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A Pragmatic Mathematics: A new skills-for-life mathematics course addressing the NSACS's revelation of the dismal quantitative literacy of America's college graduates

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1. INTRODUCTION

U.S. colleges are failing in their responsibility of training students in the practical mathematical skills necessary to successfully enter society. This is the conclusion that was reached by The American Institutes for Research's new study examining the literacy of U.S. college students (American Institutes for Research [AIR], 2006). "The National Survey of American College Students [NSACS]," is based upon a sample of 1,827 graduating students from randomly selected 2-year and 4-year, public and private, universities and colleges across the United States. According to Stephane Baldi, the NSACS's director at the American Institutes for Research, the study is intended to be used as a tool to help college and university administrators identify specific academic areas where students have literacy gaps that need to be rectified. The study reveals that students struggle most with *quantitative literacy,* which the NSASC defines as follows:

> The knowledge and skills required to perform quantitative literacy tasks, that is, to identify and perform computations, either alone or sequentially, using numbers embedded in printed

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materials. Quantitative examples include balancing a checkbook, figuring out a tip, completing an order form, or determining the amount of interest on a loan from an advertisement.

The study concludes that approximately twenty percent of U.S. college graduates completing four year degrees – and thirty percent earning two year degrees – have only *basic* or *below basic* quantitative literacy skills. This means they are unable to estimate if their car has enough gas to get to the next gas station, or calculate the total cost of ordering office supplies. The results indicate shortcomings in the educational system's preparation of students to meet the mathematical challenges of the real world.

As these shortcomings have considerable effects upon American society, the results of this study indicate a crisis which must be addressed. "Many situations bring people into contact with mathematics, including buying products, conducting business, producing products, managing people and technology, using science and technology" (Arney, 1999). The rate of growth of mathematically based occupations is about twice that for all other occupations (National Research Council, 1990). Almost 40 percent of the workforce does not have sufficient quantitative literacy for jobs that pay more than $26,900, on average. Additionally, close to two-thirds of new jobs will require quantitative skills typical of those who currently have some college or bachelor's degree. America cannot remain a first-rate economic power with a population that has second-rate mathematical literacy. Additionally, if educators cannot fulfill their economic responsibility to help our youth and adults achieve quantitative literacy, they will also fail in their cultural and political missions to create good neighbors and good citizens (Carnevale and Desrochers, 2003).

In response to the findings of the study, a new problem-based method of teaching basic mathematical skills to those students who have difficulty in applying mathematics to their everyday

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lives is presented. A course is designed which is not truly a mathematics course, but can be construed as a skills-for-life course which involves mathematics. Mathematics is not taught as a subject, but as a tool to be used on a day-to-day basis. This change in attitude impacts what is taught, what is *not* taught, and most significantly, *how* it is taught. These changes signify an appropriate response to the challenge presented by the findings of the NSACS.

The paper is organized as follows. Section 2 discusses the notion of quantitative literacy, and surveys the literature and studies regarding the emphasis on quantitative literacy in the American mathematical educational system. Section 3 relates the successful Israeli model of improving the quantitative literacy of its weaker students while simultaneously maintaining strong standards for its advanced students. Section 4 elucidates the new *pragmatic mathematic*[1] course designed to improve America's quantitative literacy, illustrates its teaching method and content, and compares it to traditional mathematics courses. Section 5 is devoted to addressing various oppositions towards the implementation of this new course. Section 6 provides some concluding remarks.

2. BACKGROUND ON QUANTITATIVE LITERACY AND ITS OPPOSITION

2.1. The notion of quantitative literacy. The concept of numeracy, or quantitative literacy, emerged in the *Crowther report* (1959), where "numerate" is defined as "a word to represent the mirror image of literacy … an understanding of the scientific approach to the study of phenomena - observation, hypothesis, experiment, verification [- and] the need in the modern world to think quantitatively." The landmark report, *A Nation at Risk* (U.S. Department of Education, 1983), calls for higher standards for all students in mathematics, as well as curricula that would teach students to "apply mathematics in

[1] Throughout this work, the term *pragmatic mathematic* will be used specifically to refer to the new course developed in this paper.

