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Individualized Mathematics

by

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A project submitted to the
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Master of Science in Education
Individualized Mathematics

by

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Chapter 1: Introduction

Mathematics education in the United States is a widely discussed and well documented topic, which often extends beyond the educational community. Statistical data depicting the current state of student achievement in mathematics can be readily accessed from the Trends in International Mathematics and Science Study (TIMSS) Report on the web at http://nces.ed.gov/timss. It is a well known benchmark, which assesses the performance of fourth and eighth-grade students of several participating countries around the world. History has proven that international developments and events can greatly affect the policies of mathematics education in the United States. Much like the Soviet’s launch of Sputnik in 1957, the 2007 TIMMS sparked much needed debate in the realm of mathematics education (Klein 2003).

According to the 2007 TIMSS Report, the United States has continued its average performance in mathematics education in comparison to other nations (Gonzales et al., 2008). Chinese Taipei, Korea, Hong Kong SAR, Japan, Singapore, England, and Russia all ranked higher than the United States. Only 10 percent of the U.S.’ fourth-grade and 6 percent of U.S.’ eighth-grade math student population classified as advanced according to the international benchmark. All of the previously mentioned countries topped the U.S. in the advanced category with China, Korea, Japan, and Singapore boasting double digit percentages for both grade levels. Singapore led the fourth grade category at 41 percent and Chinese Taipei posted 45 percent, topping the eighth-grade category. This assessment, which began in 1995, is conducted every four years. The 2007 results for the United States were quite similar
to the results from 1999-2003. These statistics are a staggering disappointment and a loud warning to the United States that drastic change in mathematics education is necessary (Gonzales et al., 2008).

These figures are alarming and resonate far beyond the educational community. In fact, they struck a chord with the President’s National Mathematics Advisory Panel under the George W. Bush Administration. The administration referred to the nation’s achievement in mathematics as being mediocre in comparison to other developed nations (Brown, 2008). American citizens shared the same concern as 97 percent polled in a 2007 ResearchAmerica survey felt that the United States needed to be a global leader in the math and scientific research arenas (“Worried about math,” 2007). A compelling need exists to develop qualified individuals possessing high math competency to fill challenging positions in the science, technology, engineering, and mathematics (STEM) work force. It stands to reason that concern would be at a high considering the importance of mathematics education and its connectedness to employment in the STEM industry. National security, economic viability, and social well-being are products of a healthy and thriving STEM industry within a capitalistic system such as the United States (Leinwand, 2009). Defense and infrastructure projects, innovative medicine, and alternative energy initiatives are just a shortlist of areas in which mathematics is deeply rooted (Brown, 2008).

It would be imprudent to suggest that math education does not serve as a pertinent foundation for the future well-being of the country and the TIMMS Reports
provide clear evidence that there is much room for improvement. What may be even more concerning than the results themselves are the implications that can be purported from them. The lackluster U.S. results of the TIMMS coupled with the magnitude of importance that the topic commands offers enough worthiness to now focus on a recipe for success.

This study focused on a comprehensive solution to poor math performance in education through the concept of individualized mathematics. More specifically, the purpose of this study was to investigate the viability and effectiveness of an individualized mathematics program known as *Accelerated Math*™ (AM) by *Renaissance Learning*™ (RL). Perhaps better known for their flagship product *Accelerated Reader*™ (AR), RL developed the AM program due to the overwhelming success of AR. Having been in existence for roughly only 15 years, AM has evolved and gained traction in the education community since its inception. Nearly all of the relatively limited research on AM has pointed to remarkably positive outcomes. This study’s objective was to determine the worthiness and practicality of AM, as a computer-based individualized program, in becoming the centrally featured curriculum program for mathematics education.

**Definition of Terms**

*Accelerated Math*: A computer-managed mathematics learning system and a registered trademark of Renaissance Learning, Inc. (Renaissance Learning, 2011).
STAR MATH: A computer based math program that assesses a student’s level of math proficiency and a registered trademark of Renaissance Learning, Inc. (Renaissance Learning, 2011).

Title I: Refers to the section of the federal Elementary and Secondary Education Act aimed at helping low-income students who are at risk of failing in school (Renaissance Learning, 2007).

TOPS Report: Standing for ‘The Opportunity to Praise Students’ the computer generated report is a component of the Accelerated Math program and displays results from practice worksheets, exercise worksheets and tests (Renaissance Learning, 2011).

Summary

Mathematics education will always serve as a high priority in the United States and with continued lackluster achievement, the sense of urgency for meaningful reform continues to grow. AM’s flexible design serves as a solution to a variety of both teacher and student challenges, thus giving the program exciting potential. The prospect of AM featuring as the choice replacement and improvement of traditional math curriculums is deserving of a more thorough investigation.

A plethora of research exists covering various topics in math education ranging from kindergarten all the way to the post-secondary level. This review focuses on the elementary through high school grade levels, including both quantitative and qualitative research studies as well as research-based articles offering
background perspective of both fact and opinion. When considering a solution to any problem, it is necessary to first investigate the causes of the problem.

This research consists of a literature review focused on identification, analysis, and evaluation of contributory factors affecting student achievement in mathematics. Various math instruction methodologies will be reviewed with a main focus on the individualized concept featured with AM. The literature review touches upon a multitude of specific factors affecting math education, however for the purposes of the literature summary it can be concisely organized under the categories of equity, psychology, and pedagogy. A general description of AM will be followed by a discussion of how the program pertains to specific factors within each category.
Chapter 2: Review of the Literature

Renaissance Learning defines Accelerated Math as a computerized tool for efficient progress monitoring and management of students’ personalized daily math practice for grades 1–12 within a formative assessment process. The program’s content is aligned to state standards and national guidelines, and teachers use data generated by this tool to differentiate instruction and address individual student needs. Accelerated Math includes separate libraries for Early Numeracy, Grades 1 through 8, Algebra 1 and 2, Geometry, Probability and Statistics, Pre-Calculus, Calculus, and Basic Math (Renaissance Learning, 2011).

It is unknown exactly how many schools are currently using AM, but research shows that schools across more than a handful of states and even three other countries, namely Canada, England, and Germany have experimented with the program (Renaissance Learning, 2007). The duration and extent to which districts and schools use AM within the math curriculum can vary greatly since the program can be utilized in many ways. AM is widely considered a practice assessment tool used for individualized progress monitoring but its capabilities extend beyond purely assessment. It has also shown resounding success as an intervention tool for regular use in response-to-intervention (RTI) programs and according to the National Center on Response to Intervention (NCRTI), AM meets rigorous scientific standards of quality for screening and progress monitoring (Renaissance Learning, 2007).

Positive outcomes have prompted schools to expand the use of AM beyond just an interventional tool for students struggling with poor math achievement. The
benefits of AM can also be extended to average through high-ability math students when featured as a regular part of daily math instruction. AM’s powerful reporting capabilities assist educators in the development of differentiated instruction and cooperative learning assignments, allowing the program to serve as the centralized component of a math curriculum. RL, in recognition of the program’s revolutionizing potential, is making a concerted effort to mainstream AM across the United States through its flexibility of tailoring the instructional content to suit various curriculums. In doing so, the development of the content libraries takes into consideration the National Council of Teachers in Mathematics (NCTM) focal points, individual states’ math standards and learning objectives, and various commonly used textbook-specific curriculums such as *McGraw Hill™*. RL considers the tailored engineering of its program to be a major step toward mainstreaming AM into education. In fact, RL has gone even further in distinguishing AM as an everyday math curriculum program by introducing a separate more concentrated program for use only with RTI called Accelerated Math for Intervention (AMI) (Renaissance Learning, 2011).

