fulfillment, permits teachers to have a wider variety of options in instruction, introduce varied strategies for a huge range of student skills, and assist students with special needs into the overall educational setting. Teachers who are prepared with educational choices are much less frustrated and are greater efficient inside their respective classrooms (Baker, 2005).

Much of the early research on the effectiveness of mathematics teaching focused on teacher knowledge of mathematics (Thompson, 2004). Teachers' beliefs about mathematics, mathematics learning, and mathematics instruction can also impact on teachers' instructional practices (Beswick, 2008; Leder, Pehkonen & Törner, 2002; Wilkins, 2008), although the contextual nature of beliefs means that it is unwise to expect consistent links between beliefs and practice.

Views about mathematics and how teaching and learning should be undertaken are not the only concerns that need to be considered in order to result into effectiveness in instruction (Gates, 2006; Sztajn, 2003). Teachers' beliefs about their students and how the students are situated in social contexts are closely related to the students' motivation to learn, and their performance in mathematics (Philippou & Christou, 2002; Zevenbergen, 2003).

With the need to promote number sense among the low numerate students, three specialized strategies were utilized in the study: general heuristic instruction (GHI) approach, conceptual model-based problem solving (COMPS) approach, and technology-supported instruction (TSI).

General Heuristic Instruction (GHI) Approach. The term heuristic was coined from a Greek word, which means 'I find'. The student is put in the place of a discoverer. The method involves finding or discovering by the student, rather than the teacher merely explaining everything to the students. Heuristic method of teaching is geared toward getting rid of the shortcomings driven by lecture method or other traditional methods used by the academics. It is a method in which students discover ways to find the root of the problem for themselves (Fasasi, 2015). Also known as heuristic methods, heuristic strategies, or simply heuristics, are rules of thumb for making progress on difficult problems (Polya, 1973). These are general suggestions on the strategy that are designed to help one to solve problems (Schoenfeld, 1985). They can be explained as non-rigorous methods of achieving solutions to problems. Bruner (1960) cited that heuristics are methods and strategies that can be helpful in problem-solving. For Goldin and Brunswick (2004), heuristic processes refer to complex, partially-defined ways of reasoning that may be given simple names such as "trial and error", "draw a diagram", "think of a simpler problem", and so forth.

Generic heuristics are heuristics that do not suggest an immediate solution strategy with which to solve a problem, instead, they suggest where a solution approach might be "found". It may be the final solution itself or a process for solving a problem like a heuristic, which might be "modified" to fit the problem. Heuristics help solve the problem directly or in finding suitable representations, simplifications and pathways to solve the problem, as "a certain formerly solved problem influences the conception of the present problem" (Polya, 1973, p. 111). They are effective, though not necessarily efficient, and frequently used as way of approaching a problem. Generic heuristics are general rules-of-thumb that can be used almost across many topics and many types of problem and are not necessarily limited to the mathematical domain. These heuristics are often learned without the explicit teaching; generalizations may be framed from experience (Tiong et al., 2005).

Heuristic teaching method has been found very useful in the teaching of mathematics (Břehovský, et al., 2013). Heuristic teaching methods are not to be limited to teaching through dialogue. In a broader context, they cover larger complexes of learning activities, including problem identification, formulation of hypotheses, asking questions, observation, experimenting, collecting data and its evaluation, comparison, discussion, generalization, result verification, etc. (Boud & Felletti, 1997).

A heuristic approach is introduced as a tool to increase students' mathematical questioning abilities. Students who have the robust perception of making use of heuristics method show better revel in identifying a mathematical problem. They also display inclination in the progress of mathematical knowledge which is advanced via multiple strategies hired in fixing mathematical issues. For this reason, their attempt of employing heuristics fosters sturdy notion on their potential in fixing mathematical troubles. How students follow heuristic strategies efficaciously in solving the mathematical trouble is hardly focused within the teaching of mathematics (Hoon et al., 2013). Staunch supporters of this approach are of the opinion that each scholar needs to be made a discoverer and inventor. The mathematics teacher’s process is not always to resolve the problems for the students, but to permit the student to solve issues by themselves after taking note of teacher’s main questions or recommendations as a way to deliver a clue to finding the solution to the problems posted (Fasasi, 2015).

Hoon et al. (2013) affirmed that students have actively engaged in solving problems in Mathematics when the teacher used the heuristic strategies. Their reflections shown in the journals indicated that they had carried out the applicable strategies of the method to fixing problems in mathematics. The techniques covered includes giving representation, making a guess calculated, and undergoing in the system.

Conceptual Model-Based Problem Solving (COMPS) Approach. In engaging for a meaningful understanding of mathematics, teachers’ effort of systematic planning for creating an ideal classroom discussion where students actively interact (Coltman, Petyaeva & Anghileri, 2002). The students’ knowledge is emphasized constantly in the mathematics classroom in order to value the mastering of mathematics (Pathania, 2011). Youssef-Shalala et al. (2014) also mentioned that the general problem-solving strategy was helpful for novices, but not for students that had access to domain-specific knowledge. The cognitive load theory was used to hypothesize that a general problem-strategy based on a make-as-many-moves-as-possible heuristic could facilitate problem solutions for transfer problems. As Rubin, Marcelino, Mortel, and Lapinid (2014) emphasized, it is especially difficult when students are taught to follow rules and procedures in a very abstract manner without going through models for better conceptual understanding. Conceptual mathematics understanding as a knowledge involves a thorough understanding of underlying and foundational concepts behind the algorithms performed in mathematics (Rille-Johnson et al., 2001 cited in Rubin et al., 2014).

