Making word-mathematical problem-solving accessible to students with dyslexia in Cyprus: a web-based approach

Kyriakos Demetriou

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The candidate confirms that the work submitted is his own and that appropriate credit has been given where reference has been made to the work of others.

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Abstract

This study was designed to explore how the use of computers can facilitate and make accessible word-mathematical problem solving for students with dyslexia in Cyprus, given their learning difficulties; that the available ICT resources in Cyprus are restricted; and that the IT skills of the majority of students and teachers are limited, in two different settings: the whole-classrooms of students with dyslexia and on an individual level.

Web-based learning environments (WBLEs) were designed in collaboration with participating teachers with the use of simple tools that do not demand specialized IT knowledge. Several word-based mathematical problems were chosen. The WBLEs guided the students following five steps. The guidance was facilitated by navigation buttons, audio instructions, pictures, and diagrams, etc. Six whole-classroom implementations were conducted where the students (including a student with dyslexia) collaborated in groups with the use of a computer. Also, eight individual implementations were conducted with two other students with dyslexia; four implementations respectively.

Data were collected through observations, interviews, tests, and computer screen capturing, and these were analysed by following thematic analysis.

It was found that the computer-assisted environment can support students with dyslexia in WMPS to a great extent. The facilities provided by the WBLEs, the benefits of collaborative and individualized learning support with the use of WBLEs, the continuous guidance and feedback provided by teachers, peers and WBLEs, can support students with dyslexia in such tasks. The short-lasting impact is an indication of the need for more frequent use of the computer for this purpose. Also, despite the limited available ICT resources in Cypriot mainstream classrooms, as well as a lack of suitable software for WMPS for students with dyslexia, and limited IT skills of students and even teachers, ICT can be embedded in the instruction with additional learning value for students, by creating simple WBLEs.

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Introduction

1.1 Overview

Inclusion portrays a broader vision of integration emphasising the rebuilding of the curricular supplies in order for them to be accessible to all pupils as individuals. Dyslexia is a specific developmental disorder that affects literacy across the life-span. According to phonological theory, people with dyslexia encounter difficulties in the presentation, storage and activation of speech sounds. Such difficulties are the answer we get when we ask someone to refer to the weaknesses of children with dyslexia. Since dyslexia is a specific difficulty of writing and speaking, it is obviously accompanied by a difficulty in dealing with numbers and thus mathematics in general, and word mathematical problem solving (WMPS) in particular. In Cyprus, all students with dyslexia are integrated into mainstream schools, a fact that constitutes a challenge for teachers who have no training of how to manage difficulties in WMPS which derive from dyslexia. The chain failures lead to underestimated self-esteem and a lack of self-confidence, a feeling that may lead to the abandonment of any attempt to cope with WMPS. There is strong literature evidence that Information Communications Technology (ICT) can be used as an ultimate tool to support students with dyslexia, differentiate instruction, and thus, equalize learning opportunities and physical access in the mainstream classroom. In this thesis, I will outline my study's framework, design and findings about how available ICT resources in Cypriot primary schools facilitate the differentiated support of the WMPS for students with dyslexia.

In this first chapter I address the issues relevant to my research topic, including research rationale, the problem and theoretical frameworks of my study. Firstly, I refer to the rationale of why this topic has been chosen and justify why this study can be deemed as innovating and pioneering for the Cypriot context. Then, a brief presentation of the theoretical framework of the study leads to the presentation of the problem that this study deals with. Finally, the aims and the research questions of this study are provided.

1.2 Rationale and context

This topic of the study was based on the core notion of equal learning opportunities as an ultimate target of inclusive education, which can be reached with the use of educational material and facilities provided by the use of new technologies in the instructions. By bearing this in mind and also by taking into account that the learning difficulties deriving from dyslexia do not refer only to difficulties in reading and writing, I explain below why this topic was chosen.

1.2.1 Equal learning opportunities

The ultimate goal of contemporary education is the adjustment of school to the special educational needs of every student and not the student's adjustment to the demands of school. Therefore the target of contemporary education is the creation of a school for everyone, which falls in line with the concept of inclusion (Vislie, 2003). This means that students with learning difficulties have the right to be educated in mainstream schools, and increases the likelihood for teachers to have a student with SEN in their classroom. Since schools consist of classes with mixed ability students, differentiation becomes necessary for achieving an effective teaching practice (Bearne, 1996). This means that the teacher is called to adjust their teaching framework to the needs, abilities and personalities of their students. The differentiation of instruction seems to be crucial but on the other hand is a challenge for the teacher, especially when the students have completely different educational needs.