It is necessary when considering a solution to any problem that one must first investigate the causes of the problem and so this review consists of literature focused on identification, analysis, and evaluation of contributory factors affecting student achievement in mathematics. The research will also critique various methodologies for attainment of improved mathematics achievement with a main focus on the individualized concept featured with AM. A plethora of research exists covering various topics in math education ranging from kindergarten all the way to the post-
secondary level. This review however will focus on the elementary through high school grade levels, including both quantitative and qualitative research studies as well as research-based articles offering background perspective containing both fact and opinion. The literature touches upon a multitude of specific factors affecting math education, however for the purposes of this literature summary it can be concisely organized under the categories of equity, psychology, and pedagogy. The AM research will be discussed in each of the categories as it pertains to specific factors within math education.

**Equity**

Modern day American education is heavily predicated on the concept of equity (Strong, Perini, & Silver, 2004). Differentiated instruction and inclusive classrooms are two recognizable initiatives that attempt to create equitable learning experiences for students subjected to such platforms. Differentiated learning requires that a teacher commit to offer a platform by which all students can progress, regardless of their ability level or previous know-how, while inclusion refers to the initiative for including students with special needs in general education classrooms (Strong, Perini, & Silver, 2004).

Differentiation and inclusion are not mutually exclusive but rather very often interdependent. Proponents of differentiated instruction argue that uniform curriculum, which is often taught using a rigid teaching style; leaves lower ability students in the dust and advanced ability students snoozing (Strong et al., 2004). In
that scenario, the teacher is truly only connecting with the group of students in between. It becomes impractical to offer differentiated instruction on a daily basis, especially in large classrooms containing greatly diverse student populations. Specific studies have shown the benefits of smaller class size on student performance across content areas (Wilgoren, 2000). Ultimately, differentiated learning seeks to accomplish a philosophy whereby students do not have to adapt to teaching styles, but rather teachers adjust to learning styles (Strong et al., 2004).

The researcher believes it is important to clarify the definition of equity as it relates to education could shift one’s opinion on whether various methodologies in education do indeed promote the concept. Inclusion may offer learning benefits, but its main objective is to offer a socially equitable experience so that students with special needs can have social interaction with their majority peers (Strong et al., 2004). Differentiated instruction offers equity in the way of pedagogy and the learning of the content (Wilgoren, 2000). It is important to make such distinctions when considering how equity should be prioritized and implemented throughout education.

Horn (2007) investigated the issue of which she labels the “mismatch” problem specifically in mathematics education. The problem is that students’ prior achievements are incommensurate with the rigorous mathematical curriculum. This problem faces students and teachers alike since students struggle to handle the material and teachers are responsible for delivering an equitable solution. The root of the cause can easily be targeted to the policymakers who called for the elimination of
remedial courses in favor of the institution of heterogeneous classes. Whole-scale de-tracking of student ability resulted, and now math teachers experience these mandates as a monumental challenge to their work (Horn, 2007).

If de-tracking and inclusive classrooms, which were meant to promote social equity, end up triggering monumental pedagogical challenges to educators, the researcher deems it necessary to determine if or how the challenge threatens the equitable treatment of students. The answer to such a question can be elusive without considering another fundamental component in the definition of equity. That is defining the "who" as it relates to equity. Advocates for equity typically focus on minority or disadvantaged groups. The researcher considers it to be justifiable since such groups can be frequently subjected to inequities; however it is essential to consider whether the remaining majority are forced to unfairly sacrifice in order to achieve so-called equity. Accelerated Math formatively assesses students on a continuous basis, differing greatly from a traditional sense of tracking since it is meant to be utilized in inclusive classrooms and assist educators in differentiated instruction (Renaissance Learning, 2011). Therefore it offers a unique solution to the challenging dilemma of equity in math education.

Renaissance Learning has published numerous quasi-experimental studies, some of which are independent, documenting significant improvements in math achievement using AM (Renaissance Learning, 2007). Elementary grade levels all the way up to the high school level have been cited in the reports as having successful outcomes using AM whether used exclusively as an intervention tool or as a whole-
scale curriculum program. Many of the studies were conducted in Title I urban and rural communities throughout the country including more than 20 states (Renaissance Learning, 2007). Student achievement was often measured using scores of the STAR Math assessment and the individual state performance exams in math. The schools, while populated mostly of students on the lower spectrum of the socio-economic scale, contained students from a variety of ethnic backgrounds including 'English as a second language' (ESL) learners (Renaissance Learning, 2007). Several of these schools chose to experiment with AM because of the consistently low math performance of their students. The results show compelling evidence of AM’s effectiveness in enhancing math achievement for struggling and under-privileged students (Renaissance Learning, 2007).

Research on AM and its effect on students’ math achievement in low performing Title I schools has also been published in peer review research journals. Ysseldyke and Tardrew (2007) conducted research comparing student performance using AM with control groups using traditional math curriculum methods. This large scale study, ranging from grades 3-10 and spanning 47 schools across the country, included a sample of 2,202 students from the following subgroups: Learning disabled, gifted, free/reduced lunch Title 1, ELL, and low achievers. Every single subgroup of students using AM outperformed the control groups on the STAR Math assessment. The greatest margin of achievement gains was made by the ELL group followed by Title 1 and then Low Achievers. The study’s significance can be
attributed to the diverse sampling of students from a broad range of grade levels as well as the promising results (Ysseldyke & Tardrew, 2007).

Teelucksingh et al. (2001) also targeted the effects AM has on math performance of ELL students. Students in elementary grade levels were sampled and showed increased achievement on the Northwest Achievement Levels Test (NALT) after intervention with AM. AM was used in conjunction with their ongoing math curriculum and the data also compared favorably to control groups not receiving the treatment (Teelucksingh et al., 2001).

Ysseldyke et al. (2003) documented results from a one year quantitative study on AM conducted in a large urban school district containing a student population of 75 percent minorities and 67 percent free/reduced lunch eligible. Students having been below national norms for math achievement were shown to surpass that benchmark after steady exposure with AM in their math curriculum. A total of 881 students from grades 3-5 were assessed using the NALT. There were nearly an equal amount of male and female participants. The results of the study showed convincing data that the students taught using the software had accelerated rates of performance as compared to the students who did not use the software. The results were also compared to a random sample of student scores from the district database, which represented students who were not part of the study sample. Those comparisons again yielded a positive result suggesting that AM has significantly favorable outcomes on student achievement (Ysseldyke et al., 2003).
Key research studies have also been conducted on AM at the high school level. A sample of 28 students from grade 11 in an Arizona high school was assessed using the Arizona Instrument to Measure Standards (AIMS). These High school juniors represented students who previously failed the AIMS at the 10th grade level. Randomly assigned to two groups, the experimental group participated in a course using AM, while the control group enrolled in the standard 11th-grade math curriculum. Amongst the experiment group, 57 percent of the students passed the AIMS compared to only 14 percent in the control group. They experienced an average performance increase of 27 percent from their previous year’s scores versus only a 6 percent increase for the control group. It is also worthy of mentioning that every single student from the experimental group exhibited higher scores on the AIMS test than the previous year (Springer, Pugalee, & Algozzine, 2007).

What makes the positive results of these studies so compelling is that they occurred across various grade levels and minority groups. The data also challenges previous critics of tracking who commonly cite that students of lower ability level do not benefit from a tracking system since they are continually subjected to less rigorous content. AM’s unique progress monitoring and individualized practice system offers low performing math students a realistic opportunity to improve their math achievement and continuously advance to more rigorous content (Renaissance Learning, 2011).

On the other side of the coin, an equitable learning experience also requires that high ability math students remain challenged with opportunities to meet their
potential. In contrast to AM-specific research, McAllister and Plourde (2008) investigate the state of affairs for gifted students in traditional math curriculum settings. A fundamental argument in advocating for the equitable treatment of gifted math students is that too much effort and resources are concentrated on underperforming students. If parity in math performance is the objective as opposed to individual students reaching their maximum potential, then perhaps the current curriculum structure is suitable. That philosophy however is contradictive to the basic theory of learning and detrimental to the development of gifted math students.