Contemporary approaches to story problem solving have emphasized the conceptual understanding of a story problem before attempting any solution that involves selecting and applying an arithmetic operation for a solution (Jonassen, 2003). Problems with the same problem schema share a common underlying structure and hence require similar solutions (Chen, 1999; Gick & Holyosk, 1983). Students need to learn to understand the structure of the mathematical relationships in word problems and should develop this understanding through creating and working with a meaningful representation of the problem (Brenner et al., 1997) as well as mathematical modeling (Hamson, 2003).

Kilpatrick, Swafford and Findell (2001) explained that visual processing, visual memory, and visual-spatial relationships all impact math proficiency since they are threads in the fabric of conceptual understanding and procedural fluency. Visual representation uses pictures, number lines, and graphs of functions and relationships to teach mathematical concepts (Steedly et al., 2008).

Learner engagement and an excellent classroom lifestyle and climate is associated with students' foundational numeracy development. Stimulated students actively participate in and feel accountable for their personal learning. Consequently, it is crucial for teachers, mainly for those teaching learners with numerous backgrounds and desires, to interact with their students in activities that are motivating (Leone, Wilson & Mulcahy, 2010).

Suurtamm, Quigley and Lazarus (2015) asserted that meaningful mathematics takes place in K to 12 classrooms that support students as they investigate, represent and connect mathematical ideas through discussion in the context of problem-solving.

Bruce (2007), who studied ways to enhance students' instructional revel in mathematics, explains that dialogue in the mathematics school room is very vital. The mathematics classroom should be like a community where ideas can be discussed, developed, debated, and understood (Bruce, 2007). Teachers guide and extend students' learning through mathematics discussion questions, sentence stems (sometimes called sentence starters), asking for examples, for justifications of work (Wagganer, 2015).

Imparting the learners with a strong basis in mathematics can play a vital role in future educational achievement. Researchers have determined that early year math skills may have a strong predictive capability for future academic fulfillment (Duncan et al., 2007).

Researchers stress the importance of coaching for conceptual understanding (Lawson, 2007; Protheroe, 2007). However, mathematics classes often focus on drills and procedural understanding (Protheroe, 2007), albeit the fact that "the curriculum is designed to help students build the solid conceptual foundation in mathematics that will enable them to apply their knowledge and further their learning successfully" (Ontario Ministry of Education, 2005 p. 4).

Technology-Supported Instruction (TSI) Approach. As cited in the study of Xin et al. (2011), the results of preliminary studies that evaluated COMPS using a single-subject design (Kazdin, 1982) indicate that there is a functional relationship between the intervention and students' improved performance on researcher-designed criterion tests that involve simple addition, subtraction, multiplication and division problems (Xin, Wiles & Lin, 2008) and on problems involving irrelevant information or multiple steps (Xin & Zhang, 2009).

Various researches verify the effectiveness of the use of technology in diverse areas of mathematics (Moore, 2012). Gargiulo and Metcalf (2010) reveal that many students experience anxiety in mathematics which blocks initial gaining knowledge of and makes transfer of abilities difficult. Cavanagh (2007) also highlights that this emotional reaction hinders running reminiscence and eventually the ability to do not forget primary records. Automaticity of primary computations is considered essential for students' mathematical fulfillment as information processing theory highlights that, without direct retrieval of fundamental information, students face greater complex responsibilities (Woodward, 2006).

If students cannot practice fluent retrieval of basic information, this limits the improvement of higher order mathematical capabilities. Integrating technology into a mathematics classroom will increase the transferal of skills, lower anxiety, promote automaticity of basic math computational skills, and will help develop higher order mathematical skills (Moore, 2012).

Technology plays an essential role in the growing understanding of basic capabilities in mathematics. For instance, the use of calculators can improve learner's capability to address problems in mathematics. Bowes (2010) explores the place of technology inside the mathematical curriculum. He further stated that technology supports achievement, enabling learners to be independent, competent and creative thinkers, as well as effective communicators and problem solvers" (p.1). Kadan and Vasquez' (2010) examination supports Bowes' declaration. He cited that calculators, DVDs, Elmos, internet-based video games, PowerPoint, projectors, Smart boards, the internet, videos, and tune were used to enhance their instruction of mathematics.

Hudson, Kadan and Vasquez (2010) reported that "Overall, targeted students in the fourth, fifth, sixth, and ninth grades improved their understanding of basic math skills by using technology. Their post-intervention test scores indicated a noticeable increase in student mastery of basic mathematics. More students earned scores of 70% or higher when compared to the pre-assessment scores" (p.3). A study carried out by Hudson, Kadan and Vasquez

(2010) attests that technology increases success, developing learners' independence as trouble solvers, capable and creative thinkers, as well as effective communicators.

Technological teaching and gaining knowledge is an essential part of the classroom in mathematics. In NCTM (2011), it was stated that "it is essential that teachers and students have regular access to technologies that support and advance mathematical sense-making, reasoning, problem-solving, and communication" (p. 1).

Researches done by Gadanidis and Geiger (2010), and Bunz (2016) established that making use of technology when teaching mathematics can help students to develop procedural skills, problem-fixing, and reasoning. In a meta-evaluation research of the impact of technology on studying, it was seen that those who use technology in their classrooms learn better than those who do not (Tamin et al., 2011). Examples of technology used in mathematics includes interactive whiteboards, apps, calculators, computer packages, laptop algebra systems, online assessment equipment, and online collaboration tools.

With the need to facilitate learning to the low numerates in teaching number sense, three specialized strategies are prevailing in the present study. These approaches in facilitating number sense learning are the general heuristic instruction (GHI) approach, conceptual model-based problem solving (COMPS) approach, and technology-supported instruction (TSI). In the study of using a general-solving strategy to promote transfer, GHI approach was helpful for developing students who are exposed to mainly route learning (Youssef-Shalala et al., 2014). On the other hand, Xin and Zhang (2009) found that COMPS intervention improved students' performance on situated word problems. Lastly, Hasselbring, Lott and Zydney (2006) opined that technology-supported instruction (TSI) can form the premise of effective methods to assist students who have difficulties with math try to achieve parity with their peers.

