

UNIVERSITY OF LEEDS



MODULE EDUC 5001M

CRITICAL STUDY

SUPERVISOR:

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CRITICAL STUDY TITLE:

Towards a Better Understanding of the Importance of
the Concept of Numeracy

WORD COUNT: 14,933

SUBMITTED BY: Murat Genc

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SUBMISSION DATE: 26 July 2010

**TOWARDS A BETTER UNDERSTANDING OF THE IMPORTANCE
OF THE CONCEPT OF NUMERACY**

by

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Submitted in accordance with the requirements for the degree of

Master of Arts

in

Mathematics Education

The University of Leeds

School of Education

July 2010

DEDICATION

I dedicate this thesis to my dear family for always being there for me when I needed most.



ACKNOWLEDGMENTS

I would like to express my gratitude to my supervisor Mr Tom Roper for his guidance, advice, thoughtful and constructive comments, and encouragement throughout my study. He painstakingly read and commented on the drafts of the study and offered sound and helpful advice when I was in doubt. Without his invaluable supervision and words of encouragement, this thesis would not have been possible.

I would also like to express my thanks and appreciation to Professor John Monaghan who gave me the confidence to believe in myself and my abilities, and who consistently reminded me to be meticulous in justifying myself throughout my work.

Of course no acknowledgements would be complete without heartfelt thanks to my close friend Mr Fazil Acar for his encouragement and great support both intellectually and emotionally. Last, but in no sense the least, I am thankful to my wife and daughter for their understanding, patience and unfailing support, which have made my stay in Leeds so rewarding and memorable.

ABSTRACT

Numbers seem to become more and more pervasive in people`s daily lives. This raises the importance of the ability to understand and interpret arguments depending on numbers in order to evaluate many of the issues that people encounter in their daily lives. In other words, people need to apply their knowledge of mathematics to a wide range of problems that continually occur in their everyday situations. Without some familiarity with this knowledge, everyday surroundings of people would remain incomprehensible to them. However, despite the importance of the concept of numeracy in people`s working and everyday lives, there has not yet been enough research done to gain more insight into it. The purpose of this paper is to discuss the contested and elusive nature of numeracy as it exists today in order to address the necessity to improve and expand numeracy provision in a variety of settings. I begin by discussing some attempts to define numeracy. Next, I have a look at the intricate relationship between mathematics and numeracy by focusing on particular characteristics of each. I then discuss what it means to be innumerate in today`s society and its consequences for both an individual and society. I also discuss the reasons for low levels of numeracy among people. In doing so, two crucial areas are developed, these concern school mathematics and numeracy and mathematics performance and affective factors. Finally, I have a look at numeracy as the use of mathematics in everyday life.

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LIST OF ABBREVIATIONS

The following abbreviations have been used in the thesis.

AAMT	:	Australian Association of Mathematics Teachers
ACACE	:	Advisory Council for Adult and Continuing Education
ALBSU	:	Adult Literacy and Basic Skills Unit
ALM	:	Adults Learning Mathematics
BSA	:	Basic Skills Agency
DfEE	:	Department for Education and Employment
DfES	:	Department for Education and Skills
DTI	:	Department of Trade and Industry
DWP	:	Department for Work and Pensions
HMI	:	Her Majesty's Inspector
NCDS	:	National Child Development Study
NCED	:	National Council on Education and the Disciplines
PSA	:	Public Service Agreement

1. INTRODUCTION

Numbers seem to become more and more pervasive in people`s daily lives. This raises the importance of the ability to understand and interpret arguments depending on numbers in order to evaluate many of the issues that people encounter daily in advertisements, forecasts, and public policies such as armament spending, international aid, environmental issues, crime rates and health statistics. Such ability to reason with numbers and other mathematical concepts is also important in becoming intelligent consumers to make informed decisions (Paulos, 1988; Willis, 1990a; Benn, 1997; Steen, 2001). When people perform calculations and estimate quantities in their daily lives, they rely on this ability to tell the time and read timetables, to be able to work with common measures of length, weight, speed, acceleration, temperature, density and capacity, to buy food, clothing or season tickets for sports, play, music, to deal with basic money matters, to check a shopping bill, to be able to read and interpret charts, diagrams, simple graphs and pictorial representations commonly shown in media, to understand statistical data and ideas of chance, to plan trips and estimate expenses, to handle funds for saving and investing, to use and understand variety of geometrical shapes in practical settings and so on (Scopes, 1973; Cockcroft, 1982; HMI, 1985: 3; Wain, 1989; Orton, 1994). Mathematical skills are also important in the workplace, and most jobs at all levels today require people to work with basic number concepts and to apply higher-order reasoning about quantities (Cockcroft, 1982; Bynner et al., 2000; The Quantitative Literacy Design Team, 2001; Hoyles et al., 2002). For example:

Farmers use computers to find markets, analyze soil, and deliver controlled amounts of seeds and nutrients; nurses use unit conversions to verify accuracy of drug dosages; sociologists draw inferences from data to understand human behaviour; biologists develop computer algorithms to map the human genome; factory supervisors use 'six-sigma' strategies to ensure quality control; entrepreneurs project markets and costs using computer spreadsheets; lawyers use statistical evidence and arguments involving probabilities to convince jurors (The Quantitative Literacy Design Team, 2001, p.1).

All of these activities fall under the heading of numeracy. It is, therefore, argued that numeracy provides a perspective and a means of understanding certain mathematical ideas and procedures encountered in everyday living. In this context, Benn (1997) writes that:

Numeracy consists of being able to make an appropriate response to a wide range of personal, institutional or societal needs. To participate fully in everyday living, adults need the ability to understand broader contexts in which numerical demands are located, to make use of appropriate communication skills, to be able to collect, present and interpret information presented in a variety of mathematical ways and to judge according to the nature of the activity and the desired outcome (p.80).

In a similar vein, Evans (2000a) states that:

Numeracy is the ability to process, interpret and communicate numerical, quantitative, spatial, statistical, even mathematical information, in ways that are appropriate for a variety of contexts, and that will enable a typical member of the culture or subculture to participate effectively in activities that they value (p.236).

It would seem clear that people need to apply their knowledge of mathematics to a wide range of problems that continually occur in their everyday situations. Without some familiarity with this knowledge, everyday surroundings of people would remain incomprehensible to them. In other words, “the numeracy demands that people encounter in their lives occur in a wide range of situations and it is important that they can make the connections and use the appropriate mathematics to cope with them well” (Kemp, 2005, p.26). However, despite the importance of the concept of numeracy in people`s working and everyday lives, there has not yet been enough research done to gain more insight into it. The purpose of this paper is to discuss the contested and elusive nature of numeracy as it exists today in order to address the necessity to improve and expand numeracy provision in a variety of settings. I will begin by discussing some attempts to define numeracy. Next, I will have a look at the intricate relationship between mathematics and numeracy by focusing on particular characteristics of each. I will then discuss what it means to be innumerate in today`s society and its consequences for both an individual and society. I will also discuss the reasons for low levels of numeracy among people. In doing so, two crucial areas will be developed, these concern school mathematics and numeracy and mathematics performance and affective factors. Finally, I will have a look at numeracy as the use of mathematics in everyday life.

2. DEFINING NUMERACY

The view put forward above argues that people need to become numerate to process, communicate and interpret mathematical information in a variety of contexts in order to survive in today`s modern society. However, it is also argued that there is no universally accepted definition of numeracy in the research literature (The American Institutes for

Research, 2006). The concept of numeracy has been much debated over many years by commentators concerned with the education of adults, because there is an issue of meaning, that is to say, it is not yet clear that what we mean when we talk about numeracy (O'Donoghue, 2002). The issue of numeracy is generally a debatable one and it is being seriously under-researched (Brooks et al., 2001) as “numeracy is a deeply contested and notoriously slippery concept” (Coben et al., 2003, p.9). Therefore, it can be seen that there exists confusion and ambiguity about the meaning of numeracy (Castle, 1992). Moreover, Withnall (1995a) observes that the term ‘numeracy’ is widely used in adult basic education, but there seems to be little or no general agreement among practitioners as to what it actually means. Deciding what forms numerical skills is a considerably difficult task. This is due to the fact that no matter what level of attainment is reached there will always be a proportion of people who are already in need of certain amount of mathematics at each level of skills. As a consequence, it can be said that “numeracy must remain a fluid term capable of re-conceptualisation according to the contexts in which it is used and by whom” (Withnall, 1995a, p.16).

2.1. THE CROWTHER REPORT AND NUMERACY

The term ‘numeracy’ was first coined in a report of the Central Advisory Council for Education known as the Crowther Report, which dealt with the education of boys and girls between the ages of 15 to 18 (Ministry of Education, 1959). The term was introduced in a section of the report concerned with the curriculum of the sixth form so that it would help remedy some shortcomings of science and arts specialists groups. For this reason, in this report, numeracy was considered as a way of improving communication between these two groups in that while the arts specialists acquire the skills to become more numerate, the

science specialist should acquire the skills and techniques to become more literate. In this way, it would secure numeracy and literacy for each group. Moreover, the Crowther Committee (1959) defines ‘numerate’ as the mirror image of being ‘literate’ (paragraph 398, p.269) and argues two aspects of numeracy as follows:

On the one hand is an understanding of the scientific approach to the study of phenomena-observation, hypothesis, experiment, verification. On the other hand, there is the need in the modern world to think quantitatively, to realise how far our problems are problems of degree even when they appear as problems of kind. Statistical ignorance and statistical fallacies are quite as widespread and quite as dangerous as the logical fallacies which come under the heading of illiteracy (paragraph 401, p.270-271).