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everyday situations". Carnevale and Desrochers (2003) underscore that "most Americans seem to have taken too little, too much, or the wrong kind of mathematics". They recommend that "to fully exploit mathematics as a practical tool for daily work and living, mathematics needs to be taught in a more applied fashion." In *Mathematics and Democracy: The Case for Quantitative Literacy* (Steen, 2001), the Quantitative Literacy Design Team remarks: "Typical numeracy challenges involve real data and uncertain procedures, but require primarily elementary mathematics. In contrast, typical school mathematics problems involve simplified numbers and straightforward procedures, but require sophisticated abstract concepts."

In their insightful discussion of quantitative (in their terms, mathematical) literacy, Amit and Fried (2002) comment that most educators struggle to supply the term with a precise definition which enables one to determine its applicability to particular students. Despite this difficulty, they contend that "at the heart of this notion lies students' openness to mathematics", rather than their mastery of particular skills. Since it is unavoidable that students will confront mathematics in their lives, educators must ensure that these encounters do not cripple them with fear. They conclude that "the mathematically literate society is, thus, one characterized by a sense of ease, of feeling at home, with mathematical ideas and mathematically presented information." A similar attitude is presented by Briggs, Sullivan and Handelsman (2004) who comment as follows:

> Providing liberal arts students with a worthwhile experience in a quantitative literacy course requires overcoming significant psychological obstacles. Students who take such courses often are victims of previous mathematics courses and instructors. As a result, they harbor genuine fears of mathematics, they have lost confidence in their quantitative skills, and they have little belief that mathematics might be of use in their future. A successful quantitative literacy

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course cannot subject students to more of the same experiences they have had in previous mathematics courses.

Although some of the characterizations of quantitative literacy found in the literature seem to differ, the difference is largely one of perspective more than of substance. Many authors focus on the practical manifestations of quantitative literacy– the possession of practical mathematical skills; while others define the underlying cause of quantitative literacy – openness to and understanding of mathematics. However one precisely defines quantitative literacy, almost all agree about its necessity in today's world. The urgent need for effective quantitative literacy courses and programs in American colleges is expressed in recent reports commissioned by the Mathematical Association of America [MAA] (Sons, 1995), The American Mathematical Association of Two-Year Colleges [AMATYC] (Cohen, 1995), and the College Board (Steen, 1997). In 2001, the case for quantitative literacy reappeared in a report that has inspired a new dialogue on the subject (Steen, 2001). A recently released report, Beyond Crossroads II, extends the dialogue on quantitative literacy by underscoring the interdisciplinary nature of quantitative literacy and making a "call to coordinate across the disciplines to create a curriculum that effectively supports quantitative literacy in our colleges (Blair, 2006)."

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2.2. Related studies. The findings of the NSACS provide evidence for the shortcomings of American college's mathematical education. This problem is not new to the American mathematical educational system. It simply provides additional evidence for the prevalence of a problem which was previously recognized as a serious flaw in the American educational system. As evidence of this problem, The Program for International Student Assessment [PISA] indicates that while U.S. high school students match their peers in other nations when it comes to mathematical skills, this is not the case regarding *practical* mathematical skills in which they ranked 24th out of 29 industrialized nations (NCES, 2004a). Furthermore, The Trends in International Mathematics and Science Study [TIMSS] finds that American eighth-grade students rank 15th internationally in mathematical achievement (NCES, 2004b). In a similar vein, The National Assessment of Educational Progress [NAEP], billed as "the nation's report card", reveals that only 36% of fourth graders, and 30% of eighth graders, have reached a level of proficiency in mathematics (NCES, 2004c). These findings, which were reported prior to the NSASC, indicated that the nation's educational techniques must be improved to better prepare students, throughout K-12, for the mathematical challenges that life presents. One would naturally assume that this problem which is prevalent throughout K-12 would not vanish in American colleges. NSACS confirms this assumption and demands that mathematics education reform be extended to American colleges as well.

In response to the findings of weak mathematical performance of American students throughout K-12, many educators have supported the implementation of a Standards-Based Mathematics Curriculum in American schools. "The NCTM Standards", developed by the National Council of Teachers of Mathematics (NCTM, 1989, 1991, 1995, 2000), shift the focus of mathematics education from memorization, rote learning, and application of facts and procedures, to the

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development of conceptual understanding and reasoning. The NCTM Standards are based on a set of core beliefs about mathematics as a body of knowledge and about the learning processes that effectively promote mathematical understanding and literacy (Goldsmith and Mark, 1999).