Hence, the use of general heuristic instruction (GHI) approach, conceptual model-based problem solving (COMPS) approach, and technology-supported instruction (TSI) provided real-life experiences in learning mathematics. Without actual-global application, students perceive mathematics too tough to relate to, uninteresting and abstract (Moore, 2012).

Farren (2008) cited that "many students expressed that Mathematics become boring, hard, and tough to narrate to due to the lack of actual-international application in preparation" (p. 3). Actual global application of it brings life to mathematics, and students are able to find it sensible and a relatable subject.

Gallenstein (2005) expressed that teachers need to connect science and mathematics knowledge to real-life situation in order for children to have a greater appreciation for the content" (p. 38). Farren (2008) reported that numerous students who received teachings that include association of mathematics with the real world asserted that they have become more inspired and interested in Mathematics even it was not one of their favorites (p. 5).

Mathematics existed in different life's conditions, which makes connecting the instruction to the real-global application as a totally viable task. Basically, it is the teachers' obligation to show the students the existence of mathematics (Moore, 2012).

Gallenstein (2005) presented how applicable math studying possibilities are present in classrooms, buildings of school, homes, and other communities. Examples of precise possibilities for real-global mastery of mathematics include field trips to local restaurants and grocery stores (p. 39). Furthermore, many educators have connected specific mathematical topics to the real-life application like measuring the area of carpet, perimeter of fence, and the addition, subtraction, and multiplication of numbers when ordering from a menu and calculating tax and tip. Giving students real-life application engages them. Increased engagement leads to increased performance (Moore, 2012).

Mathematics' underachievement is an on-going issue in the educational arena. Many learners in the elementary level are not inspired in mathematics and hence, as a consequence perform poorly. The reason for this problem may be due to negative attitude toward mathematics and the way lessons in mathematics were delivered or passed on to students.

The study of Moore (2012) validated the first-class teaching practices include actual-life utility, integrating technology differentiated training, use of manipulatives, and video games into mathematics training. With the use of said strategies, it is expected that learners from being non-numerates can become numerates after the interventions.

Poor attitudes and negative achievement in mathematics are not essentially created due to the nature of the subject. Poor teaching strategies along with ability and drill, copying from the board, and memorizing formulas create low motivation in students which in turn leads to low instructional overall performance. Teachers need to keep away from those monotonous conventional processes to be able to create an extra effective view of Mathematics of their students (Moore, 2012). If mathematics teachers are empowered to use effective strategies in teaching, learners are able to maximize their full potentials and be the real actors in their own learning.

Based on the aforementioned literature and studies, it becomes the intention of the present study to shed light on the effectiveness of the general heuristic instruction (GHI) approach, conceptual model-based problem solving (COMPS) approach, and technology-supported instruction (TSI) in addressing poor performance and underachievement (especially the cases of non-numerates) in mathematics as well making students appreciate mathematics better.

The study is generally intended to provide inputs for enhancing the pedagogic skills of teachers, particularly in the choice of strategies that would appropriately address the needs of the students.

Specifically, the objectives of the study are the following: (1) describe the numeracy level of the students before and after the implementation of general heuristic instruction (GHI) approach, conceptual model-based problem solving (COMPS) approach, and technology-supported instruction (TSI) in mathematics instruction; and (2) infer the numeracy level of the students before and after implementing the general heuristic instruction (GHI) approach, conceptual model-based problem solving (COMPS) approach, and technology-supported instruction (TSI) in mathematics instruction.

The finding focuses on the effectiveness of the identified three specialized strategies in teaching mathematics in improving the numeracy level of the identified non-numerate Grade 7 students in a public secondary school. It is limited on the non-numerates of Grade 7 because it is at this grade level that the annual Non-Zero Numerate Test is being conducted in the public schools in one cluster in a certain Schools Division. Only the identified non-numerates in the test were considered as the final respondents in the study or the experimental group where the interventions/treatments were made.

With the results of the study, the readers are hoped to be guided on their choices of strategies used in teaching Mathematics, making instruction more adaptive, responsive, and nurturing to the needs of the learners.

It is also hoped that the curriculum planners may derive insights from the suggested useful strategies in teaching mathematics. They could spearhead the inclusion and reiteration of the application of the said strategies in the various curricula in mathematics that they will be crafted, as steps in making the curricula more relevant, adaptive, and responsive to the varying needs of the learners.

Lastly, the content of the study is hoped to guide the future researchers in exploring further the effectiveness of the said activities in various settings and the inclusion of other pertinent variables that may substantiate further this research work.

METHOD

The study used the pre-experimental design of research. In pre-experimental designs, there is a single group or multiple groups observed after a certain intervention or treatment that are presumed to provide change. Here, no randomization is made. The method serves as preparatory or prerequisite to true experimental designs (Salkind, 2010). Thus, the pre-experimental one group pre-test posttest design of research fits the present study as it was conducted to serve as reference for future true experimental research. In using the design, only one group served as the experimental group (treatment group) where the three specialized strategies were applied. In this group also, the conducted pre-test and posttest served as the basis for determining the effectiveness of the general heuristic instruction (GHI) approach, conceptual model-based problem solving (COMPS) approach, and technology-supported instruction (TSI) in addressing poor and underachievement (especially the cases of non-numerates) in mathematics. The accumulated significant differences in the gain scores after the implementation of the three specialized strategies were treated inferentially.

The respondents of this study were the grade seven students of a public secondary school. Systematic sampling technique was used in distributing the non-numerates respondent-students on their respective groups. All the students were distributed evenly to each of the specialized strategies. Each group of students was assigned to a specific strategy. In using this sampling technique, the students were grouped into three by random selection.