The Crowther Committee (1959) continues to argue that “by ‘numeracy’ we mean not only the ability to reason quantitatively but also some understanding of scientific method and some acquaintance with the achievement of science” (paragraph 419 (e), p.282). In this respect, numeracy is regarded as “the minimum knowledge of mathematics and scientific subjects which any person should possess in order to be considered educated” (quoted in Withnall, 1995a, p.11). It is, therefore, seen that the Crowther Report (1959) laid a particular emphasis on the necessity of mathematical and scientific understanding as well as the ability to think quantitatively and avoid statistical fallacies in order to be considered ‘numerate’.

However, Castle (1992) points out that there is no agreement about what constitutes a minimum level of competence in mathematics which people should reach to be considered numerate in this definition. The problem lies within the vast continuum of mathematical

knowledge and extensive range of contexts in which a satisfactory level of mathematical understanding and skills are required. On the one hand, for example:

A mathematician at the Council for Scientific and Industrial Research might consider a person with matric level mathematics to be barely numerate, while a domestic worker who can take down a telephone number dictated to her over the phone might be considered by her employer to have adequate number skills (Castle, 1992, p.226).

On the other hand, there are some mathematical skills widely used by people, especially mental methods and estimation, but people might not show any level of mathematical competence needed to engage with life's diverse contexts and situations. Castle (1992) goes on to say that, as written in the Crowther Report, familiarity with the mathematical and scientific methods in order to be considered educated "is a value-laden criterion for adult numeracy which says nothing about individual mathematical competence. Many people who are educated are also mathematically incompetent" (Castle, 1992, p.226). In a similar manner, Withnall (1995a) argues that an approach to numeracy developed by the Crowther Committee ascribes it to a discrete set of competences in mathematics. In other words, the mastery of numeracy equally depends not only on a particular level of formal education in a specific length of time, but also on some standard methods of teaching mathematics. In this way, however, mathematics teachers serve as gatekeepers of mathematical knowledge. As a result, it can be seen that such an approach to numeracy comes with its own complications in that:

Unless this knowledge has been accessed and acquired, a person cannot be considered fully educated even though they may have demonstrated high levels of ability in other subjects. And who is to judge what 'fully educated' really means? In addition, this kind of definition takes no

account of the diversity of contexts in which a whole range of mathematical skills are used by both children and adults, how these may vary across different lifestyles and occupations and how they may need to change over the individual life span (Withnall, 1995a, p.11).

2.2. THE COCKCROFT REPORT AND NUMERACY

The term ‘numeracy’ is also discussed in a report on mathematics education by Cockcroft and his Committee of Inquiry (1982) called Mathematics Counts. He (1982) identifies the source of the concept of numeracy as the Crowther Report (1959) and acknowledges that the word has changed its meaning considerably since it was first coined by Crowther (1959). Cockcroft (1982) offers two dictionary definitions as evidence of this change. While the Oxford English Dictionary defines the meaning of the word ‘numerate’ as “acquainted with the basic principles of mathematics and science” (paragraph 37, p.11), Collins Concise Dictionary gives the term as “able to perform basic arithmetic operations” (paragraph 37, p.11). Cockcroft (1982) contrasts these two definitions and says that the second definition is in the spirit of the evidence reviewed by his committee. However, he (1982) argues that if numeracy is to be equated with “an ability to cope confidently with the mathematical demands of adult life” (paragraph 38, p.11), this definition is too limited because it only implies an ability to perform basic arithmetic operations not an ability to make use of them confidently in commonly encountered situations. Then, probably the most quoted definition is given by the Cockcroft and his Committee of Inquiry (1982), which uses numeracy to mean the possession of two particular attributes:

- an ‘at-homeness’ with numbers and an ability to make use of mathematical skills which enables an individual to cope with the practical mathematical demands of his everyday life;

- some appreciation and understanding of information which is presented in mathematical terms, for instance in graphs, charts or tables or by reference to percentage increase or decrease (paragraph 39, p.11).

It is worth pointing out here that these attributes must be read in the context of what Cockcroft (1982) generally argues about mathematics as a powerful means of communication (paragraph 3, p.1). Yet, Willis (1990b) states that this is slightly ironic, because on the one hand, it is true that the capacity to access ideas and arguments either involving mathematical concepts or presented in mathematical forms, and to access them critically, are important for effective participation in society, on the other hand, it is also true that mathematical expression of ideas may indeed prevent communication for a great number of people. However, Withnall (1995a) argues that the implication of Cockcroft's definition of numeracy is that "a numerate person should have sufficient confidence to be able to appreciate and understand some of the ways in which mathematics can be used as a means of communication" (p.13). This is also evident from Cockcroft's inquiry into the mathematical needs of adult life in that his main emphasis is on "the need to have sufficient confidence to make effective use of whatever mathematical skill and understanding is possessed whether this be little or much" (paragraph 34, p.10). Moreover, Evans (1989) highlights that there are several remarkable features of Cockcroft's definition of numeracy. They are its special emphasis on "confidence, practicality and its critical potential" (Evans, 1989, p.204). Evans (2000a) illustrates these features as follows:

First, attitudes, as well as skills, are considered important: confidence and familiarity ('at-homeness') count, as well as competence. Second, the criterion for which skills are important is practical: namely, relevance to the context of the person's everyday life. Third, their notion of

numeracy includes the appreciation of numerical information, as well as the use of techniques, and this appreciation is implicitly critical (p.12).

Moss (1984) also agrees that numeracy is part of people`s everyday life. The author (1984) argues that each individual pursues his/her own self-interest, and thus people`s needs are various and also change over time. Changes in lifestyles may, accordingly, affect people`s daily routines, so that numeracy is something more than basic or everyday mathematics (Moss, 1984 in Withnall, 1995a). However, Steen (1990) points out the fact that “public emphasis on numeracy can too easily lead to specifications for minimum performance, which in turn lead to minimum accomplishment. Sometimes such campaigns feature a ‘back-to-basics’ approach which short-changes all students” (p.228). For this reason, Cockcroft (1982) argues that “our concern is that those who set out to make their pupils ‘numerate’ should pay attention to the wider aspects of numeracy and not be content merely to develop the skills of computation” (paragraph 39, p.11). It is, therefore, important to note that the view of numeracy in the Cockcroft Report (1982) is clearly “beyond learning the arithmetic operations (although it obviously does not exclude this learning) and, consequently, ... , does not fit at all well with any ‘back to basics’ movement in the teaching of numeracy” (Nunes&Bryant, 1996, p.3).

Furthermore, it is also important to note that the Cockcroft report came at a time when there was an urgent need to help ‘the bottom half’, a group which had traditionally been given a very raw deal. The report was unreservedly utilitarian, focusing on the practical mathematical demands of employment and adult life generally (Gardiner, 2004). This is also evident from Cockcroft (1982)`s “Foundation list of mathematical topics” which includes number, money, percentages, use of calculator, time, measurement, graphs and

pictorial representation, spatial concepts, ratio and proportion and statistical ideas (Cockcroft, paragraph 458, p.135-140). On the other hand, Willis (1990b) observes that the Foundation list is well-defined and consists of the mathematical knowledge that is necessary for everyone to manage real mathematical demands in everyday life, but:

It is not at all clear that mastery of the topics in the Cockcroft foundation list produces numerate people, and the Cockcroft Committee has not claimed that it does. Nor is it clear that people would be numerate to an extent commensurate with their acquisition of that mathematical content. What the list does not address is the contexts in which people are expected to act, and the processes and qualities that are necessary if one is to function mathematically in those contexts. Choosing and using mathematical ideas to understand, to explain and to solve is what numeracy is about, and it is involved at every level of mathematical sophistication (p.6-7).

Nonetheless, it is important to recognise that the Cockcroft's (1982) Report has been one of the most influential and wide ranging documents published in the field of mathematics education, and thereby its 'Foundation list of mathematical topics' provides the basis for the National Curriculum for Mathematics in schools and the Adult Numeracy Core Curriculum (BSA, 2001) (Coben et al., 2003). Cockcroft (1982), in particular, argues that the curriculum must be designed from the bottom up based on his 'Foundation list' in a sense that "school mathematics can be conceived in terms of a single curriculum 'ladder' up which all students climb, at different speeds and to different heights, with pragmatic 'numeracy-for-all' first, followed later by 'mathematics-for-those-who-insist'" (Gardiner, 2004, p.5). On reflection, it seems more accurate to say that the arguments presented here by Cockcroft (1982) suggest that:

The type of mathematics given to the children must be tailored to their capabilities. It is impossible to present abstract mathematics to all types of children and expect them to get something out of it. It is much more likely that half the class will ignore what is being said because the base on which the abstraction can be built does not exist. The mathematics must be matched to each individual and teaching a mixed ability class as an entity is therefore unprofitable (Hart, 1981, p.210).

2.3. THE POST-COCKCROFT PERIOD

Evans (2000a) argues that there was much interest in teaching mathematics in a functional way as well as the discussion of Cockcroft's ideas for classroom practices in the post-Cockcroft period, but these ideas of numeracy were gradually weakened by the early 1990s and the concept of numeracy seems to have been removed from having its main position in discourses of functional numeracy. As a result, the term numeracy has been reduced into use within the numerical skills proficiency conception of mathematics learning that forms the basis for the work of the Numeracy Task Force. The National Numeracy Task Force (1998a), in this sense, mainly shows concern for the mathematical abilities of school leavers and suggests that:

Numeracy means knowing about numbers and number operations. More than this, it requires an ability and inclination to solve numerical problems, including those involving money or measures. It also demands familiarity with the ways in which numerical information is gathered by counting and measuring, and is presented in graphs, charts and tables (DfEE, 1998a, p.6).