The need for reform in collegiate mathematics education has also been documented in several national reports, and change in this area has begun. Specific recommendations for curriculum change in two-year colleges are made in *Curriculum in Flux* (Davis, 1989). A new undergraduate curriculum is put forth in *Reshaping College Mathematics* (Steen, 1989). *Everybody Counts* (National Research Council, 1989) calls for detailed changes in mathematics education starting from kindergarten all the way to graduate school. Additionally, *Moving beyond Myths* (National Research Council, 1991) proposes major changes in undergraduate mathematics education. The MAA's *Guidelines for Programs and Departments in Undergraduate Mathematical Sciences* (1993) recommends that every college graduate should be able "to analyze, discuss, and use quantitative information; to develop a reasonable level of facility in mathematical problem solving; to understand connections between mathematics and other disciplines; and to use these skills as an adequate base of life-long learning." Significant work has also been done regarding calculus educational reform in American colleges [Crocker (1990), Ross (1994), Tucker and Leitzel (1994)].

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The shortcomings revealed by the NSACS are specifically regarding students of two-year colleges and the lower division of four-year colleges. Mathematics education of these students is referred to as "introductory college mathematics" by the AMATYC's *Crossroads in Mathematics: Standards for Introductory College Mathematics before Calculus* (Cohen, 1995). *Crossroads* develops standards for introductory college mathematics education with the following two goals in mind: "to improve mathematics education at two-year colleges and at the lower division of four-year colleges and universities and to encourage more students to study mathematics." One theme in these standards is that "the mathematics that students study should be meaningful and relevant" and that the problems presented should "provide a context as well as a purpose for learning new skills, concepts and theories. A similar sentiment is described by Haver and Turbeville (1995) in their formulation of the goals of a mathematics course designed for nonscience majors. They explain:

> The goals of the course are to develop, as fully as possible, the mathematical and quantitative capabilities of the students; to enable them to understand a variety of applications of mathematics; to prepare them to think logically in subsequent courses and situations in which mathematics occurs; and to increase their confidence in their ability to reason mathematically.

In their recent report *Beyond Crossroads* (Blair, 2006), the AMATYC presents a renewed vision for introductory college mathematics education by providing new *Implementation Standards*, which "focus on student learning and the learning environment, assessment of student learning, curriculum and program development, instruction, and professionalism." These standards are designed to "clarify issues, interpret, and translate research to bring standards-based mathematics instruction into practice" in an attempt to reform American introductory mathematics education.

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Many other conferences and articles have echoed the sentiments that the American educational system must reform the way it teaches mathematics, and refocus on practical applications. *Crossroads* suggests that "introductory mathematics courses hold the promise of opening new paths to future learning and fulfilling careers to an often neglected segment of the student population" (Cohen, 1995). Despite numerous suggestions and implementations of reform in introductory college mathematics education, the recent findings of NSACS reveal that these changes have not been as widespread or as effective as would be desired. A large number of American college graduates are still failing in their quantitative literacy and are not properly prepared for the mathematical challenges which life presents. Hopefully, the adoption of the new Implementation Standards suggested in *Beyond Crossroads* will help address these shortcomings.

2.3. Opposition to an educational system focused on quantitative literacy. Despite the strong and widespread support for a shift of the American educational system towards quantitative literacy, there is some tough opposition. Kaiser (1999) reveals that the educational method in Germany is more focused on theoretical aspects of mathematics, while that of England is more focused on the pragmatic side of mathematics. Thus, the impetus towards quantitative literacy can be seen as a push that America follows England's lead. However, Gardiner (2004) strongly cautions against such an approach and furnishes evidence of the failings of the English educational system in equipping its students with basic mathematical skills. He attributes this failing to the paradigm shift which occurred in England after the publication of the Cockcroft report (Cockcroft, 1982), and advises educators to heed the warning of Hyman Bass (quoted in (Steen, 2004)), who describes with uncanny accuracy what occurred in England in the late 1980's and 1990's:

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> The main danger … is the impulse to convert a major part of the curriculum to this form of instruction. The resulting loss of learning of general (abstract) principles may then deprive the learner of the foundation necessary for recognizing how the same mathematics witnessed in one context, in fact applies to many others.

