CHAPTER – I
INTRODUCTION AND CONCEPTUAL FRAME WORK

1.1 Introduction

Recent concern over the education system’s ability to educate students in order to remain globally competitive has led to an increased interest in school reform using instructional technologies (Schank & Jona, 1999). The ultimate goal of education was to prepare students for productive and independent lives within our society (Collins & Halverson, 2010). Mathematics skills taught in the elementary grades help to provide the basic skills, knowledge and solid foundation that was necessary for children to advance in their education, making early achievement critical for future success.

Additionally, it was important to nurture and establish a positive disposition towards mathematics early on in a child’s education. Students who lack skills or possess negative attitude towards mathematics are at risk for failure in middle school, high school and beyond. Intervening at a critical and premature stage in a child’s mathematical learning will help lay the foundation of a successful mathematical future. If a student builds a strong mathematical foundation in the elementary grade levels, students will have more success in their future (Carr, 2012).

Schoenfeld (1992) further states that mathematics literacy was “a core component of intelligent decision making in everyday life, in the workplace, and in our democratic society”. As our society is ever evolving, those who are technologically literate will have access to jobs and economic empowerment, while those without such skills will not. Mathematical success in schools has usually provided further openings for students to develop technological literacy and advance into higher education and employment opportunities (Schoenfeld, 1992).
Baya’a and Daher (2009) determined that the use of mobile technology as a learning device can help students visualize mathematics and learn more easily and efficiently. Utilizing technology in the classroom can help design instruction that takes on a more student centered approach that includes project based learning, cooperative learning and independent inquiry (Lowther, Ross & Morrison, 2003). This type of teaching must be made to accommodate the skills and interests of 21st century students.

Timmermann (2010) agrees, “Pedagogy needs to reflect social changes and confirm to the needs and expectations of today’s students”. Cobcroft, Towers, Smith & Bruns (2006) conveyed that as mobile technology devices are more affordable for schools, it was important to take advantage and embrace the benefits that they can bring into classrooms and “as students’ learning styles are evolving, educational institutions must reexamine pedagogical approaches”. Barone and Wright (2009) support the notion that it was necessary to expose and prepare students to new technologies as it evolves.

Utilizing iPad devices will help young students stay well informed with the way of the future. In addition to positive advantages from exposure, Barone and Wright (2009) argue that the devices lead to an increase in teacher-student and student-student communication due to the convenience and easy way to share and transfer information. In a study conducted on how youngsters use the World Wide Web, 41% use e-mails and instant messaging to contact teachers about schoolwork (Oblinger, 2003). The iPad progresses ways learners and teachers in the classroom are able to communicate and collaborate with each other (Dhir, Gahwaji & Nyman, 2013).

Technological devices have built in tools that promote relationships among all learners that include emailing and communication applications (Dhir et al., 2013). The world in which 21st century student are growing up in was significantly different than earlier generations (Berk, 2010). Instead of reading and writing print and learning in a text only environment, students now prefer
an image-rich, visually literate setting. The use of technological devices in education can help students to communicate visually by capturing images and sharing knowledge in a peer-to-peer world (Berk, 2010).

Teaching methods have given way to a great deal of changes over the past 100 years, which makes it necessary to consider new models of teaching and the way information is translated to students (Campo, 2013). In general, many have supported the notion that in order to properly educate students for the complex world, which they will soon be a part of, integration of technology can be supportive component (Huneycutt, 2013). Students will be able to develop essential 21st century skills that they will need to be successful in their future. Research has shown that integrating technology in the classroom can be used to promote students’ learning, attitudes and overall achievement (Enriquez, 2010).

In order to achieve higher student success that supports authentic learning, many schools are transitioning towards, using tablet devices such as mobile tablets as a mean of enhancing instruction (Hu, 2011; Murray & Olcese, 2011). Schools across the globe have spearheaded the movement of integrating the iPads into the classroom. Bauleke and Herrmann (2010) convey that as students are growing up in an era of technology, it was often difficult for teachers to create memorable learning experiences for them. For this reason, it has been argued that it was necessary to incorporate the use of iPad as an enhancement to the curriculum to reach millennium-aged students. “Students are ‘goin’ mobile across the United States, and educators are adjusting instructional and operational practices to reap learning benefits” (Kiger, Herro & Prunty, 2012).

According to Preciado-Babb (2012), iPads and other tablet devices have helped students to develop new relationships with math content when they are able to practice and learn using the technologies. As technology was continuously evolving, the next major shift to incorporate 21st century
technology into the classroom has been tablet devices such as the Apple iPad (Prensky, 2012). Haydon, Hawkins, Denune, Kimener and McCoy (2012) described a study comprising the effects of a worksheet condition and an iPad condition on academic engagement in a high school setting. Results from this study reveal that more academic work was completed correctly in less time and higher levels of active engagement were demonstrated in the iPad condition as compared to the worksheet condition. This investigation reinforced the notion that students completed more correct work in the same amount of time using technology than students who did not use technology. Moreover, the study concludes that technology provides positive effects and promotes active student learning. Takahashi (2011) states that for students who have been absent, missed a lesson or need a reteach, the iPad allows for an anytime, anywhere education. Utmost, the iPad is a sleek, user-friendly device that can help to motivate all types of learners to succeed (Li & Pow, 2011). The iPad allows for many different lessons to materialize within one classroom at all times (Amin, 2010).

1.2 Backdrop of the Study

According to Francis Bacon, “Mathematics is a gateway and key to all Sciences”. Mathematics has a significant role to play in the new revolution in Science based on the technological development. Indeed there is an urgent need for innovation in teaching of Mathematics at all levels as it is a vehicle to train a child to think, reason and problem solving. A major concern in science education is the problem solving skills demonstrated by students. In spite of extensive research in the field of problem solving over the past few decades, there are still important areas in this regard that remain largely under-explored.

Due to examination pressure, teachers teach problem solving skills last in the syllabus instead of integrating them in the various topics. Teachers who have been blamed for all the undesirable things going on in society are now confronted about what to teach and what ability are to be developed among students of Mathematics. The problem is also about the process of instruction,
that is, teaching of mathematics. There is a need to educate students of mathematics not only to acquire knowledge math but also to combat its individual problems as well as the problems of the society. Research conducted mostly in Western and European cultures, has established that students who believe that they are capable of adequately completing task and have more confidence in their ability to do so, typically display the highest levels of academic achievement and also engage in academic behaviors that promote learning (Bandura, 1997; Schunk, 2001; Zusho, Pintrich, 2002).