Similarly, Coben et al. (2003) assert that the term 'numeracy' has been regarded as an essential but lowly basic skill especially since 1999 in the United Kingdom in a way that

numeracy has come to refer to the mathematics at the lower end of the Mathematics National Curriculum. The attempt is basically to formulate the concept of numeracy by broadening its meaning beyond merely knowing about numbers and operations. Accordingly, the report of the working group chaired by Sir Claus Moser (DfEE, 1999) and subsequently the national strategy for improving literacy and numeracy skills in the UK (DfEE, 2001) use a broad definition of numeracy, which is expressed as “an ability ... to use mathematics at a level necessary to function at work and in society in general” (DfEE, 1999). However, as Hughes et al. (2000) argue, “a closer inspection of the key objectives and recommended examples provided by the Numeracy Framework suggests that the priority is very much on calculation skills and number knowledge at the expense of application” (p.113). It is not surprising then, for many, numeracy has a more limited definition around basic life skills as by the Adult Literacy and Basic Skills Unit (ALBSU, 1993a) in the numeracy standards for Numberpower. ALBSU (1993a), for example, defines four skill areas of numeracy as the ability to:

- handle cash or other financial transactions;
- use till, calculator or ready reckoner as necessary;
- keep records in numerical or graphical form;
- make and monitor schedules or budgets in order to plan the use of time or money;
- calculate lengths, areas, weights or volumes accurately using appropriate tools e.g., rulers, calculators, etc. (ALBSU, 1993a in Benn, 1997, p.68).

Moreover, Brown et al. (1998) discuss the level of numeracy definition used to underpin the National Numeracy Strategy (DfEE, 1998b, p.11) and describe it as “a culturally neutral and value-free set of autonomous ‘basic numerical skills’ (ALBSU, 1993b), emphasising mental and written calculations and knowledge of number facts such as

multiplication tables” (p.363). Brown et al. (1998) argue that although there is an attempt to broaden the concept of numeracy by making reference to a variety of contexts in the preamble, the following detailed bullet points get no closer to real life than “make sense of numerical problems” (Straker, 1997 in Noss, 1998, p.2). “‘Contexts’ refers only to the artificial contexts used in textbook ‘word-problems’” (Brown et al., 1998. p.363). Hence, as Neill (2001) contends, “this emphasis on computation and early number concepts alone tends to confuse numeracy with the number strand alone, or even more narrowly equates it with numeration” (p.2). In other words, “in a majority of schools over-concentration on the practice of basic skills in literacy and numeracy unrelated to a context in which they are needed means that those skills are insufficiently extended and applied” (Department of Education and Science, 1985, p.5).

This new formulation of numeracy has also been challenged by Noss (1997). He (1997) argues that the work of the Numeracy Task Force has led to the original concept of numeracy being drained of much of its vitality in favour of a relatively narrow, number-based conception. Noss (1997) links such narrowness with the Secretary of State for Education and Employment’s campaign for literacy and numeracy as noted in the White Paper Excellence in Schools: “the first task of the education service is to ensure that every child is taught to read, write and add up” (DfEE, 1997, p.9). Furthermore, Noss (1998) raises some critical questions concerning to narrow boundaries around the concept of numeracy:

What, if anything, has been lost by the gradual erosion of broader mathematical connections in favour of basic number skills? What effects have there been on our perception of mathematical attainment as a result, and whom has it affected? More generally, what is the theoretical and

practical rationale which has driven this narrowing of the idea of numeracy, and what are its potential effects for the mathematical knowledge of the citizens of the next millennium? (p.2)

Noss (1998) also lays particular stress on the danger of equating mathematics with numeracy. This has become more obvious when the National Numeracy Project's framework has, with a small number of changes, become the Framework for Teaching Mathematics: Reception to Year 6 (National Numeracy Project, 1998) (Brown et al., 1998). Finally, as Noss (1998) points out, we have already the difficult paradox which needs to be carefully examined:

Educationalists have been right to identify lack of mathematical confidence and alienation on the part of many. But in attempting to alleviate this problem, we have risked divorcing school mathematics from its broader roots in science and technology, and ultimately, cast a fundamental question-mark over its place in the curriculum. In trying to connect mathematics with what is learnable, we have disconnected school mathematics from what is genuinely useful (Noss, 1998, p.3).

2.4. SOME OTHER IMPORTANT APPROACHES TO THE CONCEPT OF NUMERACY

The view of numeracy developed in the adult basic education sector in Australia in 1990s often focused on making meaning of mathematics, and thus mathematics is generally seen as a tool to function effectively and critically in one's daily life (Tout, 2001). For example, Johnston (1994) argues that numeracy actually involves, or should involve, mathematics, that is to say:

To be numerate is more than being able to manipulate numbers, or even being able to succeed in school or university mathematics. Numeracy is a critical awareness which builds bridges between mathematics and the real world, with all its diversity. Being numerate also carries with it a responsibility, of reflecting that critical awareness in one's social practice. So being numerate is being able to situate, interpret, critique, use, and perhaps even create maths in context, taking into account all the mathematical as well as social and human messiness which comes with it. ... Unlike mathematics, numeracy does not pretend to be objective and value-free (Yasukawa and Johnston in Johnston, 1994, p.34).

Tout (2001) comments that this approach to numeracy is very different from the one being just about number skills. He (2001) maintains that “it is about using and understanding mathematics, and that means all of mathematics, not just number skills, to make sense of the real world, and using mathematics critically and being critical of mathematics itself” (p.33). Thus, it can be seen that numeracy is not only to use and apply mathematical skills efficiently and critically, but also is the ability to interpret textual representations or symbolic notations confidently as well as communicate about mathematical information and reasoning processes in practical everyday situations to enable full participation in a wide range of life roles (Gal et al., 2002). That is to say, “numeracy is the bridge that links mathematical knowledge, whether acquired via formal or informal learning, with functional and information-processing demands encountered in the real world” (Manly et al., 2000, p.79).

The following view of numeracy from the Australian Association of Mathematics Teachers' report titled 'Numeracy = everyone's business' (1997) also seems to represent the arguments put forward above. In this report, it is proposed that “to be numerate is to use mathematics effectively to meet the general demands of life at home, in paid work, and

for participation in community and civic life” (AAMT, 1997, p.15). Willis (1992) argues that:

This rather modest proposition is unlikely to meet with much disagreement. ... Nevertheless, to take it seriously would have dramatic consequences for the practice of mathematics education in a great many educational settings. It would suggest that numeracy is not about the acquisition of even a large number of decontextualised mathematical facts and procedures. ... It would suggest that numeracy is about practical knowledge where practical should not be confused with low level, ‘hands on’ or procedural knowledge. I am using the term ‘practical knowledge’ here to refer to knowledge which has its origins and/or importance in the physical or social world rather than in the conceptual field of mathematics itself (p.84).

Then, this is why AAMT (1997) also adds that the concept of numeracy forms “a fundamental component of learning, performance, discourse and critique across all areas of the curriculum” (p.15) in school education, which requires the following items to combine in context:

- Underpinning mathematical concepts and skills from across the discipline (numerical, spatial, graphical, statistical and algebraic);
- Mathematical thinking and strategies;
- General thinking skills; and
- Grounded appreciation of context (AAMT, 1997, p.15).

Moreover, Steen (1990) emphasises that strategies to improve numeracy will be ineffective if they fail to identify that arithmetical skills constitute only a small part of the mathematical power appropriate to today`s world. Thus, he (1990) argues that approaches

to numeracy must reflect different dimensions in which mathematical ideas operate. Steen (1990) then writes five different dimensions of numeracy as follows: ‘practical’ which is for quick use in the routine tasks of everyday life; ‘civic’ which is to understand certain mathematically based ideas and procedures that may emerge from major public policy issues; ‘professional’ which is to ensure fundamental analytical skills required for employment; ‘numeracy for leisure’ which is to appreciate puzzles, games of strategy, lotteries, and sport wagers; and ‘cultural’ which is as an intrinsic part of our cultural heritage by weaving the tapestry of civilization (Steen, 1990, p.217-221). Numeracy is, therefore, regarded as “contributing to the empowerment, effective functioning, economic status, and well being of citizens and their communities” (Gal, 2000, p. ix). To put it simply, numeracy is not only essential for survival but also for civilization.

In view of these arguments, it is clear that there has been a wide range of discussions and debates about numeracy in national and international reports and literature, but all these arguments collectively support the idea that numeracy is, on the whole, perceived as the use of mathematics to choose, interpret, apply and communicate mathematical knowledge and skills in order to cope with everyday issues so that it could assure critical, effective and full participation in real life situations (Department of Education and Early Childhood Development, 2009). In the final analysis, perhaps I should also point out the fact that “it is not necessarily just commonly encountered situations that require numerate behaviour, but also new situations” (Gal et al., 2002, p.15). Therefore, as Withnall (1995b) argues, being numerate requires:

the ability to combine both mathematical and communication skills as well as the development of confidence in using numbers appropriately and competently in a range of practical situations

as they occur in an individual's life. It further emphasises the ability to access, interpret and respond, sometimes critically, to mathematically-based information both in the immediate and in the wider environment. However, the nature of this information is continually changing or appearing in new forms and it is obviously also necessary to be aware of these changes (p.14).

This seems to confirm the idea that “numerate individuals are those who respond autonomously to situations in which mathematical ideas are embedded, actively using the power of mathematics rather than delegating or ignoring quantitative issues” (Gal et al., 2002, p.15). Finally, whilst recognising that currently the concept of numeracy is heavily contested, all of the above discussions point to the conclusion that:

Numeracy encompasses the knowledge and skills required to effectively manage mathematical demands in personal, societal and work situations, in combination with the ability to accommodate and adjust flexibly to new demands in a continuously rapidly changing society that is highly dominated by quantitative information and technology (van Groenestijn, 2002 in National Numeracy Review Report, 2008, p.4).