1.2.2 Dyslexia is not only about writing and reading

There is a plethora of research focusing on dyslexia, and the difficulties of people with dyslexia in writing and reading. However, there is scarcity of research in the case of difficulties in mathematics encountered by students with dyslexia (Gagatsis, 1999, Miles, 1992, Symeonidou, 2008). The same occurs with the difficulties expressed by students with dyslexia in WMPS. This means that this research area remains unexplored and gives me the stimuli to undertake an innovating research project in this field.

1.2.3 ICT: a tool for Inclusion

There is also substantial evidence that ICT can be a tool for promoting inclusive education and equalizing learning opportunities for everyone. However, ICT resources are restricted in Cypriot mainstream classrooms (Mavrou, 2005), and therefore teachers avoid implementing them during their instruction. This minimizes the use of ICT, thus the learning difficulties of students are not accommodated by the helpfulness of assistive technologies (Vrasidas, 2014). It would, therefore, be interesting to explore how teachers can use the restricted ICT resources that are available in Cyprus mainstream primary schools in a better way, in order to help students with dyslexia overcome their potential difficulties in WMPS.

1.2.4 Why am I conducting this research?

Summing up, I am undertaking this research because as a teacher I am interested in helping students with dyslexia to overcome difficulties in WMPS with the use of new technologies. Also, I hold the view that it is an important field of research since there is a scarcity of research, and therefore there is a lack of knowledge concerning this issue, not only in Cyprus but worldwide. The scarcity of research in this field makes my project unique, which is an additional reason to conduct such a research project. In addition, my research project aims to offer answers that make it researchable and realizable.

1.3 The problem

At this point I present the problem that this study deals with.

1.3.1 Difficulties in WMPS

The value and use of mathematics in school life, as well as life after school, is undoubtedly very important. Children with dyslexia usually experience a chain of failures in school, and as a result their courage and self-confidence are substantially reduced (Markou, 1993). In these cases, opportunities for experiences of success seem to be crucial. The difficulties faced by people with dyslexia in reading and writing, inevitably cause additional difficulties in mathematics, especially in WMPS. Such difficulties are even more serious when problems with short-term and long-term memory, orientation, and automatisation abilities become more severe.

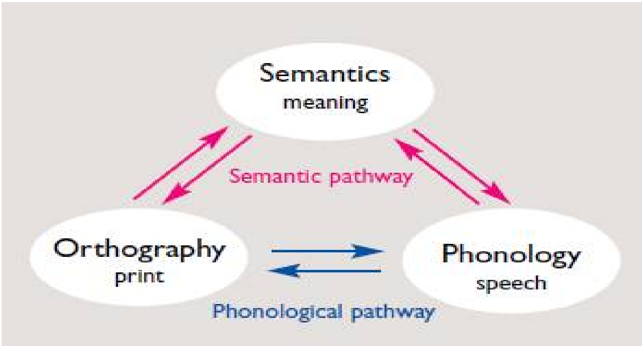

Figure 1.1 The triangle model of reading

According to the triangle model of reading (Fig.1.1), (Snowling, 2000; adapted from Seidenberg & McClelland, 1989), when the phonological pathway between orthography and phonology is weak, then the semantics and meaning are difficult to be reached. Therefore, the difficulty in decoding the letters into sounds impedes the pathway to semantics. For instance, a student with dyslexia who experiences difficulties in reading the text of a mathematical problem inevitably will express difficulties in understanding the meaning. It is obvious that he will not be able to reach the solution, especially when the language and syntax of such WMP is intricate and abstracted.

Interestingly, Malmer (2000) highlights that many students can camouflage a lack of understanding for a surprisingly long time, due in part to the teacher's failure to assess their true comprehension. Moreover, students learn patterns and routines without really knowing the underlying context. When mathematics later becomes more complex, the hidden difficulties will be revealed. Prevention seems to be the best solution in these cases (Gagatsis, 1999). Otherwise, when the teacher does not assess the difficulties, there is a necessity for effective intervention (Dowker, 2005).

On the other hand, one of the most important reasons for having difficulties in mathematics is the inappropriate teaching method followed by the teacher (Gagatsis, 1999). Three main factors lie behind this cause. Firstly, the teacher may give WMPs that have an advanced level of abstraction, thus they are difficult even to be understood. Secondly, WMPs have advanced formal demands that are not suitable for the current students' knowledge level in mathematics. Thirdly, the learning tempo may be too accelerated, and therefore, unsuitable for slower learners (Malmer, 2000).