Concept formation and utilization become most important for the development of mind and also thinking process for there is a need to develop and work on new techniques and strategies, which are suitable for our conditions. This can be done by standing on the shoulders of great educationists and psychologists to adopt the techniques and approaches developed by them to our conditions. In that direction it is required to develop and insight into works of Jean Piaget and Barbel of Geneva school and Bruner and Robert Gagne of USA. According to Piaget, there are distinct periods in logical growth. Experience is always necessary for intellectual development. (Piaget, 1970). Instructional strategies based on scientific process and students learning skills are necessary and essential for understanding scientific principles to solve problems. Presenting a problem and developing the skills needed to solve that problem are more motivational than teaching the skills without a content. Such motivation gives problem solving special values as a vehicle for learning new concepts and the skills and the reinforcement of skills already acquired (Stanic and Kilpatrick, 1989).

Approaching Mathematics through problem solving can create a context, which stimulate real life and therefore justifies Mathematics rather than treating it as an end in itself. The National Council of Teachers of Mathematics (NCTM, 1980) recommended that problem solving be the focus of Mathematics teaching, because it encompasses skills and functions, which are an important part of everyday life.
Mathematics is an essential discipline because of its practical role to the individual and society. Mathematics should be made interesting, understanding and permanent. Hence it is necessary to identify the problems of the learners and plan the learning activities before teaching and using innovative strategies for effective dissemination of instruction. So there is a growing need for appropriate Mathematics education. The most important purpose of the teaching Mathematics was the development of the problem solving ability in the pupils as well as the ability to meet and solve problems in daily life.

There was a substantial literature of problem-solving studies in mathematics education. Perhaps the best sense of the state of the art in the mid-to late 1970s can be found in Harvey and Romberg’s (1980) monograph. That volume offers a literature review and the detailed summaries of nine dissertations on problem solving, most of which offered interesting but often ambiguous or flawed results. Since problem solving has become a popular topic, one has many literature reviews to choose from. There are relevant surveys in the National Council of Teachers of Mathematics’ (NCTM) 1980 Yearbook, Problem Solving in School Mathematics; the NCTM’s (1980) Selected Issues in Mathematics Education; Frank Laster’s (1982) Mathematical Problem Solving; Issues in Research; and the Association for Supervision and Curriculum Development’s (1981) Mathematics Education Research: Implications for the 80s, from which problem solving strategies may be created.

Cockcroft (1982) advocated problem solving as a means of developing mathematical thinking as a tool for daily living, saying that problem-solving ability lies ‘at the heart of Mathematics’, it was the means by which Mathematics can be applied to a variety of unfamiliar situations. The teachers should train the students to select the appropriate strategies for the given problem situations. Students should be imbibed to the culture of logical inquiry in Mathematics. Innovative and interactive strategies induce teamwork in students. Problem solving in general was described as a “Process involved in
finding a solution to a problem and may be characterized as a systematic search through a range of possible actions in order to reach some predefined goal or solution”.

Change is an inherent quality of any society. Generally change in one important field of knowledge has an impact on the other fields also. The tremendous speed with which innovations in science and technology have been progressing has led to explosion of knowledge and skill in every walk of life. The challenge of the day, for the mankind as a whole, is to keep in pace with this impact. Therefore, the teachers of present day ought to search for improved methods and techniques of teaching to make learning more useful and education more meaningful.

Over the last two decades, many researchers have studied problem solving in mathematics from a cognitive information-processing perspective. Recent summaries of studies investigating mathematical problem solving (Garofalo & Lester, 1985; Schoenfeld, 1987; Silver, 1985) suggest that a primary source of difficulty in problem solving may lie in students’ inability to actively monitor and subsequently regulate the cognitive processes engaged in during problem solving.

The National Council of Supervisors of Mathematics (1977) asserts that “learning to solve problems is the principal reason for studying mathematics,” and the National Council of Teachers of Mathematics (1980) recommends that “problem solving be the focus of school mathematics is the 1980s.” Halmos (1980) “advocate[s] more emphasis on the problem approach to teaching.” Suydam (1980), in a research synthesis, writes, “Research evidence strongly concurs that problem-solving performance is strongly enhanced by teaching students to use a wide variety of strategies or heuristics, both general and specific.” Heuristics, or the “mental operations typically useful for the solutions of problems” have been the focus of most problem-solving research in mathematics education and the foundation for the most
developmental efforts in problem solving. Lester (1980) provides a broad and somewhat more restrained overview of the problem-solving literature. In both cases, the bulk of the research cited was very tentative. Correlations between the use of heuristics and competent problem-solving performance have been obtained (Kantowski, 1977), and results in a variety of experiments suggest that problem instruction via heuristics will enhance students’ problem-solving performance (Lucas, 1972; Schoenfeld, 1987; Smith, 1991).

Problem solving was recognized among the critical attributes identified in Kay’s 21st century learning framework (2010). Specific problem-solving skills such as analysis, transfer and metacognition also figure prominently in the revised Bloom’s taxonomy and in the facets of understanding described by Wiggins and McTighe (2005).

Polya’s ideas about problem solving influenced the field of Mathematics education for decades. Problem solving can be regarded as a situation in which an individual is responding to a problem that he or she does not know how to solve with routine or familiar procedures. Problem solving can be described as composed of three different dimensions. The Problem; the Process and the Outcomes. The Seminal work of Polya (1945) identified four steps in the process of solving mathematics problems. These steps consist of (a) understanding the problem, (b) devising a plan, (c) carrying out the plan, and (d) looking back. Hence, the problem solving process is described as linear progression from one phase to the other. Not all of the four steps of Polya, however, have received equal attention in problem solving research. For example, the second step, devising a plan, gained interest in the mathematics education community (Schoenfeld, 1985), but the fourth step, looking back, has attracted much less consideration so far (Lee, 2009). Schoenfeld (1985) devised a model for analyzing problem-solving moves that was derived from Polya’s.
Schoenfeld’s model incorporated, within Polya’s structure, findings from research on problem solving by information-processing theorists. The model described mathematical problem solving in five episodes: reading, analysis, exploration, planning / implementation, and verification. Garofalo and Lester (1985) built on Polya’s and Schoenfeld’s structures by developing framework for analyzing metacognitive aspects of performance on a wider range of mathematical tasks. Schoenfeld (1985) observed that during problem solving students display distinct categories of behavior called episodes. Critical episodes are analyzing the problem, selecting appropriate mathematical knowledge, making a plan, carrying it out, and checking the answer with relation to the question asked. As students are solving problem, not only do they need implement heuristics and utilize resources, but they also need some mechanism to evaluate their progress so that they are aware of, and critically examining, their own decision-making.