The controversial No Child Left Behind (NCLB) legislation passed in 2001 fails to directly address this issue. Instead, it uses high stakes standardized tests to determine if schools are meeting Adequate Yearly Progress (AYP) targets (McAllister & Plourde, 2008). If AYP is not met, schools are sanctioned and are threatened to lose federal funding. Mathematically gifted students will master required curriculum standards early and therefore are ready to move onto more challenging work (McAllister & Plourde, 2008). The NCLB act does not have a mandate in place for schools failing to meet the needs of those students far exceeding the standard. Consequently, funding and resources that once were allocated toward gifted programs are reallocated to programs that assist struggling students to become proficient (McAllister & Plourde, 2008). If that is considered equitable legislation, the researcher believes that to imply that gifted students are not entitled to the concept of equity. The researcher thinks this clearly does not pose a solution but rather helps
to explain the under-represented population of advanced math students in the United States according to the 2007 TIMSS.

Math classrooms throughout the country often lack the critical element of challenge for gifted students (McAllister & Plourde, 2008). Discovery learning and deeper investigation of concepts is non-existent when repeated drill and practice exercises are used to accommodate lower ability students (McAllister & Plourde, 2008). The risk that is taken with that approach is that gifted students lose motivation and interest in the subject. Brain research suggests that the brain will not maintain its level of development if students are not challenged, so challenge becomes a very significant component of effective curriculum and instruction (McAllister & Plourde, 2008). When mathematically gifted students are given content or tasks that are too easy, which is very common in mixed-ability classrooms, their mathematical ability is not fully developed (McAllister & Plourde, 2008).

McAllister and Plourde (2008) also as part of their research documented the unique and beneficial approach that teachers in one elementary school took for their advanced math students. These teachers operated under a more pure sense of the concept of equity by differentiating education to also meet the needs of advanced math learners. The teachers along with the school’s administration designed an enrichment program for mathematically gifted students. The teachers designed a unit for an out of the classroom exploratory project as part of a concerted effort to develop math concepts learned into a higher level of learning through real world application.
The advanced math students went on a trip to Disney World where they used math concepts learned in class and integrated them with problem solving activities relating to the Disney Experience. Students put together to give to the Disney Executives at the end of the project. Throughout the project, the students used higher order thinking processes. They recorded the length of time of rides, including how long it took to load and unload passengers, in order to calculate how many people they could service for each dispatch. The students also made calculations involving speed and cycle time, using time and data on the length of track. The project concluded with presentations by the students explaining their ride concept, the math used to design it, and persuasive rationale for its success at Disney World (McAllister & Plourde, 2008).

The activities involved in the math unit were a proactive approach at keeping the mathematically gifted students engaged and excited about learning. The concept of individualized mathematics with AM also serves as an example of a proactive approach to math education but also one that is not limited to a single unit or topic in the curriculum. The researcher considers outstanding mathematical ability to be a valuable societal resource, one that the education system in the United States should be nurturing instead of turning its back on. The researcher strongly supports the notion that giving gifted math students the opportunity to excel using AM is a realistic solution.

In line with that distinct prospect, Ysseldyke et al. (2004) specifically investigated the effects of AM when used with gifted math students from grades 3-6.
Students of gifted math ability using AM were compared to their peers of the same ability level without having exposure to AM. Once again, based on performance results of the STAR Math assessment, the AM group generated better outcomes. The study was valuable in that it broadened the research exposure of AM to focus on higher performing math students (Ysseldyke et al., 2004).

**Pedagogy**

The facilitation of the actual instruction of a math curriculum including strategies, research-based methodologies, and technology use, is another essential component in the analysis of math achievement (Douglas & Reese-Durham, 2008). Douglas and Reese-Durham (2008) reported on a study conducted for the purpose of comparing two pedagogical methods in mathematics to determine which leads to better student achievement. The two methods are the Direct Instruction (DI) Method and the Multiple Intelligence (MI) Method. The authors’ analyses indicated that since individuals learn in a multitude of ways such as auditory, visually, tactualy, and kinesthetically, the MI method incorporates those learning styles. By making the curriculum accessible to all students, the MI method makes learning math engaging and exciting to all students. Active and involved teaching is a step in the right direction towards academic success since it poses the question, in what ways are students smart rather than, “are they smart?” (Douglas & Reese-Durham, 2008). Douglas and Reese-Durham think that teachers should believe that all students are capable of achieving and the MI method addresses the tools and teaching strategies that will bring forth such success. Douglas and Reese-Durham discussed the
demonstration of an MI method used at an Indianapolis based school. The teachers use a multidimensional assessment that can be characterized as broad-based, real life relevant, process oriented, and based on multiple measures that provide a rich portrayal of student learning. Their teaching strategies were woven throughout the curriculum to emphasize the individualized abilities and talents that students possessed (Douglas & Reese-Durham, 2008).

Douglas and Reese-Durham described DI as a widely used, highly scripted and fast paced teaching method containing a vast number of drill exercise content. DI does not use hands on activities to reinforce principles learned. It can be compared to the banking process, by which teachers deposit information into students as opposed to providing students with opportunity to express their creativity or utilize individual assets. DI tends to be more effective when providing a review of a previously taught material, but may not necessarily exhibit the same effectiveness when teaching new curriculum (Douglas & Reese-Durham, 2008).

Douglas and Reese-Durham tested the two methods on an eighth grade math student population of 57 students in a North Carolina middle school. The students were comprised of approximately an equal amount of males and females. The researchers formed two groups so that each was a comparable representation of the other in terms of race, sex, and ability. The semester long study taught one group using a conventional DI method and the other by the MI method and tested them at the end. The results of this quantitative study using an α-.05, showed a significantly
better mean test average for the MI group which was 79.07 percent versus 71.24 percent for the DI group with a t-value of 2.06 (Douglas & Reese-Durham, 2008).

The researcher believes that a major strength of this test is that it was conducted for an extended period of time, in this case a semester long. However, since the study only compared two groups, it is difficult to determine whether other variables, such as the instructor, played a larger factor in the results than did the instructional method itself. Since students responded differently to any given type of instructional method, the researcher thinks that the test average would probably be even higher if students were specifically placed according to their own personal learning preference. Furthermore, the study implies that the MI method is best suited for mathematics overall rather than suggesting the method may be more effective for particular parts of math curriculum. Due to the diverse nature of topics within mathematics, the researcher feels it can be debated that the direct method of instruction would be best suited for certain topics. Douglas and Reese-Durham do not discuss broadly enough the perspective of the entire math curriculum and consequently the researcher considers the interpretation of the results to be very misleading.

Math pedagogy in an Accelerated Math curriculum is a compelling topic to examine since it is built to address the individualized needs of each student. Renaissance Learning emphasizes that the program was specifically designed to still keep the teacher at the center of instruction (Renaissance Learning, 2011). Therefore the teacher is still responsible for executing effective instructional methods whether it
is using the MI method, DI method, or any of the other research-based instructional strategies. The technology provides automatic processing of scoring data into useful reports for both the teacher and student. The benefit of this computer-based technology cannot be overstated from a pedagogy perspective since it frees up an enormous amount of time that a teacher would otherwise be using to create and correct assignments. That time can now better be served in developing differentiated instructional lessons based upon the teachers’ analyses of data (Renaissance Learning, 2011).