Smeets (2005) highlights that the traditional strategic approaches to WMPs cannot be learned effortlessly, due to the typical problems of students with dyslexia in learning flow, and their poor short-term memory. Students with dyslexia in this position will either start developing their own strategies, which may not be systematic, organized or feasible, or they may abandon mathematics altogether. Therefore, the need for effective intervention seems to be imperative and crucial.

Since I am focusing on difficulties in understanding the word-based mathematical problem, and the barriers related to literacy issues, I will not base my project on difficulties derived from dyscalculia. Dyscalculia refers to difficulties in learning and understanding simple arithmetic. Hence, I will base the literature review on the difficulties of poor readers, or readers who have been identified as having dyslexia in Cyprus because of their poor reading skills, and at the same time experience difficulties in WMPS.

Additionally, my research project focuses on the difficulties in mathematics that are related to literacy issues as a result of dyslexia. That is why I will focus on WMPS, and not on the general difficulties in the area of mathematics (operations, executions). Thus, the interventional implementations carried out in this study, either at whole-classroom level or individually, were based on the comprehension of word-based mathematical problems and the cognitive and meta-cognitive strategies that must be activated in order to reach the solution of the problem. Also, between different kinds of WMPs, I chose such routine problems that need the implementation of strategies other than difficult executions, complex operations on the basis of school textbooks. However, it is worth noting that it is not easy to divide WMPS with the solving of any problem in mathematics. As we try to separate the difficulties in WMPS and the general difficulties in mathematics, they will never cease to be interrelated since it is necessary to pass from the word-based part of the problem to the pure mathematical stage of solution.

1.3.2 ICT

There is substantial evidence that Information Communications Technology has the potential for providing curriculum access and equal learning opportunities for learners with special educational needs in mainstream schools, and especially for students who are considered as having dyslexia and therefore encounter difficulties in several aspects of mathematics. Smeets (2005) describes the dynamic learning environment arising through the use of educational software for classroom differentiation with an environment with rich content and plenty of authentic situations that connect the students with the real world, the active and sometimes independent learning activity, the ability of collaborative learning, and this environment that allows an adjustment of the curriculum as regards particular needs and peculiarities of each student individually.

However, one should point out that a significant amount of educational software can be found on the market. Teachers are usually interested in obtaining more information about this software, and contemplate its usefulness before acquiring it for their teaching purposes. Nonetheless, teachers should consider the individual needs of their students in order to choose the best assisting software available. In other words, teachers should be able to generalise and apply the information to their own situation (McKeown, 2000). For example, the individual needs of students with dyslexia often differ from one child to the next. Beyond the unsuitability of this software for the whole student population, most educational programs are quite expensive and not always available in different languages.

In addition, restricted ICT facilities and sources in Cyprus make any attempt to use new technologies for differentiation of instruction much more complicated. Particularly, every single classroom in all schools in Cyprus is equipped with at least one computer with full high-speed internet access, as well as a colour printer and scanner. Every school has at least one computer cluster in a dedicated classroom, which is available for all students and teachers. Although Cyprus is included in the list of countries with very well-equipped schools in terms of new technologies (Eurydice, 2011), there are many schools that are still equipped with very restricted ICT resources. Also, few educators use ICT for differentiation of their instruction (Mavrou, 2005).

1.4 Aims of the study

Given the above briefly described educational settings of Cyprus, a consideration regarding limited ICT resources, and the difficulties of students with dyslexia in WMPS - could we suggest a way of using the restricted ICT resources in the mainstream classroom in order to more effectively help children with dyslexia who encounter difficulties in mathematics problem solving, by increasing their classroom involvement, peer interaction and improving performance?

My research aims to explore the potential of using restricted ICT facilities (available, downloadable, free and non-commercial educational software/tools for designing computer-assisted learning environments) for differentiation of instruction for students with dyslexia who encounter difficulties in mathematics problem solving in Cypriot mainstream classrooms. It aims to explore the impact of the use of the available free-content software for the design of learning environments for differentiation of instruction in two different settings, on the performance of students with dyslexia with difficulties in mathematics. The two different settings were (1) students in small groups using computer-assisted learning environments for WMPS in school computer labs, and (2) students with dyslexia using computer-based learning environments for WMPS individually.

1.5 Research questions

The project aims were guided by three research questions, the main question and two supplementary questions as follows:

Main Question:

MQ: To what extent can a computer-assisted learning environment[1] provide differentiated support[2] for students with dyslexia with difficulties in WMPS in Cyprus?