Alan Schoenfeld presents the view that understanding and teaching Mathematics should be approached as a Problem Solving domain. According to Schoenfeld (1985) four categories of knowledge / skills are needed to be successful in Mathematics: (1) Resources – Proposition and Procedural knowledge of Mathematics, (2) heuristics – Strategies and Techniques for Problem Solving such as working backwards, or drawing figures, (3) control – decision about when what resources and strategies to use and (4) beliefs – a Mathematical “World View” that determines how someone approaches a problem.

The purpose of the non-routine problems is to organize data, to classify them, to address relationships, and to do several activities step by step. Problem solving strategies can be applied for the solution of both routine and non-routine problems. What are the effective factors in selecting strategies? Why are some strategies used more often? Can selection of strategies and applications be taught? Several arguments were done by the researchers in response to these questions. The problem-solving strategies found after an
investigation of the literature (Altun, 2007; Dhillon, 1998; Hatfield, Edward and Bitter 1997) are: to make a list systematically, to guess and control strategy, to plot a diagram, to find a formula, to use parameters, to work backward, to eliminate, to tabulate, etc.,

In deed Instructional Design is the systematic process of translating general principles of learning and instruction into plans for instructional materials and learning. On ‘Principles of Instructional Design’ Gagne, R.M., Briggs, L. J., & Wager, W. W (1992), lists different Stages of Instructional Design. The aim of instructional design is to make the instruction effective, efficient, appealing and cost-effective. The influence of cognitive science in instructional design was evidenced by the use of advance organizers, mnemonic devices, metaphors, chunking into meaningful parts and the careful organization of instructional materials from simple to complex. Jonassen (2008) points out that the differences between constructivist and objectivist, (behavioral and cognitive).

Two studies have attempted to make parts of the instructional design process more exact. Israelite (1984) examined the uses of student self-evaluations in formative evaluation. By comparing self-evaluations with designer and instructor evaluations and other measures, he described the uses and limitations of different types of data in formative evaluation. Cooper (1983) looked at instructional design procedures for algorithmic problem solving. Form the literature, her own experience, and the data from the tryout of an instructional product; she developed a set of instructional design rules for a class of problem-solving skills. She tested them by revising the existing product and developing two new products. The products were aimed at teaching one class of problem-solving skills in different content domains. The results showed that the instructional design rules were useful in developing effective instructional products.
There was no set of problem-solving strategies that learners can use in all situations, nor is there a set of prescriptive rules that designers can use for developing instruction for all types of problem solving. Instead, instructional designers need ways of classifying problems according to the cognitive process used in solving them. They may then be able to design generalizable instructional strategies to teach each type of process. However, many authors treat problem solving as if it were a single type of skill. Any distinctions made tend to be ill formed and inconsistent. Gagne’ and Briggs (1992) maintain that all problem solving represents a single rule-combining process.

Becoming literate in the 21st century puts new demands on learners to be able to use technology to access, analyze, and organize information. The International Society for Technology in Education (ISTE) updated its National Educational Technology Standards for Students (NETS) in 2007 to better describe skills needed to learn and live in an increasingly digital world. Leaders from the National Council of Teachers of Mathematics and International Society of Technology in Education have agreed that teachers and students must emphasize technology in mathematics to increase achievement. Although there is little consensus concerning how and when to use technology in mathematics instruction, many researchers (e.g., Stacey, 2005; Demana & Waits, 1994; Fey, Hollenbeck, & Wray, 2010) agree that, when used appropriately, technology can enhance the learning and teaching of mathematics.

Regarding the impact of educational technologies on mathematics learning, a three year longitudinal study of secondary mathematics classrooms in Australia, by Goos, Galbraith, Renshaw, and Geiger (2003) examined technology-related interactions involving computers, graphing calculators, and a device that projected screen output for whole class viewing. The authors suggest that individual cognitive reorganization occurred when students interacted with technology in a semiotic system in which their thinking was qualitatively transformed. Schwartz (1999) expanded upon how mathematical
technology can support three of the purposes for education identified by John Dewey: assisting the personal growth and development of individuals, preparation of people for the world of work, and transmission of culture.

Hoyles and Noss (1994) found that in the context of a dynamic geometry environment, the presence of a particular technological resources (features) can either enable or limit certain actions, hence affecting the available heuristics a student may use his or her problem solving. In fact, two large mathematics professional organizations in the United States (National Council of Teachers of Mathematics [NCTM], 2000; the Association of Mathematics Teacher Educators [AMTE], recognize the integral role of digital technologies in increasing students’ mathematical performance. Therefore, mathematics teachers today are required to integrate effectively digital technologies in teaching Mathematics (Grandgenett, 2008).

Studies show that prior knowledge was found to be significant predictor of mathematical problem solving performance (Byrnes & Takahira, 1993; Byrnes & Takahira, 1994; Serafino & Cicchelli, 2003). The influence of mathematical achievement and instructional models on problem solving performance was investigated as well. Numerous instructional design models are currently available to help teachers to integrate technology into a curriculum.