Gardiner concludes that "mathematics and mathematics teaching are simply *hard,* and that there is no "cheap alternative" to facing the fact that abstraction is a crucial part of elementary mathematics - almost from the outset." He cautions against making England's mistake, and suggests "that current abysmal levels of achievement indicate the need for hard work and incremental improvement, rather than the launch of yet another bandwagon." Gardiner's points are insightful and must be considered in any attempt at improving the American educational system. America must learn from England's mistakes and cannot afford to deprive its students of the true essence and beauty of mathematics, and at the same time rob them of learning its basic skills. Simultaneously, the abysmal levels of mathematical proficiency of America's students must not be ignored, and its educational methods must be improved.

3. A SUCCESSFUL MODEL FOR IMPROVING QUANTITATIVE LITERACY

In the search for a middle ground between the democratization of mathematics with its risk of "watering down" mathematics on the one hand, and the maintenance of high mathematical standards on the other, Amit and Fried (2002) present the successful model of Israel's reformulation of their National Completion Examinations in Mathematics (NCEM) administered at the end of high school. In the early 1990's, educators realized that the high level of mathematics demanded by their NCEM's intimidated weaker students, and caused many to terminate their mathematical studies as early as ninth

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grade. This presented a serious impediment to the nation's aspirations towards high quantitative literacy for its citizens. At the same time, however, they did not want to lower their standards and history of high achievement for their advanced students. To solve this dilemma, in 1996 they created an alternative for weaker students by dividing their basic NCEM into two parts. The basic part is designed with the reasonable expectation that all students can pass. One of the foci of this part of the test is mathematical questions involving common sense and everyday experience. The hope was that the weaker students would be able to face their mathematical inadequacies and strive for a modicum of success in their mathematical endeavors. Instead of insisting on a standard which these students could not achieve, Israel devised a bifurcated system which enabled its weaker students to pursue a more reasonable goal, and thereby continue their mathematical training. In order to ensure that the standards for the higher level students were not compromised, the completion of the exam demanded passing the more advanced section as well. Although this is the case, Amit and Fried comment that:

> The hope is that the *option* of taking this part of the examination independently of the rest of the examination will encourage students to continue to study mathematics earnestly until the end of high school, that they will work through the Basic Questionnaire with success, and that this sense of success will push them eventually to complete the whole NCEM. There is already evidence that this hope is not futile.

The data collected in the years following this shift indicate the success of the model. The number of students who took the basic exam increased - an indication that once the students were given the opportunity to take an exam more suited to their level, they became less intimidated and rose to the occasion. Interviews with teachers reflected that these students felt more motivated to continue studying mathematics, and gained a sense of competency through passing the basic part of the exam.

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Although the evidence of Amit and Fried is limited to high school educational reform, the concept should hold true in college educational reform as well. Assuming this to be the case, the Israeli model indicates a successful method of maintaining America's high mathematical achievement, while pursuing reforms aimed at increasing its quantitative literacy. Namely, educators must continue their advanced, more theoretical methods of mathematics instruction for stronger students, but simultaneously reach out to weaker students and provide instruction more suited to their level and interests. With this goal in mind, Section 4 introduces a new mathematics course, designed specifically for weaker students. This *pragmatic mathematic* course should not be offered to stronger students who are capable of higher mathematical achievement. By restricting the focus on practical mathematics to its weaker students, America will follow Israel's successful model and avoid the catastrophe which occurred when England "watered down" its mathematics education for strong and weak students alike.

4. THE PRAGMATIC MATHEMATIC APPROACH

This section focuses on how the lesson learned from the Israeli model should be implemented in teaching weaker students in American colleges. It elucidates the particulars of the *pragmatic mathematic* approach and differentiates it from the traditional approach.