Supplementary Questions:

SQ1: What is the impact of computer-assisted learning in solving mathematical problems for students with dyslexia?

SQ2: To what extent can collaborative learning in pairs/groups help for a more beneficial use of computer-assisted learning environments for mathematics problems solving?

1.6 Thesis outline

Chapter Two of this thesis lays out the theoretical aspects related to the topic of this project. Chapter Three presents the construction of the methodology and the instruments used for the collection of data. Chapter Four and Chapter Five provide an account of the work scheme and the methodological approaches followed for the whole-classroom and the two individual implementations respectively. Chapter Six presents the analytical methods and strategies followed for the analysis of the data generated from the three case studies. Chapters Seven, Eight and Nine present the analysis of data of each case respectively, and Chapter Ten provides a discussion of the findings in an inclusive manner, attending to whole-class results as well

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[1] Software provided by the Ministry of Education and any available free-downloadable or non-commercial internet resources

[2] If the use of ICT can improve students' performance, participation in the classroom, peer interactions, attitudes, opinions etc

as individual implementations' results. Lastly, Chapter Eleven elaborates on the contributions, implications, limitations and future work that could be developed in association with the areas investigated throughout the study.

Chapter Two
Theoretical Framework

2.1 Introduction

The purpose of this chapter is the presentation of the main aspects of this project, after the conducted literature review spanning the areas of the Cypriot educational system, the notion of inclusion, special education in Cyprus, dyslexia and learning difficulties, difficulties in WMPS, ICT and the connections between them.

2.2 Cyprus Educational System

The education service in Cyprus could be characterized as highly centralized (Angelides et al., 2004, Hadjithoma and Eteokleous, 2007, Mavrou, 2005). The Ministry of Education and Culture (MoEC) controls the curriculum which is common for every state and private school, and provides the textbooks and necessary resources for its delivery (Koutselini and Persianis, 2000). Education in Cyprus is compulsory, beginning at the age of 3. Primary school offers a six-year compulsory programme for children from 5¾. Secondary education also offers a six-year programme divided into the lower level (13-15 years old) which is compulsory, and the upper level (15-18 years old) which is optional.

Cypriot classes of state school can be characterized as “mixed-ability” classrooms. That is to say, classes formally consist of groups of children with different abilities working in the same settings. However, mixed-ability teaching naturally demands a higher level of resources for learning than direct exposition in homogeneous teaching groups (Angelides et al., 2004). Teachers usually cope with numerous challenges in mixed-ability classrooms, hence they must adjust their teaching on special characteristics, abilities and needs.

Over the last few years, the Cypriot educational system has been reforming through the introduction and implementation of the New National Curriculum (Vrasidas, 2014), which was based on the notion of humane and democratic schools for everyone (Symeonidou and Mavrou, 2014). Within the spirit of change, efforts have been made by different committees consisting of experts and academics to reconstruct the national curriculum for each subject by bearing in mind the new trends and teaching methods.

2.3 Inclusion

The ultimate goal of contemporary education is the adjustment of schools to the special educational needs of every student, and not the students' adjustment to the demands of school. Therefore the target of contemporary education is the creation of a school for everyone, which falls in line with the concept of inclusion (Vislie, 2003). This means that students with learning difficulties have the right to be educated in mainstream schools, which increases the likelihood for teachers to have students with SEN in their classroom. Since schools consist of classes with mixed ability students, differentiation becomes necessary for achieving an effective teaching practice (Bearne, 1996). This means that the teacher is called to adjust their teaching framework to the needs, abilities and the personalities of their students. The differentiation of instruction seems to be crucial, but on the other hand is a challenge for a teacher, especially when the students have completely different educational needs.

2.4 Special and inclusive education in Cyprus

In 1978, the Warnock Committee formed the Warnock Report (DES, 1978), which influenced not only the legislation in the UK but in the European continent widely. The Warnock Report supported the principle of the integration of students with SEN into mainstream school, that is to say the transfer of students with SEN from special schools to mainstream schools, and recognized their right to be educated in normal educational settings (Vincent, 1989). According to Phtiaka (2007), it was doubtlessly the strongest influence on the educational system in Cyprus concerning special education's legislative framework. Following this, a plethora of Laws, Acts and draft laws followed, with many revisions, modifications and reformulations, that constituted the precursor for the enactment of the Law 113(I)/99 for the education of students with special educational needs.