Advancements in technology make branched constructivist approach to learning possible. When designing for education, the instructional designer’s toolbox contains an ever changing and increasing number of theoretical applications and physical possibilities. With intelligent application of learning theory strategies and technology, the modern designer will find solutions to the learning requirements of the 21st century. For the instructional designer the issue was not leaving the learner adrift in a sea of content without the tools to be successful but practical ways to maximize Problem Solving Strategy and thus equip learners with the appropriate navigational tools to reach shore.
The investigation carried out by Wei-Chen Hung et al., (2010) observed that the meaningful use of technology requires, teachers to not only know how to use technology, but how the technology can be used to promote learning. Many teachers are enthusiastic about the use of iPads in the field of education. It was not surprising that teachers are extremely admired about the versatility, connectivity, mobility as well as the benefits of thousands of educational apps of the iPad. However, there has not been consensus among teachers regarding the benefits of the students’ community. At its core, iPad is expected to advance student performance as a cognitive tool that extends student capabilities (Jonassen, 2008).

In the learning ecosystem that has been transformed by cognitive tools, pedagogy maximizes learning because it was student-centered, tool-based, differentiated, personalized, and authentically assessed (Cavanaugh & Hargis, 2010). Whether the influence of digital technologies on learning was classified either as a primary or secondary factor, it affects the speed and quality of delivering instructions (Kozma, 2000). While using the iPad apps in math classroom, often students learn to use the apps with little understanding of usage of the apps along with how the mathematical concepts are interrelated. In this context the researcher made an attempt to define iPad Assisted Instruction as “an instructional strategy in which an instructional design is integrated with the use of iPad applications for learning Mathematics”. In the light of the lack of inconclusive evidence of the influence of iPads in education, and with the high expectations of their potential influence on transforming education, the present study intends to develop iPad Assisted Instruction for Mathematics learning. In that way if iPad apps are integrated with appropriate Instructional Design the Mathematics learning curve will tend to develop Problem Solving Behavior among the younger ones.
1.3 Math as Problem Solving Behavior of Students

Problem solving has been the focus of research in mathematics education for many years. The National Council of Teachers of Mathematics (NCTM) stated in the principles and Standards for School Mathematics that:

Problem solving means engaging in a task for which the solution method is not known in advance. In order to find a solution, students must draw on their knowledge, and through this process, they will often develop new mathematical understandings. Solving problems is not only a goal of learning mathematics but also a major means of doing so ………..Problem solving is an integral part of all mathematics learning, and so it should not be an isolated part of mathematics program. (NCTM, 2000, p.52).

The National Council of Teachers of Mathematics (NCTM) has identified five imperatives or needs for all students (NCTM 2000). (1) Become Mathematical Problem solvers (2) Communicate knowledge (3) Reason Mathematically (4) Learn to value Mathematics (5) Become confident in one’s ability to do mathematics. In this connection, NCTM took a significant step toward “consciousness-raising” by recommending the Standards for all students. Instead of tiring objectives- more mathematics for the college bound, less for prospective trade school students, and almost none for at-risk students–the Council asks for more mathematics–more emphasis, more complexity, more challenging goals and objectives–for all students.

Problem solving was referred to an “extremely complex form of human endeavor that involves much more than the simple recall of facts or the application of well-learned procedures” (Lester 1994, p. 668). Researchers concluded that to be a good problem solver in mathematics, students should be able to select and use task-appropriate cognitive strategies for understanding, representing, and solving problems (Mayer, 2003; Schoenfeld, 1985). Problem solving has come to be viewed as a process that requires use of many cognitive abilities and processes including intelligence (Polya, 1973; Sternberg, 1982),
creativity and originality (Polya, 1973), reading ability (Hite, 2009), spatial ability, verbal ability (Dodson, 1972), working memory (Swanson 2004), and knowledge (Lester, 1980).

Problem solving has also been examined from many different points of view (Karp, 2007b; Kilpatrick, 1985; Lester, 1994; Schoenfeld, 1985; Schroeder & Lester, 1989; Silver, 1985; Stanic & Kilpatrick, 1989). In recent years, solving mathematics problems using many different approaches has drawn more attention than before. Some researchers, in fact, considered such practice to be beneficial for students’ mathematics learning experience (Tabachneck, Koedinger, & Nathan, 1994). Certainly, this consideration appears warranted with evidence of students’ learning outcomes, albeit conflicting evidences (GroBe & Renkl, 2006). Teaching and learning experiences are not the only focus of research in solving mathematics problems using many different approaches.

Another focus involves investigating why some people solve one particular problem using different ways than others do. Some researchers have analyzed students’ choice of approaches based on certain mathematics topics (Nesher et al., 2003). Others have explored the question of selecting a particular problem solving approach from an aesthetic point of view (Dreyfus & Eisenberg, 1986; Karp, 2008; Silver & Metzger, 1989; Sinclair, 2004).

Typically, a problem solving approach was “beautiful” if it was particularly clear, simple, and unexpected. Cognitive psychologists, in addition to mathematics educators, have also been interested in studying choices of problem solving approaches (Siegler, 1983). In particular, they examined how the order in which approaches are presented affects the whole process of thinking in problem solving. Their investigations, primarily on basics arithmetic skills, pointed towards an understanding of the development of approaches and the interactions among those approaches (Geary & Brown, 1991; Roberts et al., 1997). It can be inferred thus far that research in
mathematics education needs more analysis to explain the thinking processes involved in problem solving. Even existing research in cognitive psychology has typically concentrated on (limited) elementary school mathematics topics (Star, 1999). The relationship between problem solving accuracy and performance on a measure of intelligence was investigated by researchers (Xin & Zhang, 2009; Vickers et al., 2004; Burns et al., 2006).

The cognitive component includes three general types of learning skills, which are referred to as cognitive strategies, problem-solving strategies, and critical thinking skills. Cognitive strategies include a wide variety of individual tactics that students and instructors use to improve learning. One example is use of student-generated questions before or during reading to focus the learner’s attention (Chinn & Brown, 2002).

Problem solving strategies are more complex in nature than cognitive strategies. Problem solving strategy instruction usually focuses on either the development of a general problem solving strategy or situated practice using that strategy. Recent studies report that general problem solving can be broken down into smaller individual steps that are teachable and improve learning (Dhillon, 1998). Explicit problem solving instruction helps students to develop deeper levels of understanding compared to students who do not receive problem solving training (Huffman, 1997).