The non-numerates were identified after the pre-test. The respondent-students were classified as numerates (raw score of 75 and above), nearly numerates (50 – 74), and non-numerates (49 and below) where the sixty-nine (69) final respondents were taken. From this group, three (3) sub-groups were identified and distributed to the three (3) specialized strategies. Therefore, in every specialized strategy, there were twenty-three (23) students.

The study utilized the numeracy tests as pre- and posttests in gathering pertinent data on the numeracy level of the students. All the grade seven students took the numeracy test in one of the school clusters. It is important to determine and increase the numeracy level of the students since it is one of the mandates for Mathematics teachers in every school to ensure that after the school year the students who are non-numerates at the beginning will become numerates after employing an intervention program. In this sense, Mathematics teachers become active participants in implementing the Project All Numerates (Project AN) by the Department of Education. The identified non-numerates underwent the intervention for 10 sessions with prepared lesson plans. The pre-test and the posttest were administered a day before and a day after the experimental intervention. The test used is a 100-items tool divided into five parts. Part I involved the 4F's or the four fundamental operations; Part II elicited the reading of large numbers; Part III emphasized the place value and writing word numbers in figures and vice versa; Part IV contained the operations on large numbers, and Part V consisted the problem-solving skills.

Before the conduct of the study, permission was secured from the Schools Division Superintendent and from the principal of the covered school. During the experiment, ten learning sessions on number sense were conducted for two weeks during remediation class. The learning content of the prepared lesson plans was based on the competencies of the curriculum guide and learner's material. In order to make it possible to compare student Mathematics achievement between the pre-test and posttest, the levels of difficulty were maintained. The Mathematics experts validated the lesson plans using the rubric.

The data from the raw scores of the grade seven students, gathered through the numeracy tests were checked, organized and were used as bases for classifying the students into three groups: numerates, nearly numerates and non-numerates. The mean of raw scores was described according to the provisions of the numeracy test.

After the experiment, SPSS (Statistical Package for Social Sciences) program version 24 was utilized to compare the students' numeracy level in utilizing the three specified strategies in teaching mathematics. Their achievement levels were also compared before and after the implementation of the interventions, individually per group and as a whole.

In order to test if there is significant difference in the pre-test and posttest results after utilizing the three strategies in teaching mathematics, the ANOVA (Analysis of Variance) was used. Moreover, Paired Samples T-test was utilized to compare the pre-test and posttest results as a whole.

RESULTS

Students' Numeracy Levels Based on the Pre-test Results

Table 1 shows the numeracy levels of the students before the implementation of the General Heuristic Instruction (GHI) approach, Conceptual Model-Based Problem Solving (COMPS) approach, and Technology-Supported Instruction (TSI) as revealed by the pre-test results.

As a whole, it is evident that before the implementation of the three specialized strategies in mathematics, in the conduct of the pre-test using the Non-Zero Numerates Test, the students were found to be "Non-numerates" with an average of 41.01. It means that the majority of the respondents have numeracy levels or the raw score of 50 – 74.

Table 1
Numeracy levels of the students in mathematics based on the pre-test results

Numeracy Levels	GHI	COMPS	TSI	Total	%	Average	SD	Interpretation
Non-numerates (49 and below)	23	21	22	66	95.65	**41.01**	**7.77**	**Non-numerates**
Nearly numerates (50 – 74)	0	2	1	3	4.35			
Numerates (75 and above)	0	0	0	0	0			
Total	**23**	**23**	**23**	**69**	**100.00**			

Students' Numeracy Levels Based on the Posttest Results

Table 2 shows the numeracy levels of the students after the implementation of the general heuristic instruction (GHI) approach, conceptual model-based problem solving (COMPS) approach, and technology-supported instruction (TSI) as revealed by the posttest results.

After the implementation of the three specialized strategies in mathematics, in the conduct of the posttest using the Non-Zero Numerates Test, the respondent-students are considered "Nearly Numerates" with an average of 63.36. It means the majority of the respondents have numeracy levels or the raw score of 63.36 after the implementation of the GHI approach, COMPS approach, and TSI. This also indicates that the numeracy levels of the students increased/improved after the use of the three specialized strategies in mathematics.

Before the implementation of the posttest, the treatments/interventions (three specialized strategies) were used to the treatment group accounting to 69 non-numerate students. Meaning, the students were able to accumulate ample knowledge on the topics/lessons covered by the Zero Non-numerate Test.

Table 2
Numeracy levels of the students in mathematics based on the posttest results

Numeracy Levels	GHI	COMPS	TSI	Total	%	Average	SD	Interpretation
Non-numerates (49 and below)	1	0	0	1	1.45	**63.36**	**8.69**	**Nearly Numerates**
Nearly numerates (50 – 74)	20	18	21	59	85.51			
Numerates (75 and above)	2	5	2	9	13.04			
Total	**23**	**23**	**23**	**69**	**100.00**			

Table 3 shows the comparison on the numeracy levels of the respondents before and after the implementation of the general heuristic instruction (GHI) approach, conceptual model-based problem solving (COMPS) approach, and technology-supported instruction (TSI) as treated by ANOVA or F-test.