In 1999, the Law 113(I)/99 for the Education of Children with Special Needs was passed and was followed by the publication of the regulations that govern the implementation of the Act (Angelides et al., 2004). According to this law, all children with SEN have the right to be educated in their neighbourhood mainstream school, together with their age-mates, and with the support of special teachers. An important component of this law is that it also introduces inclusive education into pre-primary education. According to the new legislation, a child can only be considered as having special needs after becoming 3 years old. The Government has an obligation to provide special education to people with special needs from the age of 3 until their high school graduation. It provides four types of attendance for students with special educational needs: attendance in mainstream schools (which constitutes the priority of the educational policy); the attendance in special units in mainstream schools (that is to say a partial integration); the attendance in special schools (for more severe cases); and finally the attendance in other places (for any medical reasons). District Committees are formed in order to evaluate the needs of children with SEN annually (Ministry of Education and Culture, 1999).

The new law introduced the ordinance of Special Education Co-ordinators who are responsible for the coordination of the inclusion of children with SEN in mainstream schools. Also, the individual curriculum of each child with SEN is formed by special educators and the child's parents, which contains details about essential facilities, infrastructure, modern technology and potential exceptions of the child from any course. In severe cases, a Special Assistant helps the pupil with special needs, as well as the special educator or mainstream classroom teacher, during the learning process and breaks (Ministry of Education and Culture, 1999).

Integration or Inclusion?

The radical changes that take place in education, both in Europe and internationally, influence the way of thinking and practice in Cyprus, as in many other countries. Attempts for the revision and development of the current educational system are being enforced in order to increase the participation and learning of children who are considered as having SEN. In 2004, Cyprus became a full member state of the European Union. This important historical event for the contemporary history of Cyprus created a new era of thinking where the concept of inclusion tends to replace that of integration, since inclusion has in fact become an educational priority (Angelides et al., 2004). Nevertheless, this is far away from becoming a reality. There are so many areas to develop in order for us to speak about inclusive education in Cyprus. Primarily, a strong political will beyond any other changes is required for such a change.

Children who may in the past have been served primarily by special teachers in segregated settings are increasingly becoming the concern of every teacher (Angelides et al., 2004). Mainstream schools are now required to be transformed in ways that will increase their capability to respond to all children. This means that all teachers are obligated to modify their practice in order to be able to effectively teach all of their students, including students with SEN, and to put into force the policies of inclusion.

Phtiaka (2002) argues that even though the Law 113(I)/99 is a pioneering step for Cyprus settings, it may not be so effective or functioning due to some difficulties and deficiencies. The number of special education co-ordinators is not satisfactory, therefore the inclusion could not be reached when there is limited co-ordination and co-operation between schools, parents, teachers and the MoEC. In addition, the author pinpoints the inadequate specific knowledge in the aspects of SEN that primary school teachers have in Cyprus. Most of them are prejudiced and have negative attitudes towards students with SEN in their classrooms. Furthermore, schools lack substantial technical and material infrastructure in order to meet the needs of differentiation; this incommodes the role of teacher (Phtiaka, 2002, Demetriou et al., 2007). Moreover, the evaluation and re-evaluation of students' needs seem often to be inadequate and problematic (Phtiaka, 2002).

Similarly, Angelides and colleagues (2004) found that teachers in Cyprus lack both the necessary knowledge and attitude in order to support or provide inclusive education. Some of them do not have the knowledge to adjust their teaching into learning conditions favourable for all children. On the other hand, there is not a climate of acceptance of students with SEN amongst their peers, especially when the teacher does not cultivate an atmosphere in the classroom that is helpful to children with SEN regarding acceptance by their classmates, and to be considered as equal members of society.

In order for inclusive education to be successful in Cyprus and elsewhere, we must exploit every available resource (Saleh, 1998). The notion of inclusion requires the development of a logic that aims primarily at bringing about improvements of educational strategies and programmes, and better use of all available resources (Angelides et al, 2004; Demetriou et al., 2007; Phtiaka, 2002). What we practise in Cyprus is more *incorporation* than *inclusion* (Demetriou et al., 2007). The legislation is good enough, but in order for it to be effectively functional, significant progress must be achieved in the field of attitudes, infrastructure, training of in-service teachers, better preparation of prospective educators and the revision of the curriculum. Teachers have the power to contribute significantly in an effort for the successful implementation of inclusion by modifying their plan of action, and responding themselves to the needs and personal needs of their students. In addition, teachers can differentiate their teaching according to the content of the lesson, the interests of each child and their tempo and level of learning, and by their responses to questions and activities, and the structures and methods of teaching (Lewis, 1992).