Regardless of strategies and methods used to solve a problem, when final answers were considered as the only indicator of mathematical problem solving performance, scores on measures of intelligence were found to be correlated with scores on measures of mathematical problem solving at a significant level. In addition, general intelligence was found to be a significant predictor of mathematical problem solving performance. (Xin & Zhang, 2009; Vickers et al., 2004; Burns et al., 2006). Mathematically gifted students were found to be more successful at understanding the complexity of problems than were non-gifted students (Sriraman, 2005). In addition, non-gifted students
displayed absence of some problem solving and generalization skills found in
gifted students. Most commonly lacking were comprehension of the problem
situation, assessment of the adequacy of the information given in the problem,
identification of the assumptions in the problem situations, and differentiation
between interrogative and declarative statements (Sriraman, 2005).

In addition, when the effects of prior knowledge and instructional
models were evaluated on student mathematical problem solving performance,
students with a higher prior knowledge had a higher mean in problem solving
scores than students with a low prior knowledge regardless of the type of the
instruction they were given (Serafino & Cicchelli, 2003). Human working
memory was declared to be the foundation of mathematical problem solving.
Working memory was found to predict mathematical problem solving
performance at a significant level (Swanson, 2004). In addition to working
memory, fluid intelligence, reading ability, processing speed, and knowledge of
algorithm were found to be significant predictors of mathematical problem
solving performance. However, working memory was found to predict solution
accuracy of word problems independent of measures of fluid intelligence,
reading skill, math skill, phonological processing, semantic processing, speed,
short-term memory, inhibition, and knowledge of algorithms (Swanson, 2004).

Reading ability has been considered a basic requirement for success in
many academic subjects, including mathematics. Solving mathematical word
problems requires strong reading comprehension and educators need to
improve students’ reading skills to improve mathematics performance
(Fuentes, 1998). Studies done by Jordan et al., 2003; Vilenius-Tuohimaa et al.,
2008; show that reading ability was found to be associated with mathematical
problem solving performance. When problems are designed with excessive
verbal content, reading achievement would be expected to influence growth in
mathematics achievement whereas mathematics abilities do not influence
growth in reading achievement. Especially English Language Learners might
perform less well on these problems because they read more slowly. From this
perspective, the influence of reading ability on problem solving performance might vary depending on the problem solver’s familiarity with the language.

One of the cognitive abilities associated with mathematical problem solving performance was spatial ability. Spatial ability was defined as the ability to generate, retain, and manipulate abstract visual images, and it was described by researchers as one of the important factors influencing problem-solving performance (Lohman, 1979). Gardner (1984) proposed a multifaceted model of intelligence in which spatial abilities were one of seven major components. Gardner described “spatial ability” as the capacity to perceive the visual world accurately, to perform transformations and modifications upon initial perceptions, and to be able to recreate aspects of visual experience even in the absence of relevant physical stimuli. Garderen also stated that spatial ability works in collaboration with logical-mathematical ability (mathematical ability and the ability to reason). Similarly, in her hierarchical “three-stratum theory” of ability, Carroll (1993) demonstrated the positioning of spatial ability in juxtaposition with verbal and mathematical ability.

Researchers found that the use of schematic images was positively related to success in mathematical problem solving, whereas the use of pictorial images was negatively related to success in mathematical problem solving. In addition to the use of schematic imagery was associated with high spatial ability (Hegarty & Kozhevnikov, 1999). In addition, spatial visualization ability was found to be correlated with mathematical-problem performance at a significant level (Garderen, 2006).

In two studies (Awofala et al., 2011, James & Adewale, 2012) verbal ability was found to be an important predictor of problem solving performance. In addition, students with high verbal ability performed significantly better than students with low verbal ability in problem solving performance (Awofala et al., 2011). In his review of research, Zhu (2007) analyzed the influences factors involved in mathematical problem solving including cognitive abilities, speed
of processing information, and many complex variables related to problem solving, such as (a) physiological differences in brains, (b) influences of sex hormones, (c) learning styles, (d) learner’s attitudes, (e) stereotype threat in mathematics tests, (f) differences in socialization, and (g) socioeconomic variables. He concluded that the findings of the studies were complex and inconsistent.

In the studies the researchers found that cognitive abilities influenced mathematical problem solving at significant levels. A joint effort from both fields in mathematics education and cognitive psychology is clearly needed. Interpreting the cognitive rationales for selecting certain approaches over many other approaches in solving advanced mathematics problems is an important area that still requires further study. Research in mathematics education demonstrates that problem solving using many different approaches improves students’ learning experiences.

Problem solving skill is highly valued. In the last five decades, many theorists and educational institutions have placed a heavy emphasis on this ability. For example, the movement of “discovery learning” (e.g., 1961) was spawned, at least in part, by the perceived importance of fostering problem-solving skill. Problem solving is not only finding the correct answer but also an action, which covers a wide mental period and abilities (Altun, 2007). In essence, the present research combines studies of students’ mathematical problem solving experiences from mathematics education, attitude and cognitive psychology. It analyzes problem solving ability via many different components of problem solving behavior and using iPad as a cognitive tool. Finally it examines the impact of iPad Assisted Instruction in teaching – learning process at secondary level mathematics education of the students’ of Fujairah – UAE.
1.4 Rationale of the Study

Instead of focusing on how young children are using the iPad in the educational field, the current study concentrates on the impact of iPad Assisted Instruction as cognitive tool on Problem Solving Behavior of secondary level students in Mathematics at Fujairah – UAE. The rationale for this study originated from researcher’s interest in the subject of technology integration in the sphere of education and his desire to explore the strategies that teacher utilizes for providing technology-enriched learning experiences to their students in teaching Mathematics Education. In fact Mathematics has been a subject, which brings forth the uniqueness of promoting all science and arts subjects. Mathematics claims itself as a tool to every subject. The New Educational Policy (1986) lays importance to the fact that “Mathematics should be visualized as the vehicle to train a child to think, reason, analyze and articulate logically”.