4.1. The traditional approach. It is common wisdom that to prepare students for life, the applicability of mathematics to everyday situations must be demonstrated (see Senge (2000), for instance). However, it is often overlooked that the role of practical examples must be different when teaching strong, as opposed to weak students. In a traditional mathematics course, taken by both strong and

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weak students, a rigorous approach is taken[2]. The focus is on content knowledge; to teach the student certain pieces of subject matter (Cohen, 1995).This subject matter is presented in a logical sequence, determined by the intrinsic mathematical development of the ideas. After a brief introduction regarding motivation for a given topic, the mathematical theory is taught in an abstract setting. The methods of computation are derived from this theory and extended to real life applications, wherever possible. The applications are essentially introduced as an afterthought to the fundamental ideas. This approach is effective in teaching advanced students who comprehend the underlying mathematical theory, follow the computational methods derived from this theory, and appreciate the practical applications enabled by these methods. They are engaged each step of the way, are truly involved in the mathematical process of gaining knowledge, and reap the full benefits of the education provided. They are not part of the troubling statistic regarding quantitative illiteracy.

This method, however, is inappropriate for students lacking in quantitative literacy. The traditional college algebra or precalculus courses, which are primarily designed to prepare students for calculus, do not provide the breadth and applicability of mathematics needed by liberal arts students (Sons, 1995). They are not interested in the theory, find the computational methods difficult, and are consequently not prepared to comprehend the real life applications. Their apathy, coupled with the intricacies of the material, obfuscates them. Due to their weakness in comprehending advanced mathematics, they are robbed of the opportunity of acquiring basic mathematical skills well within their capabilities. Unfortunately they proceed to fail a quantitative literacy test (such as NSACS) and, more importantly, are not properly equipped with the fundamental degree of mathematical ability necessary for life's challenges. It must be remembered that "making mathematics relevant and meaningful is the collective responsibility of faculty" (Cohen, 1995) and the results of NSACS reveal a failure in this responsibility which must be addressed.

[2] For a more thorough discussion of the traditional mathematics education approach, see Quirk (n.d.).

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4.2. A direction revealed by NSACS. One of the five Implementation Standards of *Beyond Crossroads* (Blair, 2006) is "Curriculum and Program Development". It suggests that:

> Mathematics departments will develop, implement, evaluate, assess, and revise courses, course sequences, and programs to help students attain a higher level of quantitative literacy and achieve their academic and career goals.

In attempting to discover an appropriate method for implementing this standard and reaching out to college students with poor quantitative literacy, one aspect of the NSACS stands out and provides direction to educators. Namely, the study reveals that students who take classes which stress analytic thinking and applying theories to practical problems, have a higher degree of quantitative literacy (AIR, 2006). This correlation *suggests* the introduction of a *pragmatic mathematic* course which reaches out to students who have no intrinsic interest in mathematics, but realize its necessity in the modern world[3]. This course addresses the frequent question posed by students, "Why do we need to learn this stuff?" The pragmatic approach better motivates the student to study mathematics. Instead of immersing students in pure mathematics and its multifarious abstractions, this course only teaches the mathematical skills necessary in the modern society, and therefore succeeds in conveying these skills to the students[4]. By giving the students a level of comfort with mathematics and allowing them to realize the power and usefulness of mathematics, they are assisted in overcoming their fear of mathematics and improving their quantitative literacy.

[3] Though the correlation does not prove that the cause of the increased quantitative literacy is these courses, it is nonetheless a correlation which suggests a direction for needed reform.

[4] Being that modern society is rapidly changing, the mathematical skills necessary in modern society are also rapidly changing. Thus, while the approach of this course is fixed, the particulars must be adjusted by the instructor to the changing demands of society. This being said, for a sample of some mathematical skills necessary in today's society, see Section 5.4.

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4.3. The pragmatic mathematic approach: What is taught? The new method that the *pragmatic mathematic* utilizes in teaching these students is exactly the opposite of the traditional sink-or-swim approach. The traditional approach unrealistically attempts to prepare all students to become mathematical experts. On the other hand, the *pragmatic mathematic* aspires to train weaker students in practical mathematical areas. The practical examples do not complement the theory, but are the focus of this course. It is not a pure mathematics class, but a preparatory class for life's challenges. As such, each lesson focuses on a problem which the students encounter in their daily lives. The syllabus is designed to have approximately 40 practical problems which will serve as springboards to introduce mathematical skills and methods. Instead of concocting unrealistic word problems to illustrate remote applications of an abstract subject, this course focuses on real life problems which every student relates to and appreciates. Rather than the example of Phil, the farmer, using the quadratic formula to help plant his field, this course considers the example of Steve, the student, using fractions to determine if he will make it to the next gas station. A teacher of this course will not be concerned about skipping abstract topics whose mathematical significance may be great, but whose practical significance is small, or nonexistent. These topics simply do not belong in a *pragmatic mathematic* course, but in a true mathematics course. Just as Shakespeare is not taught to beginners in reading, mathematical abstraction should not be taught to beginners in mathematics. Will these students comprehend and appreciate the full picture of mathematics? Absolutely not! They will not understand the theory, nor will they have a solid grasp on the rigor of the computational methods. An honest analysis leads to the realization that this is not appropriate for these students, as is evidenced by their failure to grasp *real* mathematics in the traditional educational system. In a *pragmatic mathematic* course, these students derive from mathematics the practical tools they truly need. As was the case with Israel's high school students, these positive experiences allow the students to become comfortable with mathematics. They