Table 3
Comparison on students' numeracy levels based on the pre-test and posttest results

Before the Implementation of the 3 Strategies							
Group	**Mean**	**SD**	**df**	**F**	**p-value**	**Remarks**	**Decision**
I (GHI)	42.00	8.15	68	0.29	0.75	Not Significant	Ho cannot be rejected
II (COMPS)	40.74	8.34					
III (TSI)	40.30	7.02					
Composite Mean	**41.01**	**7.77**					
After the Implementation of the 3 Strategies							
Group	**Mean**	**SD**	**df**	**F**	**p-value**	**Remarks**	**Decision**
GHI	61.65	8.86	68	0.68	0.51	Not Significant	Ho cannot be rejected
COMPS	64.48	9.52					
TSI	63.96	7.73					
Composite Mean	**63.36**	**8.69**					

Table 4 presents the comparison on the numeracy levels of the students before (pre-test) and after (posttest) the implementation of the GHI approach, COMPS approach, and TSI. The computed F-value of 0.29 is significant at 0.75 level which is higher than 0.05 level of significance. This implies that there is lack of statistical evidences to establish the difference on the numeracy levels of the students in mathematics before the implementation of the GHI approach, COMPS approach, and TSI; that their levels of numeracy is at the same level or do not differ significantly before the utilization of the three specialized strategies in mathematics.

Statistical results reveal that there is no significant difference on the numeracy levels of the students in mathematics after the implementation of the three specialized strategies given that the p-value =0.51. Hence, their levels of numeracy is at the same level or do not differ significantly after the utilization of the three specialized strategies in mathematics. It attests further that the numeracy levels of the students has increased after the implementation of the three specialized strategies in mathematics.

Lastly, Table 4 presents the comparison on the numeracy levels of the students before (pre-test) and after (posttest) the implementation of the three specialized strategies treated by T-test.

The computed t-value of -21.04, and with a p-value of 0.00 imply that there is a significant difference on the numeracy levels of the students in mathematics before (pre-test) and after (posttest) the implementation of the three specialized strategies; that their levels of numeracy has improved after the utilization of the three specialized strategies in mathematics. This implies that the specialized strategies used in teaching the non-numerates are effective and able to help the learners transcend from non-numerates to nearly numerates.

Table 4
Comparison on students' numeracy levels before and after the implementation of the three specialized strategies in teaching mathematics

Group	Mean	SD	Df	T-value	p-value	Remarks	Decision
Before the Implementation (Pre-test)	41.01	4.52	22	-21.04	0.00	Significant	Reject Ho
After the Implementation (Posttest)	63.36	4.58					

DISCUSSION

Teaching strategies assist in the accomplishment of the set goals of instruction. Teachers are able to facilitate learners' acquisition of the competencies through the utilization of various innovative teaching strategies. The K to 12 Mathematics curriculum in the Philippines (DepEd, 2012) and Mathematics standard of the United States of America (NCTM, 2000) promote the development of number sense in students. This giving of importance on said competencies makes it possible for learners to have a holistic experience in learning mathematics.

It was the intention of the present study to shed light on the effectiveness of the general heuristic instruction (GHI) approach, conceptual model-based problem solving (COMPS) approach, and technology-supported instruction (TSI) in addressing performance and underachievement (especially in the cases of non-numerates) in mathematics. The study determined the numeracy levels of the students before and after the implementation of general heuristic instruction (GHI) approach, conceptual model-based problem solving (COMPS) approach, and technology-supported instruction (TSI) in mathematics instruction and compared their level of performance in the pre and posttests.

The General Heuristic Instruction (GHI) Approach determines an immediate solution strategy with which to solve a problem. It suggests where a solution approach might be "found". It may be the final solution itself or a process for solving a problem like a heuristic, which may be modified to fit in to the problem (Polya, 1973, p. 111). Conceptual Model-Based Problem Solving (COMPS) Approach could be useful for novices but may no longer be for students who had access to domain-specific knowledge. The cognitive load theory was used to hypothesize that a general problem-strategy based on a make-as-many-moves-as-possible heuristic could facilitate problem solutions for transfer problems (Youssef-Shalala, Ayres, Schubert, & Sweller, 2014); and the Technology-Supported Instruction (TSI) Approach supported achievement, enabling learners to be independent, competent and creative thinkers, as well as effective communicators and problem solvers" (Bowes, 2010, p.1).

As deduced from the numeracy levels of the students before the implementation of the three specialized strategies in mathematics, the pre-test results revealed that the students were "Non-numerates" for having raw scores of 49 and below. It can then be said that the students need the necessary intervention to increase their abilities to competently deal with numbers and solve problems.

After the implementation of the three specialized strategies in mathematics, the posttest scores indicated that the students are eventually declared as "Nearly Numerates" for garnering raw scores of 50-74, indicating further that the numeracy levels of the students have improved after the use of the three specialized strategies in mathematics. This indicates that the students after the interventions have become nearly numerates who are able to solve problems with less errors.

Using the three specialized strategies teachers may assist the students aim high and elevate their confidence in learning mathematics. The aforesaid results further attest the achievement of the prime objective of the study gearing to the implementation of specialized strategies in teaching Mathematics to help the learners improve their numeracy levels.

Pre-test results show that there is no significant difference on the numeracy levels of the students in mathematics before the implementation of these three specialized strategies; that their levels of numeracy is at the same level or do not differ significantly before the utilization of the three specialized strategies in mathematics.

The posttest reveal that the numeracy levels of the students has increased after the implementation of the three specialized strategies in mathematics. Results also bared that there is no significant difference on the numeracy levels of the students in mathematics after the implementation of the three strategies. The improvement in the levels of numeracy of the students coming from the three groups is statistically the same after the utilization of the three specialized strategies in mathematics; that their levels of numeracy had improved using the said specialized strategies.

Lastly, the overall pre-test and posttest results reveal that there is a significant difference on the numeracy levels of the students in mathematics before (pre-test) and after (posttest) the implementation of the three strategies namely: general heuristic instruction (GHI) approach, conceptual model-based problem solving (COMPS) approach, and technology-supported instruction (TSI). Hence, it can be said that the students' levels of numeracy has improved after the utilization of the three specialized strategies in mathematics.