Together with the standards, the Principles for School Mathematics comprise key components of NCTM’s vision of high-quality mathematics education. The Principles are, in effect, ideals to live by—foundational ideas that influence curriculum and professional development on the larger scale as well as instructional decisions in the classroom on the smaller scale. The standards are more like building materials. They outline mathematics content and processes for students to learn. Instead of the multiple standards of the 1989 document, Principles and Standards for School Mathematics proposes 10 standards that “specify the understanding, knowledge, and skills students should acquire from kindergarten to grade 12.” The Content Standards–Number and Operations, Algebra, Geometry, Measurement, and Data Analysis and Probability–explicitly describe the content that students should learn. The Process Standards–Problem Solving, Reasoning and Proof, Communication, Connections, and Representation–highlight ways of acquiring and using content knowledge (NCTM 2000).
A parallel project to NCTM’s Principles and Standards began in 1985, the date of the last visit of Halley’s comet. Sponsored by AAAS (American Association for the Advancement of Science), Project 2061, is named for the date when Halley’s comet will return and assumes that children who were beginning school in 1985 will see a lifetime of changes in science and technology before the comet’s return in 2061. To prepare them for these changes, Project 2061 proposes educational reforms akin those promoted by NCTM. Culotta suggests seven major areas of commonality: (1) Less memorization (2) Involvement of teachers in the reform process (3) Integration of disciplines and study (4) Greater emphasis on hands-on activities (5) Greater focus on listening to students’ questions and ideas (6) Connections between discipline and society (7) Emphasis on the scientific process and how problems are solved.

Project 2061 defines mathematics as “the science of patterns and relationships” and describes it as “the chief languages of science” (AAAS 1989). In the project’s “Design for Scientific Literacy,” mathematics is included in most of the building blocks for a Project 2061 curriculum: “For purposes of general scientific literacy, it is important for students (1) to understand in what sense mathematics is the study of patterns and relationships, (2) to become familiar with some of the patterns and relationships, (3) to learn to use them in daily life”.

Literature on Problem Solving in Mathematics has discussed extensively the need to teach students to reason mathematically. This train of thought lead to an emergent theme in mathematics education in mid-80’s wherein researchers propounded that teaching mathematics via problem solving was the correct way to foster students problem solving and hence reasoning skills. Schroeder and Lester (1989) connected that in Mathematics, Problem solving was not a content strand but a pedagogical stance. To elaborate, the researchers proposed that in teaching any mathematics class, at any level, students be
exposed to a variety of problem solving tasks that require them to collate and analyze previous knowledge and yet offer a challenge.

Problem solving was thus seen as a means of developing students reasoning skills. Researchers have encouraged the integration of technology in the mathematics classroom (Amin, 2010; Banister, 2010; Ross et al., 2010). In United States many schools have invested in student technology because research has shown that technology could be used to promote students’ learning, engagement, and mathematics achievement (Bell, 2007; Castelluccio, 2010; Cuban, 2001; Decastro-Ambrosetti & Cho, 2002; Stevens, 2011; Suki, Suki, Eshaq, & Choo, 2010; Todd, 2010; Traxler, 2010).

The iPad is one of the most recent technology devices introduced into classrooms. The iPad has specialized applications in which multiple senses (e.g., auditory, visual, and tactile) are incorporated; the use of multiple sensory inputs has been shown to reinforce student learning and to achieve a variety of mathematics objectives (Castelluccio, 2010; Hill, 2011; Murphy, 2011; Price, 2011; Stevens, 2011). Increased understanding of technology integration, and specifically iPad Assisted Instruction in enhancing the students’ performance in Problem solving behavior in mathematics, may serve to guide teachers or schools to implement the instructional design in their own classrooms.

Use of technology help students to visualize, stimulate, solve real world problems, collaborate, research, and design whenever possible (Jong. H. Chung, 2007) and brings interdisciplinary collaboration to develop and implement innovative technological approaches (National Research Council, 2002). Moreover a more collaborative learning environment together with game-based learning technologies have the potential to enhance student learning particularly to enhance the development of skills such as self-confidence and motivation, and to allow students to reflect upon what is taught (Valstad, 2010).
Research on the iPad is necessary because, like other mobile learning devices, iPad use may have positive effects on mathematics achievement (Banister, 2010; Bauleke & Herrmann, 2010; Bell, 2007, Hill, 2010; Price, 2011). Research reveals that a significant number of schools across the globe are integrating iPad devices in their classrooms using various implementation models to enhance instructional practice. Gaps in the literature related to specific iPad implementation models and the device’s use as an educational tool, are evident.

On the other hand, upon the exploration of Oil and the beginning of development, the UAE (United Arab Emirates) focused a lot of attention on education, as His Highness Sheikh Zayed bin Sultan Al Nahyan, Former President of UAE and Ruler of Abu Dhabi, considered education among the priorities of progress. Accordingly, education witnessed a development process run by the government in which all necessary tools were provided. Education continued to be an obsession for the state, which leads to the adoption of a futuristic plan for the development of education during the next twenty years, with a vision polarized on reaching higher standards in line with the inputs of science and technology.

The plan incorporates the education of information technology, education of computer illiteracy, preserving social values and ethics, and promoting traditional values among the youth. The results of students’ achievement in UAE in the Trends in International Mathematics and Science Studies (TIMSS, 2011) show that Grade 4 students achieved a mean score of 434 in Math and 428 in Science, while Grade 8 students achieved a mean score of 456 in Math and 465 in Science. In PISA (Program for International Student Assessment) and TIMSS results, the UAE is not faring very high (The National- UAE, Jan. 2014). UAE students scored below average in PISA 2012, and were ranked 48th in Math, 44th in reading, and 46th in Science out of 65 participating organization for Economic Co-operation and Development Countries.
In the last round of TIMSS, the UAE placed below average. UAE considers these studies to be very important in order to take advantage of it an evidence-based approach to develop solutions and provide a high quality education system that reflects the goal and vision of the country. Feature measure in the UAE’s Education 2020 policy emphasizes the increasing use of Information and Communication Technology in the curriculum. A key reason why the iPad has become so popular is because of the apps that are available at very low costs, or free in many cases, from third-party providers. The ease of use, coupled with the affordable cost, had encouraged educators to purchase iPads in bulk for implementation in their classrooms across UAE.

Presently, there are over two million iPad apps and 250,000 iPhone apps available for download, many of which were designed for educational purposes. Such apps include iBooks, which allows users to download interactive electronic books (e-books) for all reading levels. Although the iPad is gaining popularity in the educational setting, little empirical research has been conducted that examines the experiences of high school teachers who utilize iPads as the exclusive method of content dissemination in the classroom (Barbour, 2012; Mang & Wardley, 2012). Instructional goals now require learners to understand and use information in real-world situations. Hence, with the introduction of technology, there is a change in instructional goals, thus the need for a change in instructional materials and instructional strategies (Kearney, Schuck, Burden, & Aubusson 2012) are necessitated.