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will enjoy the *pragmatic mathematic* as its beneficial function is immediately apparent. This method addresses the American educational system's shortcomings in educating its weaker students, and will find success in increasing the nation's quantitative literacy through teaching these students only what is truly necessary.

4.4. The pragmatic mathematic approach: How is it taught? Besides for impacting what material is taught, the *pragmatic mathematic* approach provides a new method as to *how* the material should be taught. This method is elucidated by explaining the basic approach towards each lesson in a *pragmatic mathematic* course, and then by illustration through an example. Each lesson begins by engaging the students with a practically motivated exercise. Once the students gain interest in the problem, the instructor demonstrates that its solution demands mathematics, and introduces the skills necessary to solve the problem. Instead of insisting on a rigorous mathematical solution, the most efficient method of solving the problem is illustrated. Whenever possible, tricks or shortcuts are introduced to simplify the solution. The method can be illustrated with a simple example. On a regular basis, students are faced with the task of computing a tip. Assume that their restaurant bill totals $51.07, and they want to give a 15% tip. The NSACS reveals that many college graduates are perplexed by such a task. Why is this so? Are American students incapable of such a simple procedure? Certainly not! The explanation is usually that they were never properly taught how to calculate it. They were instructed how to take 2.47% of 0.0456, and other complex percent problems. They have a vague recollection of moving the decimal two spots to the left and multiplying, but have forgotten long ago how to carry out this multi-step process. They were never shown how straightforward it is to take 15% of a number, especially when precision is unnecessary. It is in this context that percents are introduced - with the simplest, most practical problems, which can be solved by a shortcut. The instructor emphasizes the significance of rounding in real-life problems. Students are taught to quickly compute 10%, half it to get 5%, and add

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these to get the desired 15%. No student should have trouble applying this method, especially with practice. How many mathematicians evaluate a 15% tip by doing long multiplication by 0.15? Most employ some shortcut which they have discovered on their own. So why not teach this method to students who cannot figure it out by themselves? Why burden them with multiplying $51.07 by 0.15 when there is a simpler and quicker alternative? Just as in a regular mathematics course tricks cannot be allowed to substitute for real mathematics, so too in a *pragmatic mathematic* course, real mathematics cannot be allowed to substitute for tricks, and cloud the path towards a practical solution. The goal of this course is not to make its students into mathematicians, but to give them the tools and confidence needed to apply mathematics to their everyday lives. Although not every lesson lends itself to the simplicity involved in computing tips, this example illustrates the approach of this course and should, therefore, serve as a model for other lessons.

4.5. Education regarding real-life institutions. The *pragmatic mathematic* course possesses another feature which addresses the failings of college graduates in the NSACS, but is unrelated to their mathematical education per se. Often times, students are relatively well equipped with mathematical skills, but are ignorant regarding the real world institutions which invoke these skills. For instance, computing interest payments on a mortgage or credit card involve basic mathematics. Yet, even the greatest "math genius" would be unable to perform these tasks without knowing the concept of a mortgage, or the meaning of APR. This is specifically applicable to students with poor quantitative literacy who fear anything involving mathematics and, therefore, never acquaint themselves with these basic financial phenomena. With this realization in mind, this course attempts to overcome the students' fear of mathematics and teaches mathematical skills together with their accompanying real world knowledge. The concepts of interest, insurance, credit card fees, deposit slips, checkbooks, investments, odds, and other such notions are elucidated. By familiarizing students with sufficient

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applications of mathematics, they are assisted in overcoming their dread of mathematics, and become more suited to handle future situations involving mathematical skills.