3. MATHEMATICS AND NUMERACY

It can be seen that mathematics is explicitly mentioned in most of the definitions of numeracy, because it is assumed that numeracy is so closely related to school mathematics in a sense that “numeracy is to mathematics as literacy is to language” (Benn, 1997, p.67). However, as Steen (2001a) points out, there are also important differences between mathematics and numeracy in that:

One conveys the power of abstraction, the other the power of practicality; one is organized by categories inherited from the past, the other focuses on the way knowledge is used in the information age; and one is encountered mostly in school, the other mostly in real life (p.13).

The same author (2001a) goes on to reveal that:

Mathematics is abstract and Platonic, offering absolute truths about relations among ideal objects. Numeracy is concrete and contextual, offering contingent solutions to problems about real situations. Whereas mathematics asks students to rise above context, [numeracy what he calls] quantitative literacy is anchored in the messy contexts of real life (p.12).

Similarly, Manaster (2001) argues that mathematical statements or assertions are connected with relationships among abstractions, whereas inferences of numeracy are mostly related to something real. Manaster (2001) continues to argue that proofs and reasoning in mathematics are of paramount importance. In addition to this, one of the most important characteristics of mathematics is to understand why assertions based on assumptions must be true. In contrast, numeracy necessarily draws on approximations and incomplete or sometimes inaccurate data to make inferences. In this way, numeracy and mathematics are distinguished from each other as each has a distinctive feature.

On the other hand, in approaching this issue one should also consider that “the relationship between numeracy and school mathematics is problematic not least because numeracy does not seem to be an automatic outcome for many after years of compulsory schooling” (O’Donoghue, 2003, p.2). O’Donoghue (2003) states that there is a general expectation that the school mathematics experience should deliver numerate individuals, but it usually fails to do so for a significant percentage of the school-going population. This failure partly

results from both a lack of clarity in the goals of mathematics education and a clear understanding of the meaning of numeracy. He (2003) also states that the tension between mathematics and numeracy in mathematics education needs to be acknowledged and the relationship should be clarified. Furthermore, O'Donoghue (2003) proposes that numeracy and mathematics are not interchangeable. He (2003) considers numeracy as involving some ideas and concepts of mathematics, rather than vice versa, that is:

Mathematics and numeracy are not congruent. Nor is numeracy an accidental or automatic by-product of mathematics education at any level. When the goal is numeracy some mathematics will be involved but mathematical skills alone do not constitute numeracy (p.4).

Moreover, Australian Association of Mathematics Teachers (AAMT) (1997) observes that numeracy is not a synonym for school mathematics, but they are highly interrelated in that all numeracy gains strength by school mathematics. In other words school mathematics plays an important role in the development of numeracy. Therefore, it is often assumed that “if you have got the mathematical skills then you are numerate-more or less regardless of whether you use the skills or not” (National Numeracy Review Report, 2008, p.6). However, again AAMT (1997) points out that “while knowledge of mathematics is necessary for numeracy, having that knowledge is not in itself sufficient to ensure that learners become numerate” (p.12). This seems to be difficult to accept, but there has been considerable research effort indicating that knowledge alone is hardly sufficient for problem solving or further learning:

Good thinkers and problem solvers differ from poorer ones not so much in the particular skills they possess as in their tendency to use them. ... [and] acquiring skills and strategies, no matter how good one became at them, would not make one into a competent ... problem solver or

thinker. The habit or disposition to use skills and strategies and knowledge of when they applied, needed to be developed as well (Resnick&Klopfer, 1989, p.6-7).

Thus, it is perhaps counterintuitive but the arguments presented above imply that more mathematics does not necessarily lead to increased numeracy (Steen, 2001b), because “it is not at all clear that numeracy can be achieved through the acquisition of skills and standard problem solutions” (Willis, 1990b, p.7). It is, therefore, not unreasonable to suggest that:

We want pupils to be numerate, not so they can carry out feats of mental arithmetic in school, but so they can confidently apply their knowledge of mathematics to a range of situations in their subsequent working and domestic lives. There is no point in teaching pupils to be ‘numerate’ if they cannot apply what they know (Hughes et al., 2000, p.119).

There is no doubt that this view is true, but arguably the most important point when considering this issue is that:

Connecting mathematics to authentic contexts demands delicate balance. On the one hand, contextual details camouflage broad patterns that are the essence of mathematics; on the other hand, these same details offer associations that are critically important for many students` long term learning (The Quantitative Literacy Design Team, 2001, p.5).

Furthermore, the Quantitative Literacy Design Team (2001) argues that “unlike mathematics, ... , numeracy is often anchored in data derived from and attached to the empirical world. Surprisingly to some, this inextricable link to reality makes quantitative reasoning every bit as challenging and rigorous as mathematical reasoning” (p.5). In support of this view, a number of explanations have been offered by Steen (2001b):

Numeracy is not so much about understanding abstract concepts as about applying elementary tools in sophisticated settings ... [but] this is no simple feat. Numeracy takes years of study and experience to achieve. Thus numeracy and mathematics should be complementary aspects of the school curriculum. Both are necessary for life and work, and each strengthens the other. But they are not the same subject (p.108).

With this in mind, it would also be interesting to see another argument from Betty Johnston (1994), whose notion of numeracy is not simply equivalent to mathematics, that is, “just as to be literate is to have a capacity for dealing with language in some way, so to be numerate could be seen as having capacity for dealing with mathematics in some way” (Johnston, 1994, p.32). Johnston (1994) proposes that there are five strands of meaning-making in mathematics.

- **Meaning through ritual**, a minimal strand where meaning is acquired through rote-learning of atomised content;
- **Meaning through conceptual engagement**, where mathematical meaning is constructed through problem-solving, process, and cognitive dissonance;
- **Meaning through use**, where meaning is developed through use in everyday contexts;
- **Meaning through historical and cultural understanding**, where meaning is enhanced by an understanding of the genesis and cultural use of specific mathematics;
- **Meaning through critical engagement**, where meaning is generated by asking ‘in whose interest’ type questions and also questions about the appropriateness and limit of the maths model in the real situation (p.32).

So in general what is that supposed to mean about numeracy? Here is a further quote from her article, ‘Critical Numeracy’:

If we stay within Mathematics-academic maths, school maths-then we can learn it well or badly, we can learn by rote and reproduce as required, or we can find our way confidently around conceptual structures we have built. If we are lucky we can weave together these first two strands, to make meaningful Mathematics.

If we step outside Mathematics however, we can establish wider meaning by making connections to the real world-through use in daily contexts, through understanding cultural and historical origins, through asking questions about the consequences of our and others` use of Mathematics. We can weave together all five strands of meaning to make, not Maths, but what we will call numeracy (p.34).

Therefore, as Tout (2001) argues, it is important that numeracy is not downgrading or inferior to mathematics. More importantly, numeracy is a social activity because it concerns about making meaning in mathematics and being critical about mathematics. And this is why Tout (2001) says that numeracy is not less than mathematics, but more. A following quotation from Gal (1997) also seems an appropriate way to reinforce this point:

Being numerate is much more than knowing mathematics, and numeracy is not the same as mathematics. ... Most mathematics problems that students work on are contrived or are presented out of context. In contrast, real-life numeracy situations are always embedded in a context that has some personal meaning to the people involved (p.39).

Thus, it appears that “numeracy should not be equated with less mathematics but more in terms of sense making, application and decision making” (O’Donoghue 2002, p.50). However, we cannot ignore the fact that mathematics is part of what constitutes numeracy. In other words, as Coben (2000a) argues:

To be numerate means to be competent, confident, and comfortable with one's judgements on *whether* to use mathematics in a particular situation and if so, *what* mathematics to use, *how* to do it, what *degree of accuracy* is appropriate, and *what* the answer means in relation to the context (p.35).

Accordingly, numeracy must be underpinned by mathematical knowledge of an appropriate kind (Coben et al., 2003). It then follows that “truly, today's students need both mathematics and numeracy” (Steen, 2001a, p.12). It is, however, quite true that the questions like “How is numeracy different from school mathematics? How does one promote numeracy within the school mathematics context? What is the role of context and life experience in school mathematics and numeracy?” (O'Donoghue, 2003, p.3) are obviously difficult and there are also no standard answers to them. In this regard, Boaler (1998) compared the learning of mathematics in two schools where mathematics was taught in completely different ways. One had a content-based mathematical approach and the other a process-based mathematical approach. Students in the content-based mathematical environment “held a view that mathematics was all about memorizing a vast number of rules, formulas, and equations, and this view appeared to influence their mathematical behaviour” (Boaler, 1998, p.46). On the other hand, students in the process-based mathematical environment were “encouraged to develop their own ideas, formulate and extend problems, and use their mathematics” (ibid, p.49). In other words, the approach in this environment was “based on the philosophy that students should encounter a need to use mathematics in situations that were realistic and meaningful to them” (ibid, p.49). Evaluations of the students indicated that the students using the process-based approach commented “on the interest of their lessons and their enjoyment of open-ended work”, whereas the students using the content-based approach “were more concerned about a lack of understanding and their dislike of textbooks” (ibid, p.52). Despite being “highly

motivated and hard working”, many of the students in the content-based approach “found mathematics lessons tedious and boring” (ibid, p.49). The results of this study, in general, demonstrate that “even when students learn a mathematical procedure in school, if the practices that support the procedure are particular to the mathematics classroom, they will find it difficult adapting the procedure they have learned to any other situation” (Boaler, 2000a, p.392). As a consequence, as shown in Boaler`s (1998, 2000a, 2000b) studies, it is suggested that:

It is not enough to learn mathematical concepts, even when they have a chance to construct their mathematical understanding. They also need opportunities to use their mathematics, adapt and change methods, and to discuss and negotiate with other students. The environments in the classrooms at process-based school were closer to the real world and so students generally were more able and willing to use school-learned methods than students from environments that were more procedural and school bound (Kemp, 2005, p.62-63).