When a technology, such as iPad, is introduced as a tool in the academic environment, teachers must develop a new concept of what it means to learn, to understand, and to instruct. They engage in the process of assimilation or accommodation to make sense of the experience with the new technology. At the same time the use of technology in the mathematics classroom within inquiry based learning environments has increased significantly in the past few decades. An inquiry approach to the learning of mathematics requires students
to engage actively in a variety of activities in the classroom different from those used in more teacher-centered approaches.

At a larger level, if students of UAE were deficient in mathematics, they would fall short compared to their international counterparts. It was necessary to reverse this trend in order to adequately prepare students for their academics and potential careers. Mathematical preparedness was critical to provide the essential opportunities to remain globally competitive and to prepare students for the real world.

The current research regarding iPad Assisted Instruction in Mathematics classrooms was relatively new due to the novelty of the devices. There was a need to study and identify if iPad would provide academic and attitude benefits for secondary level students. In order for educators and schools to identify ways to accept the challenges of meeting high accountability measures and ways to prepare 21st century students, it was essential to recognize the impact of iPad Assisted Instruction. A student who receive an education that incorporated large amount of technology, hold a positive bias towards the integration of instructional technology. Educators believe that using technological devices within the classroom was a way to improve instruction, participation and attitudes of students. Especially with all the advantages that Apple iPad offers, all students have the chance to be an active participant in all aspects of the lesson rather than a passive observer.

Secondary level students thrive on immediate feedback and results. The immediate feedback that the technological devices proved student would offer them a sense of accomplishment, improvement in attitudes, and pride in their work. Students intend to do well and get the correct answers on programs utilized on the iPad. The instant responses can help to boost their self-confidence that drives them to work harder and put in more of an effort. Moreover, the iPads follow student-centered approaches to teaching rather than teacher-centered approaches. When students are given an opportunity to use
technology in math class, even something as simple as a calculator, a shift in students’ attitudes was evident. For example, when practicing basic multiplication, students are more willing and motivated when they can use quick response code (QR) and technology to check their own answers.

Based on research about how students think, new educational approaches, and the integration of technology into educational systems, the last few decades have seen changes in mathematics instruction in many countries (Suter, 2006). With the constant advances in technology that was available for instruction, educators must strive to ensure that students acquire extensive knowledge using iPad devices, enabling them to integrate into the world of work and meet the demands of the 21st century. It is crucial for pedagogical approaches for teaching mathematics to develop and advance alongside the progression of technology.

It was essential to maintain a balance in teaching methods in order to maintain equilibrium between the use of technology and the interaction between individuals to ensure students are able to acquire new skills in a multitude of ways (Timmermann, 2010). Also he states that if tablet devices are the only means of instruction, this may create a “digital divide” in a negative manner. In agreement, Donovan, Green & Hartley (2010) confirmed from their study that increased access to technology does not lead to an increase in student engagement.

Holcomb (2009) reports that in a research study conducted in Texas that employed a one to one laptop program, results did not increase student achievement. Hu (2011) also reports that there was no evidence found from studies conducted in California and Maine of increasing state test scores as a result of one to one devices.

Though the students’ were provided with iPads on one to one basis, there were no expected outcomes with the students of Fujairah – UAE, in the
performance of their Problem Solving Behavior in Mathematics. Overall, not all technology implementation programs were successful or have a positive impact on teaching and learning. It was necessary to implement tablet devices like iPad in Mathematics classrooms in a strategic way to ensure positive benefits.

An important part of the inquiry approach is that students are expected to learn through problem solving, as opposed to learn for problem solving. Technology, such as the iPad in this case, includes the hardware, the functional software or applications, as well as the form that teacher and students use it. Applications and activities of certain types of software are often targeted to some particular mathematical concepts or skills to be developed by students. Since technology is not reaching its potential in classrooms, it is imperative to develop an appropriate instructional design based on the needs and requirements of the students. The technology alone cannot help the students to achieve better results. Also, with the traditional method of curriculum delivery the students could not achieve the results expected by the system. Hence there is a need to focus on integrating instructional design along with iPad Assisted instruction to enhance the students’ Problem Solving Behavior in Mathematics.

Research is needed to determine how classroom teachers are using the iPad as an instructional tool, how teachers are attempting to make curricular and disciplinary connections, how their pedagogy is or is not changing as a result, and the types of student interactions that are occurring during iPad-integrated activities. It is in this way, the investigator realized the importance of developing and implementing of iPad Assisted Instruction to enhance the performance of Problem Solving Behavior in mathematics among secondary level students.

1.5 Scope of the Study

One technology device per student, also known as one-to-one or 1:1 computing, became evident early in the 21st century (Lui & Milrad, 2010).
Penuel (2006) described 1:1 computing as based on three characteristics: “(1) providing students with use of portable laptop computers loaded with contemporary productivity software, (2) enabling students to access the Internet through schools’ wireless networks, and (3) a focus on using laptops to help complete academic tasks” (p.331). Thousands of schools worldwide have joined the 1:1 initiative (Kraemer, Dedrick, & Sharma, 2009; Lui & Milrad, 2010).

Officials in many U.S. districts have incorporated school-wide 1:1 technology programs with successful outcomes (Houghton Mifflin Harcourt, 2012; Lui & Milrad, 2010, Oliver & Corn, 2008; Rosen & Beck-Hill, 2012; Spires et al., 2012; Warschauer & Ames, 2010; Zucker & Hug, 2008). Lei and Zhao (2008) used a one-year 1:1 laptop program in a middle school and found increase in student achievement, technology proficiency, and parent involvement.

Zucker and Hug (2008) found the use of 1:1 laptops in a high school physics classroom was effective to promote student-centered learning, but student learning was not measured in the study. Oliver and Corn (2008) found private middle school students using classroom tablets had a higher school attendance, better technology competencies, and a decrease in negative student behavior.