Xin, Wiles, and Lin’s (2008) research was unique in that it looked into potential benefits of integrating literacy skills to math pedagogy. By symbolizing words into mathematical expressions, the researchers hypothesized that the story grammar concept would improve student performance on word problems. The researchers conducted this quantitative study with fourth and fifth grade students to test the hypothesis. The theory suggested that math was often thought of by students as plugging numbers into a formula that in turn spits out an answer. The methodology of using more word problems, particularly in the context of a story, allowed students to use a problem-solving thinking process. Devising a strategy to solve the word problem fits well with the story grammar concept in literacy. It involves breaking down the text systematically to determine what the question is asking and then applying an appropriate solution method. Too often math teachers tell students to pick out cue words that tell them what mathematical computation to use in order to solve the problem. According to the researchers, that is a bad habit
and detracts from the student’s ability to contextualize the entire problem. The researchers observed student tendencies, during the baseline condition, to impulsively take numbers in word problems and apply mathematical operations to produce answers. The results of the interventional test, using the story grammar approach, did in fact yield improved results. The intervention led to an observable enhancement of the participants’ pre-algebra skills and ability to develop mathematical equations to solve for unknown quantities (Xin et al., 2008).

Fuchs et al. (2006), in a quantitative study investigated the effects of using a pedagogy style called schema-broadening instruction (SBI) in mathematics education. SBI attempts to hone in on students’ background knowledge, schema, when working on mathematical applications. The philosophy that supports the bases of the methodology is that students are more likely to make connections between math and real world when presented with real world topics of which they are familiar with.

The study was conducted on a group of 445 math students in grade 3 across seven different schools in an urban district. The results of the study reinforced prior findings on this matter, which showed evidence that SBI strengthens mathematical problem solving (Fuchs et al., 2006). The researcher thinks that the story grammar method and the SBI method may be very practical and effective strategies in specific cases, but should be thought of more as tools rather than a comprehensive shift in pedagogy.

While significant in its own right, the research in Xin et al. (2008) and Fuchs et al. (2006) failed to offer a comprehensive solution to math education. Just as in
Douglas & Reese-Durham (2008) research, the studies’ touch upon the effectiveness of a few instructional methodologies however the implementation challenge still remains. Consistently meeting individual student learning needs throughout a math curriculum filled with diverse topics is a tall order for any math educator. The researcher finds that it becomes increasingly difficult in inclusive class settings with largely varied learning abilities.

To better illustrate this difficulty, Horn’s (2007) research documented two separate math faculties’ views on the issue deemed the “mismatch” problem. Horn collected data through observation of collaborative faculty meetings in which discussions were held on the topic of setting math curriculum and lesson plan strategy. The discussions from both schools involved conversations on how the math teachers struggled to find equitable assignments for their classes. The teachers expressed difficulty in finding “group worthy” assignments since the standard protocol would always leave one particular group of students feeling left-out, distressed, or even under-challenged (Horn, 2007). Horn also pointed out that the faculty discussions identified the all important discrepancy between a slow learner and a learner having limited mathematic exposure, a discrepancy that profoundly impacts teaching strategy (Horn, 2007).

Strong similarities were revealed amongst the two schools’ faculties in that both groups felt they were trapped in a no-win situation. Faced with the dilemma of either watering down curriculum or failing large numbers of students, teachers asked
themselves; do they remain loyal to the rigor of the curriculum, or do they teach to
the level of their students? One teacher responded:

I’m trying to find group-worthy activities so that the kids that are slow learners can contribute and can, you know, feel smart, but I don’t know if I can find activities that are group-worthy activities like that. Because I can feel the, um, frustration of the fast learners, “This is easy! I already know the answer!” And then there’s kids that are slow learners that are like, “Give me a chance to find the answer!” and it’s almost like they kind of give up because they feel like it’s a speed competition, like who can get the answer the fastest kind of thing. And I’m trying to close the gap between that and that’s been one of my frustrations I think.

Teachers were left torn between the subject and their students, struggling to
compromise and reconcile their commitments to both (Horn, 2007).

Accelerated Math can address these concerns that teachers have of reaching
all students. As its main feature, continuous progress monitoring is accomplished via
automatic creation and scoring of personalized practice, exercise assignments, and
tests. By providing teachers with invaluable assessment data through its
revolutionizing computer-based progress monitoring capabilities, AM serves as a
bridge between student needs and teacher instruction. The data depicts what learning
objectives and topics students are having success with and ones that they are
struggling with. Teachers can analyze information on a class wide or student by
student basis so that whole-class and individualized instruction can be more
adequately planned. Therefore teachers can more easily incorporate cooperative
learning experiences into their classrooms by grouping students according to their
individualized learning needs (Renaissance Learning, 2011). Since practice
assignments can be so quickly generated and tailored to student specific needs and
ability, a teacher can always keep students busy and appropriately challenged. Advanced students can work collectively on practice questions while a teacher experiments with alternative instructional strategies in a small group of students struggling with the same concept. Teachers would also be better informed in pairing up two students with differing strengths and instructional needs, thereby creating peer learning opportunities (Renaissance Learning, 2011).

Another area that individualized math curriculum purports to improve upon is technology inclusion. Betne and Castonguay (2008) discussed this topic specifically by surveying a sample of college students at LaGuardia Community College to gather data on the use of technology and library resources in their undergraduate mathematics courses. The study was conducted to highlight the researchers’ suggested lack of alternative mathematics resources available to students. The researchers point out the obvious downturn in library usage as the current generation looks to the Internet for much of its research needs. Librarians’ roles have changed as a result and their skills are focused more on assisting individuals to comprehensively search a variety of databases for research materials. The librarians questioned in the study believe that students’ reliance on the internet has contributed to less than adequate proficiency in navigating through academic databases. The issue becomes compounded in regards to mathematics students who, according to the survey, very rarely use academic references other than course textbooks. Many of them are unaware of the research journals and online resources that exist within the mathematics content area. The researchers make the compelling point that failing to
incorporate technology into math assignments and utilizing technology resources such as software programs and online applications in the math curriculum, severely limits learning opportunities. They warn that continuing down this stagnant pedagogical path in mathematics will leave students out of touch in a present world consumed in technological advancement (Betne & Castonguay, 2008).

The findings of Betne and Castonguay’s study support the idea that infusion of technology within mathematics education is still not mainstream enough. Students in college level math classes not being familiar with useful technology tools or alternative math resources implies that they may not have been exposed to them at the high school level (Betne & Castonguay, 2008). Betne and Castonguay believe that technology activities using online math program applications and research assignments needs to be a critical piece of a reformed mathematics education philosophy. It is meant to provide an engaging learning opportunity with real world relevance and application (Betne & Castonguay, 2008). However, the study’s findings appear to lack corroborating evidence amongst other freshman college students at private and state universities and colleges to suggest that exposure to technology at the high school level in mathematics is lacking.

The researcher believes that Accelerated Math software itself exemplifies technology and basing a math curriculum around this computer-based program would thereby offer a constant integration of technology in math education. Through AM’s Home Connect technology, access of the program is available at home for students and parents. Practice time is essential for mastering many computational processes in
mathematics and the program allows for students to obtain adequate practice at the touch of a button (Renaissance Learning, 2011). New practice assignments can be automatically generated that are tailored individually to a student. The program can easily create a whole new set of practice questions focusing only on the topics and objectives that a student has not yet mastered. Instantaneous feedback is a valuable feature for teachers and students alike. Students receive that feedback in the form of a TOPS (The Opportunity to Praise Students) report. TOPS reports include the score of the assignment, which problems the student missed, and progress toward individualized goals. Many of the practice assignments are multiple-choice which can be quickly scanned and graded but free response and word problems can also be generated. The program even has a built in error analysis tool for incorrect multiple choice answers selected (Renaissance Learning, 2011).