The findings of the present study are in unison with the following studies: a study which implemented the general-solving strategy that promoted transfer and GHI approach was proven helpful for developing students who are exposed to mainly route learning (Youssef-Shalala et al., 2014); Xin and Zhang (2009) found that COMPS intervention improved students' performance on situated word problems and finally Kaplan et. al. (2013), strongly believed that the most effective strategy in teaching number sense is through the use of technology-supported instruction (TSI).

In the light of the findings, the students improved from being non-numerates to nearly numerates which reflected the effectiveness of the three specialized strategies in improving their numeracy levels. However, it is also evident that students did not meet the numerate level which is the highest target of the schools. The outcome of the study, though, could be an indication that with efficient monitoring and scaffolding of the strategies in instruction, the students could attain the numerate level at the end of the school year.

Hence, the success of the numeracy program can only be achieved at the end of the schooling since an intervention could be done on all the grading periods. In addition, teachers could intensify further the use of various activities coupled with the three specialized strategies in mathematics by using parametric devices such as rubrics, templates, and reflective journals for the students to track further their performances in the same way, school heads could also provide an intensive observation on the remedial classes conducted to the students for more feasible technical assistance for both teachers and the students.

Finally, it can then be concluded that the three specialized strategies help the learners in improving their numeracy levels, especially the struggling students (non-numerates).

This study hopes to have contributed in testing empirical specialized strategies in Mathematics to help the struggling learners improve their academic achievement that could be benchmarked by other teachers and schools. Moreover, the study suggests the exploration of other relatively empirical strategies to serve as interventions for the struggling learners.

REFERENCES

Baker, P. H. (2005). Managing student behavior: How ready are teachers to meet the challenge? *American Secondary Education*, 33 (3), 51-64.

Baker, S., Gersten, R. & Lee, D. (2002). A synthesis of empirical research on teaching mathematics to low-achieving students. *The Elementary School Journal*, 103, 51-73. Retrieved from http://www.press.uchicago.edu/ucp/journals/journal/esj.html

Beswick, K. (2008). Influencing teachers' beliefs about teaching mathematics for numeracy to students with mathematics learning difficulties. *Mathematics Teacher Education and Development*, 9, 3–20.

Boud, D. & Felletti, G., E. (1997). The challenge of problem-based learning. Second ed. London: Kogan Page.

Bowes, K. (2010). Technology: Its place in math standards and getting it there. Retrieved from users.math.umd.edu/~dac/650/bowespaper.html#National Council of Teachers.

Břehovský, J., Eisenmann, P., Ondrušová, J., Přibyl, J, & Novotná, J. (2013). Heuristic strategies in problem solving of 11-12-year-old pupils. Proceedings of SEMT ´13, Prague, 75-82.

Brenner, M. E., Mayer, R. E., Moseley, B., Brar, R., Duran, R. & Reed, B. S. (1997). Learning by understanding: The role of multiple representations in learning Algebra. *American Educational Research Journal*, 34(4), 663-689.

Bruce, C. D. (2007). Student interaction in the math classroom: Stealing ideas or building understanding. What Works? Research into Practice. Retrieved from http://www.edu.gov.on.ca/eng/literacynumeracy/inspire/research/Bruce.pdf.

Bruner, J. S. (1960). *The process of education.* Cambridge: Harvard University Press.

Bunz, R. (2016). *Evaluating and integrating educational technology in the elementary mathematics classroom.* Unpublished Master's Thesis, Brock University, St. Catharines, Ontario.

Burns, M. K., Codding, R. S., Boice, C. H. & Lukito, G. (2010). Meta-analysis of acquisition and fluency math interventions with instructional and frustration level skills: Evidence for a skill-by-treatment interaction. *School Psychology Review*, 39(1), 69-83. Retrieved from http://www.nasponline.org/publications/spr/index-list.aspx

Cavanagh, S. (2007). Math's anxiety confuses the equation for students. *Education Week, 26*(24), 12.

Chen, Z. (1999). Schema induction in children's analogical problem solving. *Journal of Educational Psychology*, 91, 703-715.

Coltman, P., Petyaeva, D. & Anghileri, J. (2004). Scaffolding learning through meaningful tasks and adult interaction. Reader in Teaching and Learning. T. Wragg. London, Routledge Falmer.

Dehaene, S. (1999). The number sense. How the mind creates mathematics. *Science Spectra.* Issue: 16, pp. 74 – 75.

Department of Education (2012). Policy guidelines on the implementation of grades 1 to 10 of the k to 12 basic education curriculum. *DepEd Order No. 31 series 2012*. Pasig City, Philippines.

Duncan, A. (2011). Sharpening mathematics tools for the 21st century, NCTM Summing Up. Retrieved from http://www.nctm.org/about/content.aspx?id=29275

Duncan, G. J., Dowsett, C. J., Claessens, A., Magnuson, K., Huston, A. C., Klebanov, P. & Japel, C. (2007). School readiness and later achievement. *Developmental Psychology*, 43(6), 1428–1446.

Farren, V. (2008). A reflection on my teaching practices using students' math moments. *College Quarterly, 11* (4), 74-81.

Fasasi, K. M. (2015). Effects of heuristic teaching approach on academic achievement of senior secondary school mathematics students in Girei local government area of Adamawa State, Nigeria. *International Journal of Innovative Science, Engineering & Technology*, 2(6), 598-606.

Fennell, F., & Landis, T. E. (1994). *Windows of opportunity: Mathematics for students with special needs*. Reston, VA: National Council of Teachers of Mathematics, 187-203.

Gadanidis, G., & Geiger, V. (2010). A social perspective on technology enhanced mathematical learning - from collaboration to performance. *ZDM*, 42(1), 91–104.

Gallenstein, N. (2005). Engaging young children in science and mathematics. *Journal of Elementary Science Education, 17* (2), 27-41.