Lemke, Coughlin, and Reifsneider (2009) showed that a 1:1 laptop initiative was used to improve mathematics achievement, grade point average, and student learning. Most 1:1 initiatives that were examined for achievement outcomes had occurred in the middle school setting or high school setting; the elementary setting results were unknown and not researched (Penuel, 2006). As another reason to identify the effects of incorporating 1:1 iPads into mathematics instruction was that iPad has been one of the most popular 1:1 computing tablets available; more than 300,000 devices were sold on iPads’
first day on the market. The appeal of any 1:1 device initiative might generate widespread publicity (Lei & Zhao, 2008).

Development of Problem Solving Behavior will enhance the competency in terms of Math achievement. The iPad Assisted Instruction not only enhances the students’ engagement and discussions in the Math class, but also develops their problem solving ability in Mathematics (Mugundan & Ramganesh, 2016). In an Australian mixed-methods study, researchers examined the effects of 1:1 laptop computing for elementary students with netbooks and showed that on average the participating students used the netbooks for approximately one hour a day (Larkin & Finger, 2011).

The low usage was disappointing to researchers and investors who financially supported the 1:1 initiatives. Simply supplying a classroom with laptops or iPads would not ensure mathematics advancement; teachers needed to utilize the devices effectively to enhance instruction and student learning (Holcomb, 2009). Even with supportive academic programs, Holcomb (2009) presented dozens of 1:1 studies in which students showed no academic achievement growth. Based on poor results and overwhelming maintenance costs, officials in many schools and districts that were participants in 1:1 laptop initiatives in the U.S. discontinued the programs (Warschauer & Ames, 2010).

Learners need to know to monitor and regulate their own learning processes when solving problems. This study believes that the iPad Assisted Instruction as cognitive tool on Problem solving Behavior helps learners to exhibit cognitive processes, to analyze, and manage their own thinking in pursuit of knowledge acquisition in order to solve problems in Mathematics, gain insight and creativity to become critical thinkers.

As the predominant objectives of learning methodologies is to develop problem solving behavior the present study is committed to validate and integrate appropriate instructional design with technology so called iPad so as
help students develop their problem solving behavior in mathematics, for which a model on problem solving behavior in mathematics is developed. This model is set to help students learn any topics in math with proper understanding through developing problem solving behavior. Thus the problem solving behaviors are believed to enable students attempt or encounter any problem in mathematics.

1.6 Statement of the Problem

Of all the subjects, Mathematics is the most technical and hence happens to be the most demanding subject. It is an important need to devise innovative problem solving strategy that facilitates Mathematics teaching to the greater altitudes of understanding. Paris and Winograd (1990) argue “Students can enhance their learning by becoming aware of their own thinking as they read, write and solve problems in school”. Teachers can promote this awareness directly by informing students about effective problem solving strategies and discussing cognitive and motivational characteristics of thinking.

Wertheimer (1985) believed that building adequate problems representation, goal-directed planning, inference and elaborating by using one’s world knowledge, testing hypotheses, applying heuristics and comprehension monitoring are seen as basic operational building blocks of problem solving, as well as thinking skills. The investigator has identified different components and the process of the development of the components of problem solving skills. Therefore, the present study aims to develop an instructional model to enhance the performance of the secondary level students on Problem Solving Behavior in Mathematics.

The present study takes cognizance of the different stages of instructional design in its development of instructional model. In particular the study is based on Dick & Carey, ADDIE, KELLER’S ARC, ROSS AND KEMP, ROBERT GAGNE’, ASSURE, and Merrill Devid’s First principles of instruction, has adopted several learning theories, which has helped in the
development of an instructional model for the problem solving skills. The methods adopted in schools for teaching mathematics, at present, concentrate on mere understanding of the subject-knowledge, but adopting instructional strategies based on modern instructional theories could develop skills required for problem solving. Mathematics is closely associated with problem solving, as problem solving is closely associated with cognition. If one is able to control and regulate his own cognitive processes, he or she can develop problem-solving behavior, which contributes to the extent for Mathematics education.

The concept of iPad Assisted Instruction used in the Instructional Design on Problem Solving Behavior of secondary level students in Mathematics, as it will ensure the quality perspectives of Problem Solving Behavior. In this study, the investigator examined the cognitive and behavior changes that occurred when students were immersed in a collaborative environment where the instructional design that is integrated along with the iPad apps.

Although the studies reviewed are pertinent literature to the present investigation, none of them has attempted to develop an iPad Assisted Instructional design with problem solving strategies for developing problem solving ability in mathematics among the secondary level students of Fujairah in UAE. The purpose of this study was to examine, iPad Assisted Instruction as cognitive tool on problem solving behavior of secondary level students in Mathematics. Specifically, the researcher sought to examine what pedagogical shifts are occurring as a result of continuous and systematic application of iPad Assisted Instruction in mathematics classroom, and to determine what types of learning interactions can be observed among the multicultural students. Hence the research problem has been selected and stated as “Impact of iPad Assisted Instruction as cognitive tool on Problem Solving Behavior of multicultural secondary level students in Mathematics at Fujairah – UAE”.
1.7 An Overview of the Study

This study is organized into six chapters. Chapter I, Introduction presented an overview of the need of the study, the purpose of the study, the research questions, and the Statement of the Problem.

Chapter II, Literature Review, describes past studies from the fields of mathematics education, iPad as cognitive tool in mathematics instruction, the need for iPad in Math teaching, and definitions of mathematical problem solving using many different approaches. It continues with expositions of different perspectives and recommendations on this pedagogy, along with students’ learning experiences with iPad in Math class room. Given the study’s focus on iPad Assisted Instruction in Math class, the chapter concludes with research on the impact of iPad in Math class.

Chapter III, Methodology, details the research design of this study. It describes about the Control group and Experimental group students. It also explains the procedure used to Asses the students’ problem solving ability evaluation and concludes with a discussion of the students’ attitudes towards mathematics survey.

Chapter IV deals with the design of the study which involves objectives, hypothesis, research design, construction and validation of the research tools. Analysis and interpretations drawn from the data are provided in the Chapter V.

The final Chapter VI gives summary of the major findings, Recommendations, Suggestions and Conclusions. Bibliography is adhered to APA (American Psychological Association) format style. Annexure provides Attitude Scale for Mathematics Learning (ASML), Mathematics Problem Solving Behavior Assessment Scale (MPSBAS) 1 & 2 and Publications.