As stated earlier, AM is not meant to replace the importance of the instructional component of math education. The teacher decides when and how often students practice using AM and plan the instruction around it. Studies have indicated better achievement progress in the programs which used AM more frequently (Holmes, Brown, & Algozzine, 2006). Also, teacher proficiency and training with AM has shown to be critical for successful implementation (Brem, 2003). As such, RL offers training and professional development for educators with the objective that AM’s features and capabilities are effectively utilized (Renaissance Learning, 2011). Direct method instruction and practice drill using AM can often be very effective, but the teacher must still incorporate differentiated strategies and exploratory learning.
opportunities when appropriate. The researcher thinks that how well math teachers efficiently and productively assimilate AM in their math classrooms will go a long way in determining the programs worthiness of becoming a mainstream fixture throughout math education.

**Psychology**

A popular school of thought highlighted by Keller (2007) is that math performance is substantially affected by psychological factors, more so than in other educational content areas. Confidence in one’s math ability is imperative to meet the challenging curriculum demands facing today’s students (Keller, 2007). Those psychological factors have been widely discussed in the context of gender. It is thought by many that males and females have varying feelings about the subject of math which affects performance (Keller, 2007). More specifically, the theory known as stereotype threat theory (STT) is the fear that one's behavior will confirm an existing stereotype of a group with which one identifies and can often affect performance (Keller, 2007).

Although STT is relevant beyond the context of only gender, Keller’s (2007) research focused on the stereotype that females are less competent in mathematics than their male counterparts. Keller sought to test the validity of STT amongst females in mathematics. Keller administered two math tests to over 100 math students in grade 10 in German secondary schools. The tests included both low and high difficulty math questions. One test, given to the experimental group, was specifically attributed the STT threat. The researcher told that group of test takers
that males outscored their female counterparts on the test that they were about to take. The other test, given to the control group, did not mention that males outperformed females on that particular test. The results showed that female performance on the difficult test questions under STT was significantly lower (.45) compared to the results of the unthreatened females (.62). Low difficulty questions had little discrepancy in performance as did all results taken from the male pool. The findings strongly support STT and the effect it has on females answering difficult questions.

STT should be considered a significant cause of anxiety and a threat to self-efficacy and self-worth to females in mathematics (Keller, 2007). The self-worth theory of achievement motivation holds that in situations in which poor performance is likely to reveal low ability, certain students, deemed self-worth protective, intentionally withdraw to avoid the negative implications of poor performance (Keller, 2007).

Thompson and Dinnel (2007) also conducted research on the impact of psychological factors and its effects on female students in mathematics. This particular study focused on the concept of self-worth protection and how its existence adversely affects both effort and achievement amongst female students. The study’s results reinforce claims that females are in fact more likely than males to display characteristics of self-worth protection in evaluated math activities (Thompson & Dinnel, 2007).

The implications of the self-efficacy factor of women in math education can also loom significant in a career context (Walsh, 2008). For example, the highly female populated field of nursing requires pertinent mathematical skills in calculating
medicine dosages (Walsh, 2008). Walsh (2008) discovered how psychological factors of self-efficacy and anxiety affected a population of third semester nursing program students. Walsh gave a 50-question qualitative survey to 108 participants with results capturing meaningful data documenting common remarks about math anxiety to include confused, stressed, strained, frustrated and freaked (Walsh, 2008). Several participants mentioned having a low self confidence in their math ability as well as a previous lack of awareness of mathematical relevance in nursing. Many of them stated that they had low self confidence in their math ability and also mentioned that practice and individualized tutoring built up their confidence levels (Walsh, 2008).

The connection between individualization and confidence is one that AM is built around and its benefits are not limited to any one subgroup or gender (Renaissance Learning, 2001). That was the impression made upon a sixth grade math teacher, who described her students collectively as feeling empowered and highly motivated by the immediate feedback that AM delivers students (Renaissance Learning, 2001). It is also worth reiterating that the previously discussed research on AM included sample populations containing females and lower performing students, of whom may be more likely to have psychological factors adversely affecting their math performance. Since math performance can at least be considered partly linked to student psychology, the successful results of the AM studies would suggest that the program has positive psychological effects. That sentiment is given further credence
as the results of a study by Ysseldyke et al. (2003) indicated overall improvement of class structure and behavior in an AM environment.

Psychological factors impacting math achievement extends beyond those related to gender. Researchers of another study surveyed students in a math club discovering that the reason for its success and popularity was due to the fun factor (Papanastasiou & Bottiger, 2004). Students taking part in the math club at the Kansas City middle school did so voluntarily and were outwardly enthusiastic about it. The students played math games and often worked in groups to solve problems.

Although AM does not compare directly with a math club, parallels can be made of the two in regards to motivation, enjoyment, and cooperative learning. The main purpose of Papanastasiou and Bottiger’s (2004) study was to determine motivating factors that led to the success of the math club for the purpose of offering considerations for successful math pedagogy. A total of 107 students ranging from grades 5-8 participated in the survey, which included a balanced mix of male and female students. The most commonly recorded answers from the survey were that the club was fun, enjoyment of being with friends, competition, and working together as a group (Papanastasiou & Bottiger, 2004).

Accelerated Math has the unique benefit to create individualized practice sheets so that no two students have the same set of questions. Researchers have reported this to be a valuable cooperative learning tool so that students can work with one another without concerns of cheating or copying (Renaissance Learning, 2001). The automated assignment creation capabilities of AM give teachers an option to
quickly and efficiently organize cooperative learning groups (Renaissance Learning, 2011). Ysseldyke and Tardrew (2007) reported collective qualitative improvements amongst the classrooms in their AM study. Educator responses within this research praised AM’s individual instruction capability mentioning also that students spent more time academically engaged (Ysseldyke & Tardrew, 2007). Furthermore, the descriptions revealed that students enjoyed math more and took greater responsibility for their work. Eighty percent of AM educators stated that students were learning basic math skills better (Ysseldyke & Tardrew, 2007).

A separate research study was conducted by Calderhead, Filter, & Albin, (2006) to test the hypothesis that interspersing easy questions amongst difficult ones on math assignments positively affects students’ on-task behavior. According to the researchers, the subject of mathematics is unique in that it requires learners to focus for extended periods of time to develop and master skills. Also, student skills will not fully develop if they are not used regularly (Calderhead et al., 2006).

As previously mentioned, teachers commented how students’ use of AM keeps them on task. At the discretion of the teacher, AM can be used extensively for repetition exercises necessary for mastering skills (Renaissance Learning, 2011). AM’s content libraries contain an exceptionally large database of questions for each math topic in the curriculum allowing a teacher to use practice assignments often. The program’s assignment generating capabilities make it simple for a teacher to intersperse questions based on difficulty, spiral topics into one assignment, or revisit a previously learned topic (Renaissance Learning, 2011).
Calderhead et al. (2006) obtained results on target with their hypothesis that students did indeed show a higher percentage of on-task behavior while working on interspersed work packets, versus using the baseline packets that were not interspersed. There is a growing consensus that the concept of interspersing increases compliance on more difficult tasks by triggering a psychological effect of gratification or internal positive reinforcement from the successful completion of easier tasks (Calderhead et al., 2006).

Gaeddert (2001) discussed how research using AM triggered that same type of psychological response. The TOPS reports motivated students to master topics and move forward to the next one (Gaeddert, 2001). Surveys of students using AM revealed that their attitudes were significantly more positive than the students in the control classes. Surveys given to parents with children in the AM intervention classes also indicated more positive attitudes toward math than the parents of children in the control classes (Gaeddert, 2001).

Chiu et al. (2008) presented findings from a qualitative study in which they analyzed the psychological effects of math tracking and was specifically conducted due to discrepancies in prior findings. Previous research had shown in some instances that students in lower tracks have negative effects to their self-esteem and self-concept by making upward comparisons, which is comparing themselves to peers in higher tracks (Chiu et al., 2008). Conversely, research also exists reporting the opposite, whereby students in higher tracks had negative effects to self-concept caused by comparisons to their peers within the same track (Chiu et al., 2008). Low
track students had a positive self-concept effect because they were likely able to perform on par with their peers included in the same track (Chiu et al., 2008). The conflicting results stem from whether comparisons made across tracks versus within track has more of an impact on self image and which type of comparison is more frequently made by students.