Gargiulo, R.M. & Metcalf, D. (2010). *Teaching in today's inclusive classrooms: A universal design for learning approach.* Belmont, CA. Wadsworth Cengage Learning. Retrieved from ERIC.

Gates, P. (2006). Going beyond belief systems: Exploring a model for the social influence on mathematics teacher beliefs. *Educational Studies in Mathematics*, *63*(3), 347–369.

Gersten, R. & Chard, D. (1999). Number sense: Rethinking arithmetic instruction for students with mathematical disabilities. *Journal of Special Education, 33(1),* 18–28.

Gersten, R., Chard, D., Jayanthi, M., Baker, S. & Lee, D. (2006). A meta-analysis or research on mathematics interventions for elementary students with learning disabilities. *Review of Educational Research*, 79, 1202-1242. doi:10.3102/0034654309334431.

Gick, M. & Holyosk, K. H. (1983). Schema induction and analogical transfer. *Cognitive Psychology*, 15, 1-38.

Goldin, G. A. & Brunswick, N. (2004). Problem solving heuristics, affect, and discrete mathematics. *ZDM*, 36 (2), 56-60.

Grafman, J. & Cates, G. (2009). The differential effects of two self-managed math instruction procedures: Cover, copy, and compare versus copy, cover, and compare. *Psychology in the Schools*, 47, 153-165. doi:10.1002/pits.20459

Halberda, J., Ly, R., Wilmer, J. B., Naiman, D. Q. & Germine, L. (2012). Number sense across the lifespan as revealed by a massive internet – based sample. *Proceedings of The National Academy of Sciences*, 109(28), 11116 – 111120.

Hasselbring, T. S., Lott, A. C. & Zydney, J. M. (2006). Technology-supported math instruction for students with disabilities: two decades of research and development. Washington, DC: CITEd, Center for Implementing Technology in Education (www.cited.org).

Hoon, T. S., Kee, K. L. & Singh, P. (2013). Learning mathematics using heuristic approach. *6th International Conference on University Learning and Teaching* (InCULT 2012).

Hoon, T. S., Singh, P., Han, C. T. & Kee, K. L. (2013). Heuristic approach experience in solving mathematical problems. *Educational Research*, 4(8), 607-611.

Hudson, S., Kadan, S., Lavin, K. & Vasquez, T. (2010). Improving basic math skills using technology. Retrieved from: http://web.ebscohost.com.ezproxy2.drake.brockport.edu/ehost/detail?vid=21&hid=15

Hulac, D. M., Dejong, K. & Benson, N. (2012). Can students run their own interventions?: A self-administered math fluency intervention. *Psychology in the Schools*, 49, 526-538. doi:10.1002/pits.21614

Ingram, S. (2011). What is a strategy: Fundamentals of strategic planning. Actionable Strategic Planning. December 8, 2011. Retrieved from http://www.actionablestrategicplanning.com/?p=61

Jonassen, D. H. (2003). Designing research-based instruction for story problems. *Educational Psychology Review*, 15, 267-296.

Jordan, N, C., Glutting, J. & Ramineni, C. (2010). The Importance of number sense to mathematics achievement in first and third grades. *Learn. Individ. Differ.*, 20(2), 82–88.

Kaminski, E., (2002). Promoting mathematical understanding: Number Sense in action. *Mathematics Education Research Journal*, 14(2).

Kazdin, A. E. (1982). *Single-case research designs: Methods for clinical and applied settings.* New York: Oxford.

Keller, C. (2011). Using a familiar risk comparison within a risk ladder to improve risk understanding by low numerates: A study of visual attention. *Risk Analysis*, 31(7), 1043 – 1054.

Keller, C. (2014). Numeric and graphic risk information processing of high and low numerates in the intuitive and deliberative decision modes: An eye-tracker study *Judgment and Decision Making*, 9(5), 420-432.

Ketterlin-Geller, L., Chard, D. & Fien, H. (2008). Making connections in mathematics: Conceptual mathematics intervention for low-performing students. *Remedial and Special Education*, 29(1), 33-45. doi:10.1177/0741932507309711.

Kilpatrick, J., Swafford, J. & Findell, B. (Eds.). (2001). Adding it up: Helping children learn mathematics. Retrieved from http://www.nap.edu/catalog.php? record_id=9822.

Lach, T., & Sakshaug, L. (2005). Let's do math: Wanna play? *Mathematics Teaching in the Middle School*, 11 (4), 172-176.

Lawson, A. (2007). Learning mathematics vs. following "rules": The value of student-generated methods. What Works? Research into Practice. Student Achievement Division.

Leder, G. C., Pehkonen, E. & Törner, G. (Eds.). (2002). Beliefs: A hidden variable in mathematics education? Dordrecht: Kluwer.

Lembke, E., Hampton, D., & Beyers, S. (2012). Response to intervention in mathematics: Critical elements. *Psychology in the Schools*, 49, 257-272. doi:10.1002/pits.21596.

Leone, P., Wilson, M. & Mulcahy, C. (2010). Making it Count: Strategies for Improving Mathematics Instruction for Students in ShortTerm Facilities. Washington, DC:

Lipkus, I. (2007). Numeric, verbal, and visual formats of conveying health risks: Suggested best practices and future recommendations. *Medical Decision Making, 27,* 696–713.

Lipkus, I. & Peters, E. (2009). Understanding the role of numeracy in health: Proposed theoretical framework and practical insights. *Health education & Behavior, 36(6),* 1065–1081.

Lock, R. H. & Gurganus, S. (2004). Promote number sense. *Intervention in School and Clinic*, 40(1), 55 – 58.