The success of the course will be increased by designing hands-on lessons. This can be accomplished by distributing: checkbooks, deposit slips, credit card offers, cell phone plans, lottery rules, odds for sporting events, food labels containing nutritional information, and any other material which invokes mathematics. This arouses the interest of the students and allows them to realize, in a concrete manner, the value of improved quantitative literacy.

4.6. Comparable courses. A similar, but more sophisticated, pragmatic course design is suggested by Bernard L. Madison (2004). The University of Arkansas course, developed by Madison, is centered on newspaper and magazine articles which can only be understood or critiqued by applying mathematical skills. A comparison between his course and the *pragmatic mathematic* course indicates that the subject matter and mathematics involved in Madison's university course are more complex and are suited to higher level students.

Another similar liberal arts mathematics course is offered at University of Colorado at Denver by William L. Briggs. The course has three stated goals: (1) to strengthen and broaden students' quantitative skills; (2) to restore students' confidence in using those skills; and (3) to demonstrate the immediate relevance and applicability of mathematics to students' lives and careers. (Briggs et al., 2004). From their experiences, the authors conclude that "if student engagement is secured early in the course, it can change student attitudes favorably and lead to an effective learning experience." It would be a fruitful study to thoroughly compare the three courses (Madison's, Briggs's and the *pragmatic mathematic*) in their content and degree of success.

5. ADDRESSING OBJECTIONS TO THE PRAGMATIC MATHEMATIC COURSE

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This section discusses a number of objections which can be raised against the implementation of the *pragmatic mathematic* course in American colleges.

5.1. The level of the course. One might raise the following objection to the *pragmatic mathematic* course: "Is this truly a college mathematics course? After all, the mathematical topics covered are of an elementary nature and should have been mastered before entering college. Students who have difficulty with these skills should take remedial classes to rise up to college standards!" To this objection, two responses are offered. Firstly, the NSACS revealed the sobering fact that *thirty* percent of *graduates* of American two-year colleges are severely lacking in their practical mathematical skills. This is compared to the *zero* percent of students who graduate without remediation or placing out of remedial courses. Colleges are simply not succeeding in preparing their students for life. What good is a mathematics education which prepares students to pass a test requiring numerous calculations, if they stumble as soon as they encounter a real life mathematical problem? Is this truly a college mathematics course? Although it is not a college course in the current educational system, that is precisely the problem. It should be, as indicated by the results of the NSACS. Educators cannot ignore the findings of this national study and blindly assume that the current approach is flawless. They must rise to the challenges presented by the directors of the study and change the manner in which weaker students are educated. The *pragmatic mathematic* course suggested in this paper rises to this new challenge.

Additionally, one cannot judge the level of a mathematics course merely by the technical skills it involves. Any mathematics teacher is well aware that many students who have mastered the requisite technical skills become dumbfounded by challenging word problems. This explains why many students performed poorly in the NSACS test of practical mathematics skills, despite the fact that all community college graduates have either passed or placed out of remediation. Mathematics cannot

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be limited to the application of step-by-step algorithms, but must include understanding, thinking and applying mathematics to new situations. This is arguably the most difficult and important part of mathematics, and is precisely what the current educational system is failing to teach its students. Thus, although the *pragmatic mathematic* course covers mathematical skills which are considered elementary in their technical level, it teaches its students how to understand and apply these skills to new problems. It therefore truly merits the status of a college-level mathematics course.

5.2. The scope of the course. Another objection which might be raised is that by restricting its lessons to truly practical examples, this course unnecessarily limits the scope of its students' mathematical education. After all, by the end of the semester its students have only learned how to solve approximately 40 practical problems. A more traditional approach, however, would provide students with tools to handle a larger variety of problems. There are two responses to this objection. First, although the lessons are centered about practical problems, these problems are invariably solved by mathematical methods which can be generalized to other problems. These 40 problems train the students to think mathematically and prepare them to solve other mathematical challenges. More importantly, Amit and Klein (2002) note that the major hindrance to students' advancement in mathematics is not their weak intellectual faculties, but is their frightful attitude towards mathematics. Because of their early failings in mathematics, they shy away from anything involving mathematics. An effective method of overcoming this obstacle is through accustoming students to applying basic mathematics, and helping them realize the usefulness of mathematics in making important decisions. A course meeting the *Crossroads* standards is one in which "the students will have the opportunities to be successful in doing meaningful mathematics that fosters self-confidence and persistence" (Cohen, 1995). When mathematics is presented as a concrete tool instead of an abstract pursuit, it becomes demystified in their minds. By breaking through their inner resistances, educators can open up a world