4. LEVELS OF NUMERACY AMONG PEOPLE

In the previous sections, I have tried to find a meaning for numeracy and its relationship with mathematics. I would now like to discuss the levels of numeracy among people as it is often argued that low levels of numeracy have an enormous impact on adults` lives as well as their country`s economy (Evans, 1989; Benn, 1997; Bynner&Parsons, 1997). The evidence about the levels of adults` numerical abilities in the United Kingdom comes from several studies. The first major study about adult numeracy levels is the Gallup survey submitted to the Cockcroft enquiry into the teaching of mathematics in schools. It was carried out by the Advisory Council for Adult and Continuing Education (ACACE) in February 1981 and based on a sample of almost 2,900 adults. This survey found that

questions on simple operations such as addition, subtraction, multiplication and division were answered correctly between 64 and 88 percent of the time, but the questions on railway timetables and understanding inflation were answered correctly less than 60 percent of the time. The level of performance was analysed by gender, age, social class and the terminal education age. However, the question on the rate of inflation was more widely misunderstood with many participants. They answered this question by thinking that a decrease in the inflation rate necessitated a decline in the general level of prices, but did not. This particular incorrect answer reveals that there exists not only confusion between the level of inflation and the price rises, but also despair that their expectations are not satisfied (Evans, 1989).

Moreover, in January 1997, the study carried out by Bynner and Parsons (1997) aims to demonstrate that poor numeracy skills would have a major impact on adult life. In their study, *Does Numeracy Matter?*, data were obtained from the National Child Development Study (NCDS). This was national longitudinal enquiry involving more than 17,000 people born in a single week in 1958, and “information was collected from the whole sample of cohort members at birth, 7, 11 and 16, using a variety of sources” (Bynner&Parsons, 1997, p.4). Cohort members, at age 37, in the 10 percent sample were interviewed. They also sat on functional literacy and numeracy skills assessments. The authors (1997) found that:

People without numeracy skills suffered worse disadvantage in employment than those with poor literacy skills alone. They left school early, frequently without qualifications, and had more difficulty in getting and maintaining full-time employment. The jobs entered were generally low grade with limited training opportunities and poor pay and prospects. Women with numeracy difficulties appeared especially vulnerable to exclusion from the clerical and

sales jobs to which they aspired. Men`s problems were less clearly differentiated between occupations (Bynner&Parsons, 1997, p.27).

As noted in the section on ‘Defining Numeracy’ of this paper, another major report on adult literacy and numeracy was published by the Working Group chaired by Sir Claus Moser on 26th February 1999 and publication of the report heralded a new era for adult numeracy in the UK. The Moser Report, *Improving Literacy and Numeracy: A Fresh Start* (DfEE, 1999) bluntly concludes that:

1.4 The situation for numeracy is both worse and more confusing because the tests are weaker and the evidence is controversial. Estimates of the percentage of adults having some numeracy problems range from 30% to 50%. We regard 40% as a reasonable figure to have in mind in this report. But we also adopt a division often used (even if arbitrary) between ‘low’ and ‘very low’ numeracy, the latter category being those with very severe difficulties. On this basis something like one in five adults have very low numeracy. The following are survey findings about numeracy:

- one in three adults in this country cannot calculate the area of a room that is 21 by 14 feet, even with the aid of a calculator;
- one in four adults cannot calculate the change they should get out of £2 when they buy the goods displayed in Figure B.

1.5 What is clear from research is that very limited numeracy can be as serious as poor literacy for the individual, in certain jobs and indeed for the economy (DfEE, 1999).

However, Coben et al. (2000) argue that such studies are always open to dispute in terms of process, sample and structure and type of questions. Another fundamental problem is that there is no general agreement yet on the meaning of numeracy, as it is subject to deep

definitional ambiguity (Evans, 1989; Withnall, 1995a; Coben et al., 2003). That is, real meaning of numeracy depends on the users (Foyster, 1990). In other words, numerate behaviour includes a mixture of mathematical and contextual knowledge, so that numerate behaviour is context specific and that people are more or less numerate with respect to particular activities rather than they seem to be from tests of their numerical skills. Therefore, it has been proposed that instead of asking how many people are innumerate we need to ask in what contexts they are innumerate (Kemp&Hogan, 2000). Nonetheless, as Benn (1997) points out, it cannot be denied that, these types of studies, taken together, raise serious questions over numeracy levels of the adult population in the UK.

4.1. INNUMERACY

As the above studies indicate, there seems to be a serious and persistent problem of innumeracy amongst adults. Castle (1992) argues that innumeracy is more prevalent among people of all ages and in all socio economic groups than illiteracy. Similarly, Steen (1990) has raised concerns that “for each person who never learned to read, there must be a hundred who boast that they were never any good at math. That imbalance is especially troublesome in an age of data and measurement, of computers and statistics” (p.228). In support of their view, Benn (1997) points out that numeracy problems and low levels of mathematical qualifications are widespread at all levels of society. Even those with higher levels of education are susceptible. The evidence of low levels of numeracy is quite obvious in the case of the research test given to about 200 students in the Netherlands. One of the problems of this test had involved a newspaper clipping, which is the following:

The Netherlands has about 14 million inhabitants, against the more than three billions of the US, which is 200 times as many. The area of the Netherlands is roughly 40,000 square metres, against the 33,000 square kilometres of the US, which is a thousand times as much (Treffers, 1991, p.335).

These students were asked to comment on the clipping given above. The results of the research showed that:

5% of all of them rightly objected that the ‘thousand times’ must be wrong and should be replaced with a million, though by no means did they question that million. 10% rightly argued that the area must be wrong. The Netherlands as large as a sports park of 200 by 200 metres? And on the same scale the US a rectangle of 200 by 150 kilometres? A few noticed that on the strength of these data the density of the population of the Netherlands would be rather high: 400 people per square metre. And one student compared the data on the US population with an estimated world population of no more than 5 billion. But the great majority of the students agreed with the calculations or at most objected against the lack of precision in such formulations as ‘two hundred times as much’ and ‘a thousand times as much’ (Treffers, 1991, p.335).

Treffers (1991) argues that this research test has revealed significant results about the arithmetic abilities of the students. Obviously, the scores on the clipping problem are very poor. “But in fact, it is much worse. The 200 subjects tested were not primary school children but-keep to your chair!-first year`s students of teacher training colleges, which means future primary school teachers!” (Treffers, 1991, p.335).

Given these facts, we could say that there has been growing concern about the extent of low levels of numeracy (Coben et al., 2003). Mathematician John Allen Paulos (1988) coined the term “innumeracy” to refer to an inability to estimate accurately as well as an inability to cope comfortably with probability and statistical concepts. Paulos` (1988) first example in his famous book, *Innumeracy: Mathematical Illiteracy and Its Consequences*, runs as follows: The TV weathercaster announced that there was a rainy Saturday a 50 percent chance and a rainy Sunday another 50 percent chance, and then concluded that there was a 100 percent chance for a rainy weekend. Even though he explained the mistake, nobody in Paulos` company protested. He (1988) then notes that “in fact, unlike other failings which are hidden, mathematical illiteracy is often flaunted: ‘I can’t even balance my check book.’ ‘I’m a people person, not a number person.’ Or ‘I always hated math.’” (p.4). According to Paulos (1988), in the present case, the example of mathematical illiteracy is the inability to argue on probabilities. Paulos (1988) alerts the international community to the consequences of innumeracy pointing to a potentially serious problem, as societies are more and more inclined to use mathematical models for problem solving. Hence, Paulos (1988) convincingly argues that:

In an increasingly complex world full of senseless coincidence, what is required in many situations is not more facts—we are inundated already—but a better command of known facts, and for this a course in probability is invaluable. Statistical tests and confidence intervals, the difference between cause and correlation, conditional probability, independence, and the multiplication principle, the art of estimating and the design of experiments, the notion of expected value and of a probability distribution, as well as the most common examples and counter-examples of all of the above, should be much more widely known. Probability, like logic, is not just for the mathematicians anymore. It permeates our lives (p.134).

Finally, it is not surprising to find that we live in a world in which mathematical and statistical knowledge are growing and expanding at a formidable rate over the years and they are embedded deeply and subtly in the world around us (Benn, 1997). It is also not surprising then, that “the mathematical requirements of different groups are varied but insufficient levels of mathematics for the individual’s needs can have major detrimental effects on life chances and participation in society” (Benn, 1997, p.73). Thus, given its pervasive nature, innumeracy may have serious consequences not only for an individual but also for society.

4.2. CONSEQUENCES OF INNUMERACY FOR AN INDIVIDUAL

4.2.1. Restrictions on Access to Further Education

It is argued that the effects of innumeracy on individuals are serious. For example, as Benn (1997) illustrates, there may be some restrictions on their freedom of access to further education because of mathematical entry requirements. Besides, “because of the sequential nature of mathematical knowledge, innumeracy inherited from early years becomes an insurmountable obstacle to subsequent study of any mathematics-related field” (Steen, 1990, p.226). This is very evident in a California sociologist Lucy Sells` survey in 1972. In her survey of educational and vocational opportunities for American woman, she lays particular stress on how school mathematics and its sacred position as the gatekeeper may limit access to further education:

Without four years of high school math, students at Berkeley were ineligible for the calculus sequence, unlikely to attempt chemistry or physics, and inadequately prepared for intermediate

statistics and economics. Since they could not take the entry-level courses in these fields, 92 percent of the females would be excluded from ten out of twelve colleges at Berkeley and twenty-two out of forty-four majors (reported in Tobias, 1978, p.13).