Martel, H. A. (2009). Effective strategies for general and special education teachers. senior Honors Theses. 210. Retrieved from: http://commons.emich.edu/honors/210

McCallum, E., Skinner, C., Turner, H. & Saecker, L. (2006). The taped-problems intervention: Increasing multiplication fact fluency using a low-tech, classwide, time-delay intervention. *School Psychology Review*, 35, 419-434. Retrieved from http://www.nasponline.org/publications/spr/index-list.aspx.

Mohamed, M., & Johnny, J. (2010). Procedia – Social and Behavioral Sciences. Volume: 8, pp. 317 – 324.

Moore, N. D. (2012). Alternative strategies for teaching mathematics. Education and Human Development Master's Theses. 130. Retrieved from http://digitalcommons.brockport.edu/ehd_theses/130

National Council of Teachers of Mathematics (2000). Principles and Standards for School Mathematics. Reston, VA.

National Council of Teachers of Mathematics (2011). A position of the National Council of Teachers of Mathematics. What is the role of technology in the teaching and learning of mathematics? Retrieved from http://www.nctm.org/Standards-and-Positions/Position-Statements/Strategic-Use-of-Technology-in-Teaching-and-Learning-Mathematics/

Ontario Ministry of Education (2005). The Ontario curriculum grades 1-8 mathematics. Retrieved from http://www.edu.gov.on.ca/eng/curriculum/elementary/ math18curr.pdf

Pathania, A. (2011). Teachers' role in quality enhancement and value education. *Acad. J.,* 14(1), 19-26.

Philippou, G., & Christou, C. (2002). A study of mathematics teaching efficacy beliefs of primary teachers. In G. C. Leder, E. Pehkonen, & G. Törner (Eds.), Beliefs: A hidden variable in mathematics education? (pp. 211–231). Dordrecht: Kluwer.

Polya, G. (1973). *How to solve it: A new aspect of mathematical model. (2nd ed).* Princeton, New Jersey: Princeton University Press.

Protheroe, N. (2007). What does good math instruction look like? *Principal, 87*(1), 51-54.

Reyna, V. F., Nelson, W. L., Han, P. K., & Dieckmann, N. F. (2009). How numeracy influences risk comprehension and medical decision making. *Psychological Bulletin, 135(6),* 943–973. http://dx.doi.org/10.1037/ a0017327.

Rille-Johnson et al. (2001). *In* Rubin, R. J., Marcelino, J., Mortel, R. & Lapinid, M. R. C. (2014). Activity-based teaching of integer concepts and its operations. Presented at the DLSU Research Congress 2014, De La Salle University, Manila, Philippines, 6-8, March.

Rubin, R. J., Marcelino, J., Mortel, R. & Lapinid, M. R. C. (2014). Activity-based teaching of integer concepts and its operations. Presented at the DLSU Research Congress 2014, De La Salle University, Manila, Philippines, 6-8, March.

Salkind, N. J. (2010). Pre-experimental designs. *In* Encyclopedia of Research Design. Retrieved from http://methods.sagepub.com/reference/encyc-of-research-design/n330.xml

Schoenfeld A. H. (1985). *Mathematical problem solving.* Orlando, FL: Academic Press.

Starr, A. (2013). *From magnitudes to math: Developmental precursors of quantitative reasoning.* Unpublished Dissertation, Duke University.

Steedly, K., Dragoo, K., Arafeh, S. & Luke, S. D. (2008). Effective mathematics instruction. *Evidence for Education*, 3(1), 1-12.

Sundling, N. (2012). Effective mathematics intervention programs for students in grades three through five. Unpublished Master's Thesis, Northern Michigan University, November.

Suurtamm, C., Quigley, B. & Lazarus, J. (2015). Making space for students to think mathematically. What Works? Research into Practice. Research Monograph #59. Student Achievement Division.

Sztajn, P. (2003). Adapting reform ideas in different mathematics classrooms: Beliefs beyond mathematics. *Journal of Mathematics Teacher Education, 6*, 53–75.

Tamin, R. M., Bernard, R. M., Borokhovski, E., Abrami, P.C. & Schmid, R.F. (2011). What forty years of research says about the impact of technology on learning: A second-order meta-analysis and validation study. *Review of Educational Research*, 81, 4-28.

Thompson, A. G. (2004). The relationship of teachers' conceptions of mathematics and mathematics teaching to instructional practice. In B. Allen & S. J. Wilder (Eds.), Mathematics education.

Tiong, J., Siew, Y., Hedberg, J. & Lioe, L. T. (2005). A Metacognitive Approach to Support Heuristic Solution of Mathematical Problems. Presented in a Research Conference Proceeding.

Wagganer, E. L. (2015). Creating math talk communities. *Teaching Children Mathematics*, 22(4), 248-254.

Wilkins, J. L. M. (2008). The relationship among elementary teachers' content knowledge, attitudes, beliefs, and practices. *Journal of Mathematics Teacher Education*, 11, 139–164.

Woodward, J. (2006). Developing automaticity in multiplication facts: Integrating strategy instruction with timed practice drills. *Learning Disability Quarterly*, *29* (4), 269-289.

Xin, Y. P., & Zhang, D. (2009). Exploring a conceptual model-based approach to teaching situated word problems. *The Journal of Educational Research*, *102*, 427-441.

Xin, Y. P., Wiles, B., & Lin, Y. (2008). Teaching conceptual model-based word-problem story grammar to enhance mathematics problem solving. *Journal of Special Education*, 42, 163-178.

Youssef-Shalala, A., Ayres, P., Schubert, C., & Sweller, J. Using a general problem-solving strategy to promote transfer. *Journal of Experimental Psychology: Applied*, Volume 20(3), Sep, 2014. pp. 215-231

Zevenbergen, R. (2003). Teachers' beliefs about teaching mathematics to students from socially disadvantaged backgrounds: Implications for social justice. In L. Burton (Ed.), Which way social justice in mathematics education? (pp. 133–151). Westport, CT: Praeger.