Chiu et al. (2008) gave nearly 200 mathematics students in grade 7 of a Mid-Atlantic junior high school a survey containing questions across the domains of self-concept, self-esteem, and social comparisons. The self worth scale used in the survey had an internal consistency reliability of .77 (α) (Chiu et al., 2008). The major finding of the study was that students more often make comparisons within track than across track. Tracking did show to effect self-concept in mathematics but not over all self-esteem (Chiu et al., 2008). Another important finding was that when students' grades were controlled, tracking's effect on self-concept was no longer significant.

Accelerated Math is a progress monitoring system, far different from a traditional tracking concept. The intention of the program was never to identify student ability levels for the purposes of separating students into different tracks. In fact, it should be considered a viable alternative to tracking. The program is designed to address individualized abilities and learning needs of students, so that teachers can effectively teach in diverse settings (Renaissance Learning, 2011).

The most intriguing discovery from Chiu et al. (2008) was how the factor of self-concept diminished significantly when grades were not considered, implying that the actual grades influenced self-concept rather than tracking alone. AM’s TOPS
scoring reports for practice exercises do not serve as a summative assessment posted in the teachers graded book (Renaissance Learning, 2011). Students can therefore progress without fear of being poorly graded. The positive psychological effects of such a process should not be underestimated especially considering the findings from Chiu et al. (2008).

Yeh (2010) investigated intrinsic motivation as it relates to student assessment in mathematics. Yeh documented that a major problem in current assessment methodology of group testing is that it labels students as below and above average, inadvertently demoralizing below-average students. This can lead to a depressed effort and achievement for affected students, perpetuating the gap in achievement between lower ability students and their peers. That gap can originate from very small differences in early achievement which become magnified by the current structure of schools.

Accelerated Math through its individualized instruction and assessment system may be especially suited to remediate these differences and could open the door to a drastic shift in how students are assessed in mathematics education. The psychological experience of learning math for both high and low achieving students can be altered through a structure where instruction is individualized and students are appropriately challenged. The continual formative assessment process of AM fosters the development and mastery of math topics and learning objectives for all students, confirming that he or she is successfully advancing to higher levels. The goal is for
students to master objectives, move forward to new topics, and continually build upon their math skills (Yeh, 2010).
Chapter 3: Applications and Evaluation

Upon extensive review of the literature on mathematics education, I determined conclusively that math performance is on the decline in the United States and the nation is falling behind several others throughout the world. Evidence exists on the importance of math education, directly linking it to several significant occupational demands. The research also presents the identification and analysis of factors contributing to poor math performance in education, including equity issues, instructional challenges, and psychology.

In a quest for finding a comprehensive solution to the problem of underperformance in math, I found most concepts failed to address more than just one problem. Some concepts fail to benefit particular groups of students, some do not remedy the instructional challenges of teachers, and others neglect to consider the psychological effects. The concept of individualized mathematics using AM was the most comprehensive solution in addressing multiple issues in math education and a track record of improving performance based on quantitative data. The existing research does not however capture AM educators' thoughts and opinions on whether the revolutionary program should become a more widespread, centrally featured component in math education throughout the United States.

Purpose

Expanding upon the existing research on AM, the objective of this study was to obtain qualitative data through direct questioning of math educators currently using
AM in its current form. I created a questionnaire (see Appendix) to determine the participants' personal thoughts on the implementation of AM as both a central component and mainstream curriculum program in math education. The questions were directed at gathering supporting rationale for such opinions including teacher experiences with AM as well as benefits and drawbacks of the program.

Participants

I targeted a participant population offering a balanced representation of grade levels ranging from elementary to high school. I used an Internet search to create a list of schools across the United States currently using AM and attempted to contact all school administrations from the list. Two AM teachers from two separate schools agreed to participate.

Participant One is a female math teacher using AM in her third and fourth grade classrooms. The elementary school is located in a small, suburban town in the southeastern region of the United States. She has 21 years of experience teaching mathematics and began using AM since its inception, nearly 15 years ago. Her student population in terms of ability is approximately half on grade level or higher, while the other half is below grade level, some of whom have learning disabilities. The race/ethnicity of her students is both white and African American.

Participant Two is a male teacher using AM at the high school grade level. The high school is located in a suburb of a large city in the midwestern region of the country. He has 29 years experience teaching mathematics and six years of
experience with AM. He currently uses AM with a population of under-performing students in Remedial Algebra and higher-performing students in Advanced Placement (AP) Calculus. He described the demographic of his remedial algebra students as representative of the school’s demographic, which is 65 percent Hispanic, 10 percent African-American, 10 percent Asian, and 15 percent White.

Procedures

I sent the questionnaire (see Appendix) electronically to the participants. To mitigate security concerns and enhance protection of participant confidentiality, I required that the completed questionnaire be returned by mail. I asked the participants to provide as much detail and specifics to accurately and effectively answer the questions. I compiled and analyzed the responses to decisively gage the participants’ feelings as to whether they consider AM worthy of mainstream implementation as was the purpose of the study. I include, in the results summary, supporting data from the questionnaire that form such opinions.

Questionnaire

The questionnaire (see Appendix) was made up of 35 questions surrounding the participants’ experiences, opinions, and context in which they use AM. The questions address the topics of equity, pedagogy, and psychology as outlined in the review of literature. A particular subset of questions directly address the study’s purpose while others aim to gather personal, in-depth accounts of participants’ direct experience using AM, providing valuable qualitative data to support their opinion.
Chapter 4: Results

Equity

Participant One considers AM to be equally suited for all ability levels indicating that higher ability students always remain challenged and lower ability students keep motivated at the idea of jumping tracks. She added that AM is effective for nearly all of the math topics she teaches, claiming “A small number of my state’s standards do not mesh.”

Participant Two concurred that AM is conducive to all ability levels since top end students can continue progressing at an accelerated rate, while the needs of the lower ability students are identified and met. He felt that all the topics in algebra work well with AM and aligned with state learning standards. However he also wrote, “Although there were certain topics that AM was strong at presenting, the correlation between AM and the AP Calculus test seemed to be fairly low.” Furthermore he expressed, “AM has shown to have a greatest impact on the low ability students. The confidence level of these students continues to grow as they attack problems that are at the appropriate level of difficulty.”

Student Experiences

Participant One documented that AM positively affects student achievement in her classes. She wrote, “My students, as a whole, always loved and enjoyed this program! It builds healthy competitiveness and provides instant results.” Participant Two wrote, “Students, who after experiencing academic success with the program,
decided to continue on in their math education. We have had at least 70 students over the last four years jump tracks in the math curriculum because of their success with AM.” He also mentioned that parental feedback on AM was very positive. Participant One did not provide an answer on parental feedback.

Both participants agreed that AM is better suited at keeping students engaged and on task than a traditional math curriculum. They were also in agreement that students are more likely to set individual goals if they use AM. Participant One described her students’ behavior by saying, “My students have, as a whole, always loved/enjoyed this program!” Participant Two expressed his observations, “There are less behavioral problems because of the proximal goals of the program. Students have less time to get in trouble because they are more engaged in the academics.”

In response to the question of whether students seem motivated and responsive to the individualized feedback from the TOPS (The Opportunity to Praise Students) reports, Participant One answered with a definitive, “Yes!” Participant Two mentioned, “They are encouraged when they see their progress. There are times when the student comes up short, over and over on the same objective. If the students’ needs are not meet, the TOPS report will continue to be discouraging.”