In addition to limiting access to further education, innumeracy may have a negative impact on people in education or training to complete their studies successfully, because they are supposed to “use the necessary skills, including numeracy skills, at a high level, to think critically about the material presented and to be able to present convincing and logical arguments of their own” (Kemp, 1995, p.377) such as “interpreting and writing scientific and psychological reports, interpreting tables in sociology, understanding the nature of population growth in environmental science and using timelines in history” (Kemp&Hogan, 2000, p.9). In fact, this can be summed as follows: On the one hand, it is difficult to escape from the conclusion that numeracy skills of people have important influences on the success and the effective participation in education, but on the other hand it is unfortunate that:

Despite years of study and life experience in an environment immersed in data, many educated adults remain functionally innumerate. Most students leave high school with quantitative skills far below what they need to live well in today`s society; businesses lament the lack of technical and quantitative skills of prospective employees; and virtually every college finds that many students need remedial mathematics (The Quantitative Literacy Design Team, 2001, p.1-2).

4.2.2. Restrictions on Access to Employment

It can also be argued that access to jobs, rewards of income, promotion and careers may also be restricted by low levels of numeracy, because mathematical skills and

qualifications are not only demanded as an essential element for numerous jobs but also have an important impact on people`s employment prospects (Benn, 1997). In this regard, Benn (1997) argues that the individuals lacking in numeracy skills, in general, tend to avoid any career, job or training which seems to involve mathematics. Her position is supported by Bynner et al. (2000):

Poor numeracy skills are a major disadvantage for adults, particularly in the ever more demanding world of work. Surveys have shown that both men and women lacking numeracy skills are more likely in their early careers to be out of the labour market, or engaged in low-grade work in unskilled manual jobs without training (p.26).

It is, therefore, important to note that there exists a clear requirement for the use of mathematics in employment. Another argument in support of the above view is in the influential report of the Cockcroft Committee (1982):

Many jobs require the employee to make explicit use of mathematics-for instance, to measure, to calculate dimensions from a drawing, to work out costs and discounts. In these cases, the job cannot be carried out without recourse to the necessary mathematics (paragraph 65, p.18).

The link between mathematics and vocational opportunities had also been studied by Lucy Sells (1978). She is cited as arguing that:

Knowledge of algebra and geometry divides the unskilled and clerical jobs from the better-paying, upwardly mobile positions available to high school graduates. ... mastery of high school algebra alone will enable a high school graduate to do so much better on a civil service or industrial entrance exam that he or she could immediately start working at a higher level and be

earmarked for on-the-job training as well. Just one more year of high school math could make the difference between a starting salary of \$8,000 and one of \$11,000 (Sells, 1978 in Tobias, 1978, p.26).

Furthermore, it would be interesting to see Harris` work in this context. She (1991) has investigated the mathematical activities which people exhibit in a variety of workplaces by carefully studying what types of problems they actually solve in their working life. Harris (1991) has found that there exists a wide range of aspects of mathematics underlying many activities, even though people who use mathematics with confidence remain convinced that they cannot do it, that is to say:

Mathematics is seen as something different from practical daily arithmetic, although paradoxically, in daily conversation when the word ‘mathematics’ is used, people usually start talking about arithmetic. When some arithmetic is needed in a workplace and where it causes no problems, it is perceived as just common sense (Harris, 2000, p.171).

It is thus argued that people are unaware that they are engaging in mathematical activities in their work. The term ‘common sense’ is here known as ‘invisible mathematics’ which is the mathematics one can do but which one does not think of as mathematics (Coben, 2000b). Noss (2002) puts it quite simply, “mathematics is not always visible: it lies beneath the surface of practices and cultures” (p.35). Or, in Kanes` terms, it is “useable-numeracy” rather than “visible-numeracy” (Kanes, 2002, p.2-3), that is, “numeracy is the knowledge defined by its use in dealing with tasks and problems occurring in everyday situations and the workplace” (Kanes, 2002, p.3). Moreover, Hoyles, Noss and Pozzi (1999) observe that “as the mathematical structures which underpin many professional practices become less visible within various technologies, it becomes more necessary (and

more difficult) to study the complex ways in which mathematics enters into the picture” (p.48). For example, the research for the Science, Technology and Mathematics Council by a team from the London Institute of Education has shown that “mathematical skills in the workplace are changing, with increasing numbers of people involved in mathematics-related work, and with such work involving increasingly sophisticated mathematical activities” (Hoyles et al., 2002, p.6). Similarly, Noss (1997) argues that sophisticated mathematical skills are required for controlling inputs, identifying erroneous processes or defective products, deciphering mathematics related messages, estimating expected results, exercising quality control, using technological instruments and so on. Noss (1997) further argues that although there is less emphasis on precise completion of computations in one’s head or with paper and pencil which can be carried out by computers more effectively, there is more emphasis on an ability to think in a mathematical way. A parallel argument can also be found in the research study for the Science, Technology and Mathematics Council:

We noted a trend in the case studies for workers at all levels of organisations being required to possess an appropriate level of mathematical literacy. This is partly because of the need to delegate to individuals responsibility for monitoring workplace activity in relation to business goals, but also the need to communicate mathematically-expressed decisions and judgements to others (Hoyles et al., 2002, p.12).

Overall, all these findings have provided indications that necessary mathematical skills and knowledge are often among the prerequisites needed in a variety of workplaces. It is thus a commonly held view that poor numeracy reduces employment opportunities, but of course it would be wrong to conclude that everybody lacking necessary numeracy skills is going

to have employment difficulties (Bynner et al., 2000). Perhaps we can more confidently conclude that:

Those with numeracy problems are going to feel the squeeze most when the economy contracts. And as the nature of employment changes, these are the workers who are going to have to struggle hardest to obtain and hold on to jobs, and to advance their positions in them. In order to ‘level the playing field’, the numeracy skills of this target group clearly needed to be raised (Bynner et al., 2000, p.43).

4.2.3. Low Level Confidence in Constructive Skills and Critical Insights

In his book, *200% of Nothing*, Dewdney (1993) takes the arguments noted above a stage further by showing how politicians, advertisers, stockbrokers, salespersons, special interest groups and just about anybody who makes use of numbers, charts and graphs can manipulate individuals by playing upon their innumeracy. Dewdney (1993) focuses on abuses in that “math abuse exploits innumeracy by twisting logic and distorting numbers” (p.2). In this way, some people easily become victims of deception of those he (1993) calls ‘maths abuser’. In other words, lack of ability to understand the rules of percentages, averages, fractions, ratios, statistics and basic mathematical ideas can have immediate and real cost for such people such as money, property and freedom of choice.

As Withnall (1995b) illustrates, an example where there is a clear lack of appreciation of mathematical rules as well as necessary critical thinking skills comes from the excitement which greeted Britain’s National Lottery in November 1994:

Although the media must bear some responsibility for the hype which surrounded the first draw, few punters appear to have been discouraged by the news that the chance of scooping a 2 million jackpot with a solitary 1 ticket was one in 13, 983, 816. There also appeared a proliferation of advice on strategies for maximising winnings, none of which in reality, of course, could overcome the enormous odds against winning a fortune (Withnall, 1995b, p.10).

A similar view is also taken by Evans (1989) writing about ideological consequences of innumeracy at the individual level, but Evans (1989) prefers to talk about low levels of numeracy instead of innumeracy in a sense that “innumeracy may be an inappropriate term since it is unlikely that there are many people in industrialised societies who, having received at least a primary education, are completely unable to cope with very simple arithmetical operations” (Withnall, 1995a, p.14). Evans (1989) discusses that lack of both competence and confidence in constructive skills and critical insights can lead people to become dependent on the views of the professionals or experts and leave them open and susceptible to the mathematical mystique. Evans (1989) continues to discuss this dependency and ascribes it to the fact that “people lurch between two traps: uncritical acceptance of claims made, and an equally uncritical rejection, based not on a consideration of the evidence, but on prejudice or the unexamined authority or experts” (Evans, 1989, p.213).

In the same context, Ernest (2001) argues that people need to view the world through mathematical eyes and use it in their lives to empower themselves both personally and as citizens, because the use of mathematics in modern life has been growing too rapidly in a way that almost all activities in human life are controlled numerically. He (2001) goes further by revealing that a wide range of issues in modern society are regulated by hidden mathematical systems. Therefore, the ability to understand the rules of mathematics allows

people not to rely on others in situations in which personal decisions would be based on the issues like stock markets, voting, tax and welfare benefits, agricultural and educational subsidies, etc. As a consequence, as Ernest (2001) persuasively argues, it seems hard to deny that:

Much of our experience of life is already mathematised. Unless schooling helps learners to develop the knowledge and understanding to identify these mathematisations of our world, and the confidence to question and critique them, they cannot be in full control of their own lives, nor can they become properly informed and participating citizens. Instead they may be manipulated by commercial, political or religious interest groups, or become cynical and irrational in their attitudes to social, political, medical and scientific issues (Ernest, 2001, p.288).

4.3. CONSEQUENCES OF INNUMERACY FOR SOCIETY

There are also social consequences of inadequate levels of numeracy. Evans (1989) emphasises that these consequences lead to production loss in terms of both quantity and quality, less efficient use of resources, production of inaccurate or redundant information, and threats to life. The following examples from the Government Statisticians` Collective (1979) may be taken as typical consequences of low levels of numeracy:

One example was when, following the accidental omission of a zero by an Olivetti employee reporting the firm`s exports, ... generated a phoney balance of payments crisis. Another was when the trade figures went haywire over a period of many months because a clerk at one point copied two lines of figures onto a coding sheet in the wrong order. ... A major error in Home

Office migration figures resulted from accidentally counting the same set movements twice (p.144).

After identifying serious errors due to simple arithmetic mistakes, the authors point out that: “serious errors would certainly occur less often if staff had the ability to recognize figures as implausible and the initiative then to get them sorted out” (Government Statisticians` Collective, 1979, p.144).