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of mathematics which was previously closed to these students. Once students become comfortable with mathematics, they readily learn the basic skills they need. Thus, while the initial approach of this course is limited to the practical, its objective extends much further. Hopefully, this course will provide an effective method of reaching those students which the educational system has failed thus far, and will enjoy the success of Israel's model which reached out to its weaker students in the reformulation of its NCEM's.

5.3 Avoiding the "England Disaster". Beside addressing the troubling results revealed in the recent studies, this new course stands up to Gardiner's objections as well. In order to avoid the "England disaster" which resulted from shifting the focus of *all* mathematics education towards the practical, this syllabus should *only* be used as a substitute for a "liberal arts mathematics" syllabus. In general, students who take this course are those who have no plans of advancement in mathematics, but need to satisfy a college requirement. These classes attract students who struggle with quantitative literacy. Since the studies underscore the failings of the traditional methods for the lower twenty to thirty percent of students, it is only these weaker students who must be targeted by a new approach. However, this syllabus must *not* be implemented for stronger students who can, and *must* learn the true rigor and theory involved in mathematics. The Israeli model, which found success through clearly differentiating between its standards for stronger and weaker students, must be followed. Advanced classes must continue in the traditional educational approach, keeping in mind that "numeracy and mathematical literacy are desirable byproducts of school mathematics" (Gardiner, 2004). America will thereby maintain the strengths of its stronger students, while simultaneously alleviating the weaknesses of its weaker students.

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5.4. The quantity of material. One may suggest that there are not enough practical mathematical problems to provide material for an entire semester. In order to address this concern, numerous examples are listed by topic. These examples are merely a fraction of the numerous problems which students with poor quantitative literacy are confounded by on a daily basis. Paying attention to every day experiences furnishes many similar examples. Teachers are encouraged to elicit examples involving mathematical reasoning from the students' daily routines. As the objective is to help the students gain the mathematical skills which they require in their lives, they will direct the instructor to the areas they find difficult. Additionally, such an approach is an effective means of fostering the interest of the students.

5.4.1 Financial Topics. Comparing credit card offers; computing interest on a credit card based upon APR; computing simple and compound interest on mortgages, loans and investments; balancing checkbooks; deposit slips; comparing investments: stocks, bonds, cash, mutual funds; determining profits/losses on investments; retirement plans; income taxes.

5.4.2. Consumer Topics. Comparing the value of two products in the grocery store; comparing nutritional information on food products; comparing cell phone offers; comparing prices for different types of gasoline: full vs. self and premium vs. regular; computing miles per gallon of a car; determining if a car has enough gas to reach a gas station; metric system conversions; computing tips; determining square yardage of a room to buy carpet; analysis of insurance premiums using mathematical expectation; comparing insurance plans based upon deductibles, percent coverage and out-of-pocket expenses; determining price of an item with a given percent off sale; estimating and determining sales tax.

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5.4.3. Recreational Topics. Understanding probability; methods of counting; analysis of lotteries; odds for sporting events; examination of card and dice games; interpreting statistics, bar graphs, line graphs, and circle graphs.

5.4.4. Miscellaneous Topics. Mixture problems; work problems; averages and grades; greatest common divisor and least common multiple; speed/miles per hour; and scientific notation.

6. CONCLUSION

Many studies have underscored the failing of America's mathematics educational system in imparting quantitative literacy to its students at all levels. The NSACS has provided new evidence of the severity of this problem in the nation's colleges. The *pragmatic mathematic* course is a new suggestion to help remedy this problem. Educators at both two-year and four-year colleges are encouraged to offer this course as a liberal arts mathematics course. The author of this paper requests to be kept informed of any progress. Hopefully, this course will build a foundation for raising the quantitative literacy of American college graduates and adequately preparing them for the challenges of the modern world.

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