When asked whether students liked the computer-based aspect of the program, Participant One wrote, “They love when they get to scan their cards.” Participant Two shared, “They love running the program themselves. They have taken ownership of AM.”
Instruction

When asked whether AM diminishes the instructional role of the teacher in any capacity, Participant One responded, “It totally enhances my role. It provides practice in a variety of ways with a variety of types of questions for the same skill.”

Participant Two had a similar opinion and wrote:

AM has enhanced my instructional role in the classroom. Once I gained the confidence in using AM in the classroom, I found myself helping more students on a one-to-one basis. I also found myself giving shorter but more lectures during the class hour.

Questions that pertained to AM and its impact on differentiated instruction and cooperative learning also yielded similar answers from the participants. Participant One believes ardently that differentiating instruction is made easier because of AM. Regarding AM and cooperative learning groups, she wrote, “I have students who have already mastered objectives to work with those who need extra help.”

Participant Two thinks the program’s assistance with differentiating instruction is one of the program’s greatest benefits. He wrote, “A teacher can quickly see where the intervention boxes are coming up and print an exercise that will address the student’s needs.” On the subject of cooperative learning he added, “I use the student ranking list and create my cooperative learning groups from this list. I want to make sure that each group contains students of various levels in their math skills.”

Additional instructional questions related to AM addressed progress monitoring, efficiency, teacher training, student feedback and full utilization of the
program features. Participant One indicated that AM is extremely time saving and efficient because of its automated assignment and scoring capabilities. She found the progress monitoring feature very helpful and stated, “I use it to plan and implement my small group instruction.” She found that the instant feedback feature is highly valuable. Commenting on AM’s error analysis feature, she wrote, “I use this as a re-teaching component, review back over the skill as needed and have the students correct some/all of their mistakes.” In response to training and utilization, she felt adequately trained on AM, but added, “I’m sure I could always improve.” How she utilizes the program is left up to her own discretion and the only feature she is aware of that has not been utilized is the Home Connect feature.

Participant Two found that AM enhances efficiency. He wrote, “It has improved my efficiency considerably and has allowed me to test more and keep accurate records.” He also found great value in the progress monitoring capability of AM, thereby helping to create heterogeneous work groups, stating, “The teacher’s feedback is more constructive, encouraging the students to master the objectives.” Also, the program allows him to be more analytical of individual students needs by identifying objectives in need of intervention. The curriculum can then be better adjusted to meet the student’s needs. Regarding the topic of training, he wrote, “There is always more to learn and there is a learning curve to teaching with AM. When I first started with the program, I was not adequately prepared. I am getting better teaching with it every year.” In response to fully utilizing the program’s capabilities, he indicated, “There are decisions made at the administrative level that
can hinder using AM to its full potential.” On the subject of the Home Connect feature, he wrote, “This has been a challenge for us. We are far from maxing out in students using the home connect feature.”

Comprehensive Solution

The remaining responses related directly to the study’s purpose, which was to determine the participants’ thoughts on the worthiness of AM as a viable comprehensive solution to declining math performance and their opinion of whether the program should become a mainstream, centrally featured component of math curriculum throughout the country.

Participant One felt strongly that more schools must consider AM. Her opinion was that every elementary and middle school would benefit from AM. She wrote, “I do not know how beneficial it would be for primary” capturing her uncertainty of AM’s potential benefit on students below the fourth grade level. She is in favor of mainstreaming AM, but she does not consider it the central component of the curriculum. She considers the teacher and the instruction the centerpiece of education stating, “AM along with other programs is a wonderful supplemental piece”. When asked about the frequency of use, she indicated, “Typically on a daily basis. I use it to review, remediate, accelerate, and/or practice math skills and especially for differentiated instruction.” Summarizing her profoundly positive experience with AM, she wrote, “If I were to move to a school that did not use AM, I
would have a very difficult time replacing this valuable component of my math program. I am a believer in this program!

Participant Two shared much of the same sentiment, documenting his daily use of the program and deeming it a critical component of the curriculum. He wrote, “It is not the centerpiece but far from being just supplemental.” He also supports the notion of mainstreaming AM stating, “The program is very impactful. Once teachers become confident using the program, more schools will be using it.” He did express some uncertainty on the impact AM would have in higher level math courses such as Calculus by saying, “The correlation between AM and the AP test is questionable,” Overall though he certainly believes the benefits extend beyond only remedial classes such as his Remedial Algebra class. In summation he wrote:

I have had a very positive experience using AM. It has been instrumental in helping me develop a differentiated classroom. I want to stress the importance of the continued support that I have received from the company. Teacher training is critical, once the teacher has gained the confidence in using the program, more students will be jumping tracks in the math curriculum.
Chapter 5: Conclusions and Recommendations

Conclusions

The findings of this study expand upon the already promising research on AM by offering new perspectives of two teachers’ direct experiences with the program. In a broader sense, the findings provided a valuable contribution to educational research in mathematics as a whole. Accelerated Math is an attractive concept of individualized mathematics that has been molded to fit different curriculums, grade levels, and state learning standards. Its computer-based technology and capabilities offer a unique and comprehensive solution to the multiple challenges facing mathematics education.

Student Oriented

Much has been made in education of prioritizing an equitable learning experience for all students (Strong et al., 2004). The topic is often more heavily scrutinized as it pertains to mathematics, due to commonly varied ability levels amongst students in this subject area (McAllister & Plourde, 2008). The literature on AM indicated that all students are afforded the opportunity to accelerate their learning, jump tracks, and most importantly meet their math learning potential (Renaissance Learning, 2011). The results of the questionnaire decisively support the notion presented in the literature that AM accommodates all ability levels. The
participants’ additional comments on how students enjoy using the program further solidify the characterization of AM as student oriented.

**Teacher Oriented**

Based upon the concept of inclusive instruction and its prevalence in today’s classrooms, administrators place emphasis on the teacher to provide equitable learning experiences (Wilgoren, 2000). Differentiated math instruction is both a challenge and responsibility for educators teaching in inclusive classroom environments (Horn, 2007). Automated practice, scoring, and feedback features equip teachers with valuable tools to plan and enhance their instruction (Renaissance Learning, 2011). The responses of the two participants from this research study convincingly coincide with the literature’s description of AM as a teacher oriented support tool. The participants concur that AM is highly effective in differentiated lesson planning and creation of effective small workgroups, both of which are extremely important in inclusive math classrooms.

**Mainstreaming**

The responses from the two participants overwhelmingly indicate their support for the AM program. Both participants agreed that implementation of AM should become mainstream. Coming from very experienced math teachers directly using AM on a daily basis, their favorable opinions on mainstreaming is worthy of further investigation. Their supporting comments highlight how one program can meet several educational challenges such as differentiated instruction, RTI,
cooperative learning and individualized learning. I feel that since AM addresses both
teacher and student needs while offering the efficiency of computer-based
technology; it deserves mainstream recognition as a comprehensive, forward-thinking
program for math education.

Accelerated Math has gained notable recognition since its inception, yet the
majority of schools in the U.S. are not using the program (Renaissance Learning,
2007). I believe that based upon the favorable literature and positive results of AM,
greater attention should be given to the program’s existence as well as the benefits it
offers to math education. Increased awareness may generate a more widespread
consideration by school districts across the country to experiment with AM and
ultimately lead to mainstream implementation of the math learning program.

**Recommendations for Future Research**

Accelerated Math and the individualized math concept have the potential to
bring about an exciting and progressive transformation in math education, one that
utilizes technology in the classroom to support both teachers and students. Moving
forward, I recommend continued research on AM to increase awareness of the
program and expand its credibility as a comprehensive solution to the declining math
achievement of U.S. students.