Moreover, the report jointly produced by HM Treasury, the DTI, the DfES and the DWP set out “the importance of skills to the economy in raising productivity, and in reducing income and social disparities across society” (HM Treasury, 2004, p.5). In this report, the social and economic problems are associated particularly with a significant number of people in the UK lacking basic skills such as literacy and numeracy, that is:

In the long run, the prosperity of an economy depends upon how productive it is. In turn, productivity depends in part upon the skills of the workforce, known as human capital. Human capital can affect productivity both directly, by improving labour productivity, and indirectly, by facilitating innovation and investment. The UK is less productive than some other countries and its relatively poor skills explain part of the gap (ibid, p.2).

Thus, “there are productivity benefits to the economy and wider benefits to society as a whole from higher skills” (ibid, p.27). That is to say, “skilled workers will be better placed to adapt to the new business and production techniques that technological change will bring (ibid, p.17), thereby ensuring “a stable, prosperous economy characterised by full employment” (ibid, p.51). Besides, “improvements in skills allow individuals to move into better-paid employment ... and increasingly provide the security of employability” (ibid,

p.51). This points to the fact that, “while there are still likely to be jobs in the future that do not require a high level of skills, those with low skills are more likely to find themselves left behind as the economy changes” (ibid, p.18). Therefore, as HM Treasury (2004) reports, it is important to recognise that:

While the skills profile in England has improved in recent years, economies worldwide are also becoming more skilled, and England is starting from a relatively low base. Even meeting the 2010 PSA target to improve the number of workers with level 2 skills, England is likely to lag behind the best performing countries internationally on its stock of low-skilled adults. So, while focusing on current ambitions is important, it is also necessary to remember that these may just be the first step towards long-term change. If the country is to meet the global challenges of international competition, accelerating technological change and changing patterns of consumer demand, then not only will every adult need to be equipped with a basic level of skills, but every adult will need to constantly improve and update their skills throughout their working lives (p.33).

4.4. SOME EXPLANATIONS FOR LOW LEVELS OF NUMERACY

4.4.1. School Mathematics and Numeracy

I have argued that the development of people`s numeracy is very important even essential if they are to function effectively in all areas of modern life. Otherwise, there are some potential consequences of poor numeracy such as limiting access to further education, reducing employment opportunities and career progress, ineffective participation in society and so on. It is for this reason that there are continuing demands that we must raise the levels of numeracy in our society. With this in mind, Willis (1992), at the same time,

argues that “numeracy is about using mathematics. Any scale purporting to describe the competencies involved at various levels of numeracy should, therefore, in some way describe levels of use of mathematics” (Willis, 1992, p.85). However, again the same author (1992) argues that the irony of this is that:

While the present call for higher levels of numeracy is based on assumptions about the intrinsic usefulness of mathematics, narrowly traditional ways of defining the subject and success within it, an implicit acceptance of the ‘naturalness’ of the mathematical meritocracy, and the use of mathematics as a filter prevent any real change (p.93).

Moreover, as a major outcome of school mathematics, it is argued that “... students must appreciate that with mathematical knowledge and understanding they acquire desirable power. For they must learn that mathematics can help in the solution of their problems and in their own decision making” (Howson&Wilson, 1986, p.22). In reality, there is no question of the importance of mathematics as providing the desirable power for the students to deal effectively with their problems, because it is mathematics that is powerful and crucial for future citizens (Hoyles&Noss, 2000). However, we simply cannot ignore the fact that “much of the power of school mathematics resides not in the mathematics but in the myth of mathematics, in the meritocratic prestige of mathematics as an intellectual discipline” (Willis, 1990b, p.17).

It is also argued that numeracy is interdisciplinary in a sense that it is involved in different learning contexts in school. However, mathematical concepts are not always easy to understand as such because they are presented as ideas, not as numbers (Nunes et al., 1996). In this context, Chapman et al. (1990) note that “there are important numeracy skills involved in making sense of information across a range of apparently non-mathematical

fields” (p.114). They (1990) demonstrate that concepts used in geography and social studies involve mathematical ideas, but students remain unaware of this. For instance, the terms like ‘inflation’, ‘mortality/fertility’, ‘enlargement/dilation’ and ‘speed/velocity/acceleration’ are the expressions which are frequently found in text, and involve the idea of ratio, a general mathematical concept which is not obviously recognised in the context of other disciplines. Clearly, these terms require mathematical skills and, actually, students may well have the necessary skills, but few students realize that they will need to use mathematical understanding to make sense of subject specific matters. It is unlikely that they will deploy this understanding unless they are told explicitly to do so. Even for a numerate person, this is not always a conscious process (Chapman et al., 1990). Moreover, the Quantitative Literacy Design Team (2001) observes that the problem of a disconnection of school mathematics from meaningful contexts is particularly acute and one of the major impediments to numeracy in today’s schools. Unfortunately, many students suffer from this disconnection in that it leads to “a stunning absence of common number sense” (p.6). Furthermore, the members of the Design Team (2001) propose that:

To be useful for the student, numeracy needs to be learned and used in multiple contexts-in history and geography, in economics and biology, in agriculture and culinary arts. Numeracy is not just one among many subjects but an integral part of all subjects (p.6).

However, “traditional school mathematics curricula do not deal uniformly with all aspects of numeracy” (Steen, 1990, p.221). Regrettably, the truth of the matter is that “school mathematics is simultaneously society’s main provider of numeracy and its principle source of innumeracy” (Steen, 1990, p.222) as its large emphasis on “computation, rules, and procedures, at the expense of depth of understanding, is disadvantageous to students, primarily because it encourages learning that is inflexible, school-bound, and of limited

use” (Boaler, 1998, p.60). Consequently, this leads us the same conclusion reached by Boaler (2000b) who reveals that students reported that:

They did not even attempt to make use of school-learned methods in the real world, not because of the form or structure of the mathematical problems they encountered ... but because the environments of the classroom and their everyday lives were too disparate. The students believed that adopting classroom practices in the real world was inappropriate, so they did not attempt to draw upon school mathematics (p.114-115).

4.4.2. Mathematics Performance and Affective Factors

It is important that students need to learn to make better use of the mathematical skills that they already have (Chapman et al., 1990). In this way, as noted in the previous section, “... one of the most important things that students can gain from school mathematics is the attitude that mathematics really can help” (Chapman et al., 1990, p.114) as this forms the essence of informed numeracy (Willis, 1990b).

However, Hind (1993) argues that, for most of the adults, memories of school mathematics are sadly memories of failures in a sense that their problems with mathematics originate in the school classrooms. It seems to start when the teacher fails to communicate effectively. The learner then fails to understand what is being taught. At the same time, the learner’s embarrassment prevents him/her from asking for any clarification. Therefore, lack of understanding is never remedied. Accordingly, it leads to further misunderstandings and undermining confidence due to the hierarchical structure in which mathematics is taught. On the other hand, mathematical qualifications are basically needed to access to further education or employment. This automatically produces pressure on the learner. Later on,

this pressure may turn into feelings of anxiety and anger. Hence, the learner deals with such pressure by showing no interest or understanding of mathematics (Hind, 1993 in Benn, 1997). For example, the following quote from a series of reflection on schooldays by Margaret Drabble, a famous British author, well illustrates the view put forward above:

I dropped mathematics at 12, through some freak in the syllabus ... I cannot deny that I dropped maths with a sigh of relief, for I had always loathed it, always felt uncomprehending even while getting tolerable marks, didn't like subjects I wasn't good at, and had no notion of this subject's appeal or significance.

The reason, I imagine, was that, like most girls I had been badly taught from the beginning: I am not really as innumerate as I pretend, and suspect there is little wrong with the basic equipment but I shall never know.

... And that effectively, though I did not appreciate it at the time, closed most careers and half of the culture to me forever (The Guardian, 5 August 1975 in Evans, 1989, p.204).

Benn (1997) observes that the majority of adults who dislike mathematics have probably had a traumatic school experience with it. Thus, if a real life problem is thought to involve mathematics then it is simply avoided and rather than perform school mathematics various alternative strategies are employed. Moreover, Benn (1997) indicates that this avoidance and dislike of mathematics can automatically move into the realms of phobia. Furthermore, in a research study carried out by Sewell (1981) for the Cockcroft Inquiry "to provide evidence and information on the mathematical needs of adults in daily life" (Sewell, 1981, p.1), it was shown that negative feelings about mathematics ranging from a lack of confidence to anxiety discouraged members of her sample. The findings of Sewell's study are so important that the Cockcroft Committee (1982) frames their recommendations to a great extent to address adults' negative attitudes towards mathematics. For example,

Cockcroft (1982) reports that the results of this study suggest that there are many people who are not able to deal confidently and competently with many everyday life situations which force them to effectively use mathematics. That is:

The estimates which those who were interviewed gave of their own mathematical competence did not relate closely to the extent to which they made use of mathematics. There were some who said that they managed very well but who appeared to avoid numbers and others who, although apparently highly competent in the conduct of their everyday affairs, were very hesitant about claiming mathematical skill. There were also some who, while apparently able to perform adequately in the situations which they normally encountered, admitted that they were working at the limit of their mathematical competence and were anxious lest anything more complicated should be required of them (Cockcroft, 1982, paragraph 20, p.7).

This inability to think calmly and confidently whenever faced with the mathematical tasks was also studied by Ashcraft and Kirk (2001). They (2001) found that “math anxiety disrupts the on-going, task-relevant activities of working memory, slowing down performance and degrading its accuracy” (Ashcraft&Kirk, 2001, p.236). Indeed, Noss (1991) acknowledges that many people are motivated to learn mathematics in order not only to help themselves cope with life but also to enable themselves to make sense of their life, but “mathematics, at least the mathematics of the school classroom, is typically seen as hard-edged, as a subject in which meaningless problems are posed at best about real but material objects but often about unreal and meaningless objects” (Noss, 1991, p.81-82) Moreover, Hilton (1980) argues that the features of the curriculum experienced by many people are most conducive to the spread of mathematics anxiety and avoidance. He (1980) specifies these features, “taken principally but not exclusively from the elementary curriculum” (p.181), as ‘rote calculations’, ‘memory dependence’, ‘unmotivated

problems', 'spurious applications', 'tests and authoritarianism'. These are all very real factors that inhibit the learning of mathematics in school. Therefore, as in the example quoted from a series of reflection on schooldays by Margaret Drabble, "most people leave school as failures at math, or at least feeling like failures. Some students are not even given a chance to fail" (Tobias, 1978, p.26). In consequence, as Gagne (1983) highlights, "it has been true over a long period of time that some people do not do well in mathematics and that some people end up not liking mathematics" (Gagne, 1983, p.10). However, what is really surprising, and even equally worrisome, is that it seems likely that at the present time many students "have difficulties retrieving [even] basic arithmetic facts from long-term memory, and these difficulties often persist despite intensive instruction on basic facts" (Geary, 2004, p.5).

5. NUMERACY AS THE USE OF MATHEMATICS IN EVERYDAY LIFE

I argue that numeracy is about improving people`s use of mathematics in their everyday lives. It is in these situations where they will be required to use mathematics in order to effectively function in today`s modern society. In this respect, it is important to note that:

The learning and the doing of mathematics should fit into the natural intellectual rhythms of the child. That is to say, the mathematics should be clearly seen to be relevant to the life of the child. It should be motivated as responding the child`s natural curiosity and desire to understand and master the child`s world (Hilton, 1980, p.180).

On the other hand, it would also be important to note that the relevance of mathematics to be learned is understandably important for people to do their work successfully, but placing it into real contexts is frequently seen as a general panacea (Barr, 1993) as well as

the difficulty in finding how to “teach mathematics so as to support adults` functioning satisfactorily in their work and everyday lives” (Evans, 2000b, p.289). We can develop a variety of activities that the typical individual takes part in, but in the usual basic education or college pre-calculus course, people`s activities that they are involved in will change over their lifetime because of the differences between people (Evans, 2000b). Furthermore, as Quadling (1982) argues, this also presents us with a curricular problem in a way that only some people will ever use any particular piece of mathematics. For example, in his words:

Engineers and navigators obviously need to know some trigonometry, a subject that is of no use whatsoever for pharmacists and bank employees. Economists need to understand statistics, but not electricians. And, of course, few children at school can be sure what work they will do in later life (p.412).

In this regard, Evans (2000b) suggests that “the mathematics taught must be flexible and powerful, that is able to be generalised or transferred to other contexts” (p.289). Thus, it is at least arguable that “mathematics can be learned in school, embedded within any particular learning structures, and then lifted out of school to be applied to any situation in the real world” (Boaler, 1993, p.12).

In fact, research suggests that students do not automatically use their mathematical knowledge in other areas. Lave (1988) argues that “in the description of everyday practice it is difficult to detect problems to be solved or conventional scholastic problem-solving activity” (p.141). She (1988) found, for example, that while performing problem solving activities, “math is almost always more structured by, than structuring of, grocery shopping in the supermarket” (p.123). That is to say, social relations, values and occasions play a significant role in shaping and developing the structure and meaning for problem solving

activities. This contradicts the assumptions “either that activities and settings are isolated and unrelated, or that some forms of knowledge are universally insertable into any situation” (ibid, p.122). As a result of this, Lave (1988) claims that all knowledge is context-specific and situated and such transfer of knowledge is basically difficult. However, as Schliemann (1999) points out, it cannot be denied that:

When faced with new problems, people constantly rely upon their previous experiences to understand the new situation. Therefore, even if we do not subscribe to a view of transfer as the application of ready available strategies to new situations we need to understand how everyday knowledge developed in a specific setting can be brought into play when people deal with new problems at school (p.22).

In his study of numerate practices, Evans (2000a) investigates the issue of transfer in depth by drawing on a wide literature base and proposes a new perspective on the transfer of learning. Although there are severe limitations on the possibilities of what Evan (2000a) prefers to call ‘translation’, he is optimistic about it. He (2000a) holds the view that “calling the process translation/ transformation reminds us that the translation can be ‘free’, as well as ‘strict’, and the mathematical tools (such as the procedures for calculating) may themselves be changed in the process” (p.233).

Moreover, everyday mathematics research studies have documented how people use highly effective informal mathematics and solve problems through their own invented means or through methods commonly used in special settings (Carraher, Carraher&Schliemann 1985; Saxe, 1991; Nunes, Schliemann&Carraher, 1993; Harris, 1997). For example, in their study of ‘mathematics in the streets and in schools’ on schoolchildren who made a living selling watermelons, coconuts or lemons in the streets of Recife, Brazil, Carraher et

al. (1985) found that “performance on mathematical problems embedded in real-life contexts was superior to that on school-type word problems and context-free computational problems involving the same numbers and operations” (p.21). Another example of this may be taken from the study conducted by Nunes et al. (1993). Participants of this study were farmers, carpenters and their apprentices, construction foremen, and fishermen. The authors (1993) conclude that “study of street mathematics revealed the existence of considerable potential for learning and understanding mathematical concepts in people who have often been treated as unfit to learn mathematics in school” (p.153), thereby “realistic mathematics education appears to be successful in bringing children to build their knowledge of school mathematics on the foundation of their already available knowledge of street mathematics” (ibid, p.154).

Thus, it can be argued that through learning activities in the classroom, students can come closer to a wide range of situations and tools for use and reflection upon mathematical concepts and relations from different perspectives, but learning about mathematics in the classroom is only meaningful if reflection upon mathematical relations is accompanied by meaningful and socially relevant situations where, as in everyday situations, mathematics becomes a tool to achieve new relevant goals (Schliemann, 1999). Accordingly, “the mathematics used outside school is a tool in the service of some broader goal, and not an aim in itself as it is in school” (Nunes, 1993, p.30). In this way, “the situation in which mathematics is used outside school gives it meaning, making mathematics outside school a process of modelling rather than a mere process of manipulation of numbers” (Nunes, 1993, p.30). However, “the process of schooling seems to encourage the idea ... , that there is not supposed to be much continuity between what one knows outside school and what one learns in school” (Resnick, 1987, p.15). Therefore, as Benn (1997) puts it, here the

knowledge of numeracy becomes important, not just for utilitarian or abstract purposes or goals, but within the context of students` attempts to understand their own individual and collective lives and to make their lives more meaningful and functional. Finally, this brings us to the conclusion that:

Schools can and must engage students in situations that are part of their everyday experiences as well as in situations that are new for them. But meaningfulness and the student`s own resources and approaches to deal with problems should always be the main focus of learning activities. By explicitly recognizing these alternative methods of representing and solving problems teachers can understand more clearly how students think and better design situations to help them to advance and to cope with new situations and problems, as independent and participant adults (Schliemann, 1999, p.29).

6. CONCLUSION

In short, the arguments I have presented in this paper demonstrate that “numeracy is a multifaceted and sometimes slippery construct” (ALM Newsletter, 1999, p.2). However, “although we can neither precisely define nor measure numeracy, we can improve it. Especially in an age of computers, we really must take steps to improve the level of numeracy in all segments of society” (Steen, 1990, p.229). The importance of this lies in the fact that “effective participation in society is limited if the citizenry is not capable of interpreting, producing or questioning statistics. Inadequate levels of numeracy will deter individuals or groups from seeking out evidence and intelligently criticising authority” (Benn, 1997, p.74). Moreover, “poor numeracy constitutes a disadvantage in relation to access to the labour market and success within it” (Bynner&Parsons, 2000, p.42-43). Therefore, “numeracy is driven by issues that are important to people in their lives and

work, not by future needs of the few who may make professional use of mathematics or statistics” (The Quantitative Literacy Design Team, 2001, p.18). Yet, the important point to note is that, “developing numerate behaviour is a matter of acquiring and constructing functional knowledge and skills by solving real problems in the course of action in authentic real-life situations and learning how to reflect on this learning” (van Groenestijn, 2003, p.233). This in turn means that:

There needs to be a move away from mathematics as being a series of procedures to memorise. Fundamental to being functional with mathematics is being able to bring deep understanding of key ideas and concepts to bear to make sense of ‘novel’ situations. Teaching must therefore ensure that students not only have opportunities to apply mathematics in this way, but careful thought also needs to be given to how learning can be developed out of such experiences (Wake, 2005, p.15).

As a consequence, “only by encountering the elements and expressions of numeracy in real contexts that are meaningful to them will students develop the habits of mind of a numerate citizen. Like literacy, numeracy is everyone’s responsibility” (The Quantitative Literacy Design Team, 2001, p.18). Thus, more research is needed to better understand the concept of numeracy, especially in today’s society “‘awash in numbers’ and ‘drenched with data’” (Orrill, 2001, p. xv). In this context, some key areas for further research include:

- Factors affecting the transfer and generalization of numerical skills from the classroom to actual practice (Gal, 1993, p.35);
- To what extent does adult ‘school math’ align with adults’ out-of-school numeracy practice? (Ginsburg et al., 2006, p.39);

- An appreciation of how adults` everyday experiences and knowledge can be used to facilitate learning, as well as the challenges involved in developing teaching methods and materials that take advantage of learners` knowledge (Gal, 1993, p.35);
- An exploration of the curricular and instructional implications of new workplace numeracy requirements, especially those stemming from the quality movement in industry and the emerging need for skills that can enable companies to implement quality monitoring and statistical process control schemes (Gal, 1993, p.35);
- How do teachers recognize, attend to, and engage with learners` positive and negative emotions (including fear, anger, frustration, elation, satisfaction, etc.) in the context of classroom numeracy activities? (Ginsburg et al., 2006, p.40)

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