Although AM has been gaining some recognition, I believe that it has barely
scratched the surface in terms of mainstream consideration by state educational
authorities and local school district administrators. Several reasons may be
contributing to this, such as the misconception that AM is designed only as an intervention tool for students with learning disabilities. Perhaps it is because the concept is too drastic a shift from traditional math education models. It could also be due to budget constraints of local school districts. First year installation, licensing fees, and on-site training costs approximate $7,500 for 250 students with annual renewal fees of approximately $2,000. Then again, having only been around for 15 years with limited research, it may take more time for the word to get out on AM. The responses of the two participants also uncovered the effects that teacher training or lack thereof can have when implementing a new program. I believe that continued research targeting these questions is necessary for the continued evaluation and promotion of what I believe is a unique and exciting program.

**Expand the Number of Participants**

I recommend that future studies expand upon the very number of participants by offering an enhanced representation of the population of teachers who are using AM. The literature revealed that many of the school districts currently using AM have students from low income populations (Ysseldyke et al., 2003). Expansion of the teachers could be achieved by contacting schools where teachers are using AM with students from various demographics such as socio-economic status, race, geography, population size, grade level, and achievement level.

I also recommend interviewing school administrators, such as principals and district superintendents, to obtain qualitative feedback on the decision process for AM
implementation and its use with a variety of student populations. I believe that continuing to collect qualitative data reflecting a variety of individuals' perspectives on AM could prove valuable in validating the effectiveness of individualizing mathematics education through use of the program.

**Investigate Awareness of Accelerated Math**

I also believe future research on AM should seek to gauge the awareness level of the program amongst math department heads and school administrators throughout the U.S. education system. In order for schools to assess the quality of the program and its potential educational benefits they need to be made aware of its existence. Interviews with principals and superintendents of schools not currently using AM could be conducted to discover if awareness even exists and, if so, the extent of their knowledge of the program.

I believe the objective of the research should be centered on whether or not AM is a viable solution for improved math performance. In order to narrow the target population and adhere to the research objective, I recommend selecting from schools that currently do not use AM and rank below average on their respective state math exams. Administrators of these identified schools could be interviewed and asked what they know about AM. For those who are aware of AM, they could be asked if they have or will consider implementation. For those administrators who are not aware, the researcher could then discuss some of the potential benefits of AM. The results of this research could produce quantitative data on whether or not awareness
existed but also qualitative feedback from the open discussion that ensues. The quantitative data could also be categorized based on demographics such as geographical, grade level and socio-economic status to determine if any significant patterns emerge. For the administrators who were previously not aware of AM and open to consideration of its use, follow up interviews could be conducted the following school year to determine if AM was implemented and any results because of its implementation.

**Determine Rationales Against Accelerated Math**

Regardless of how prevalent unawareness of AM may be, I think that it is important to investigate the rationale of aware administrators who choose not to implement the program. Just as most other things are in life, decisions related to implementation of education programs and services are impacted by funding sources. For this reason, I believe investigation is warranted on whether budgetary constraints of school districts prevent AM implementation in some circumstances.

That investigation could also target schools using AM exclusively for special education students to determine if the program could only be funded by special education funding sources (Renaissance Learning, 2007). The No Child Left Behind Act also impacts federal funding that could play a role in whether schools can afford new programs (McAllister & Plourde, 2008). Qualitative interviews with administrations whose schools currently use AM could shed light on the effects cost has on implementation and expansion of AM.
Any type of change can often be intimidating as well as challenging. Therefore, deciding to make a substantial shift in math instruction to an individualized computer-based program can be a daunting undertaking for a school administration, teachers, and students. This may prove to be another factor as to why administrators are not implementing AM. I recommend that future interviews with administrators involve discussion on professional development and training for the implementation of new programs. Specifically as it relates to AM, a significant part of AM's first year implementation involves personnel training so that the program is utilized effectively (Brem, 2003). The interview could be designed to encompass the topic of training and participants made aware that on-site training costs are included in the price of the program.

Participant Two expressed his personal experience with AM and how lack of adequate training in the beginning hindered his instruction. Future research could also investigate the intensity of professional development that current AM teachers received and the effects it has had on their instruction and capacity in which they use AM.

The findings also indicated that the Home Connect feature, enabling student and parental access to AM at home, was not utilized to its fullest potential by either participant and in turn by his or her students. Research has found that students achieve greater success when the Home Connect feature is used frequently (Holmes, Brown, & Algozzine, 2006).
Cost and training are two examples of factors involved in the decision making process for AM implementation. Future research should seek to reveal other reasons that administrators cite for not implementing AM. I recommend future researchers explore these areas to generate further understanding of the potential benefits of AM.
References


Appendix

“Teaching with Accelerated Math™” Questionnaire

Instructions: Please attempt to provide as much detail and specifics as possible in your responses. Doing so enhances the quality of the collection data and the overall research objective. Please add as much space as necessary between questions. Hand written or typed responses are both acceptable.

Grade Level _________

1. How many years of math teaching experience do you have?
2. How many years experience do you have using Accelerated Math™ (AM)?
3. Why did your school/class decide to use the AM system?
4. Describe the makeup of your students in terms of their math ability, inclusion of special needs students, and ethnic diversity.
5. Is AM better suited for one particular group of students more than another? (i.e. lower ability, higher ability, minority, special needs) If so, please explain. Do all students stand to benefit from AM?
6. Is AM more effective for certain topics, units, or even grade levels more than it is for others?
7. Would you describe the content and questions contained within the program to be aligned properly with state learning standards?
8. How does AM affect student achievement in your classroom?
9. Do you feel adequately trained with AM?
10. Would you say you are using the program to its fullest capabilities?
11. How often and in what capacity is AM used in your classroom? Does it serve as the centerpiece of the curriculum or is it used sparingly, perhaps only for specific purposes (RTI, pre-assessment, unit testing, quizzes, practice, certain units)?
12. Do you believe the capacity in which you are using AM is the best possible and most effective? Is that left up to your own discretion or is that decision made at the administrative level?

13. Regardless of the capacity in which your specific class uses AM, do you believe it should be used more often and serve as the centerpiece of the curriculum?

14. How efficient and time saving has the program been for you considering its automated assignment creation and scoring capabilities?

15. How helpful is the progress monitoring information in assisting you, the teacher, in identifying both individual student needs and whole class learning needs? Is that information used to plan instruction?

16. Does AM make it easier for the teacher to differentiate instruction to meet individual learning needs?

17. Describe if and how AM assists teachers in forming cooperative learning groups.

18. Does AM enhance or diminish the instructional role of the teacher in any way? What instructional components, if any, does AM have?

19. Does using AM make it easier to incorporate other forms of technology inclusion? Are other technology learning programs compatible with AM?

20. Is AM better suited than traditional math curriculums in keeping students on task and engaged?

21. Would you say that student behavior is affected when using AM? If yes, how so?

22. How does AM change the way a teacher provides students with feedback? Does AM require a comprehensive change in the manner in which you assess your students compared to a traditional math program?

23. Do students seem motivated and responsive to the individualized feedback from the TOPS reports?

24. How useful is the error analysis feature in explaining how or why an incorrect answer was chosen?

25. How have students responded with the technology aspect of AM? Do they like using a computer-based program?
26. Do you think students are more likely to set individual goals because of AM’s design?

27. Explain how well AM is at consistently keeping students of varying ability within the same classroom adequately challenged and engaged?

28. Do students use the Home Connect feature and how often, if any, do students use AM outside of the classroom?

29. How is the parental feedback on the program?

30. Overall, how impactful is this program and should more schools take notice of it?

31. Should every school and grade level be using this program?

32. If the decision was yours, would you choose to use AM in your math class?

33. What changes, if any, would you like to see with AM?

34. Overall, summarize how positive or negative your experience using AM has been.

35. Please add any other comments or details of your experience with AM that you wish to share.