Although the Law 113(I)/99 is based on the idea of inclusive schools (Barton, 2002), the MoEC does not prohibit the existence of special schools. Not only have special schools continued their operation, but special units have been transferred into mainstream schools. Obviously, the MoEC has not yet abandoned the principle of the medical model because it continues to block the integration of more severe cases in the general school. The idea that some children must attend special schools because of the severity and uniqueness of their needs, refers to the ideology which considers disability as a problematic and marginalized status. This confirms the assumption that discrimination is deeply rooted and an integral part of the Cypriot social system (Charalambous, 2004). There is much criticism on the segregation of students with SEN through the legislation and curriculum in Cyprus. Despite the efforts of the new national curriculum for the creation of a more democratic and humane school for everyone, it seems that much more of an effort is needed in order for us to talk about inclusion in Cyprus (Symeonidou and Mavrou, 2014).

For the purposes of my research, I will use the terms *'Inclusion'* and *'Inclusive education'* with the meaning of attendance in ordinary school, a meaning derived from the Educational Law 113(I)/1999 (MEC, 1999). Beyond the *'attendance'* in mainstream schools and the *education* of children with SEN in the mainstream school, the Law 113(I)/1999 does not refer (directly) to the terms *'integration'* or *'inclusion'.* However, for more severe cases of SEN, the Law refers to the term of *'incorporation'* which is probably associated with the notion of *'integration'*. Moreover, it is important to mention that students with dyslexia are educated in mainstream schools, and there is no special school for the education of students with dyslexia in Cyprus. Therefore, when I refer to the *inclusion* of students with dyslexia in mainstream schools, I imply that the student attends an ordinary school and they are a part of the mainstream classroom, and therefore educated and treated equally as their classmates. However, these students are not fully included in everyday learning routines of their mainstream classrooms, since they withdraw at least twice a week in order to receive remedial education in individualized settings within the mainstream school (Symeonidou and Mavrou, 2014).

2.5 Dyslexia

Dyslexia is a specific developmental disorder that affects literacy across the life-span (Reynolds et al., 2003, Snowling, 2000). The medical model initially provided an ill-defined description of dyslexia terms, but nowadays this definition is out of use and has been replaced. Dyslexia has been acknowledged as a consequence of a problem in phonological processing (Coltheaer, 1996).

There are many definitions of dyslexia but no official consensus has been reached. At this stage I will comment on the definitional debate of dyslexia. However, a thorough critique on it cannot be made since numerous definitions of dyslexia have been proposed. Therefore, I will focus on those viewing dyslexia as a discrepancy between IQ and reading skills, the definition proposed by the Orton Dyslexia Society in 1994 and is widely considered as accepted and working, and the definition constructed by the Expert Advisory Group and presented in the Rose Report (2009). I will also refer to the dominant definition of Dyslexia in the Cypriot context later on.

Scientific research has described dyslexia as a congenital, neurocognitive deficit which firstly appears when a child begins to read, write and spell, and continues throughout their life. It is a developmental, not permanent condition having psychological effects on the individual throughout their life (Turkington and Harris, 2002, Mavrommati, 1995). Yet, students' with dyslexia difficulties alter over time in conjunction with their chronological age and stage of cognitive development (Anastasiou, 1998).

Stanovitch (1998) stated that a child can be diagnosed with developmental dyslexia if it underperforms in reading skills compared with its peers, and if it fails to reach the appropriate reading skills after two years of schooling. This failure must not be supported by the existence of other cognitive or neurological deficits.

“Developmental dyslexia is traditionally defined as a discrepancy between reading ability and intelligence in children receiving adequate reading tuition” (Ramus et al., 2003; p.841). The discrepancy view is based upon the notion that students with low IQ will probably face difficulties in various domains, reading being just one of them, and on the basis of exclusionary measures, those with poor reading abilities and poor general mental abilities should not be considered as having specific reading difficulties (Elbeheri and Everatt, 2009).

As Turner and Nicholas (2000) have said, IQ has long been considered a determinant factor of academic attainment. In a similar vein, Thomson (2001) supports that “the evaluation of intelligence is an important element of the assessment of dyslexia” (p.35). This implies that IQ might indicate who could improve if additional and appropriate literacy training is provided, and who would remain stable and finally fail as a result of their low intelligence (Elbeheri and Everatt, 2009).

Yet, Flowers et al. (2000), paraphrasing Thorndike’s worry, say that IQ tests can only measure people’s functioning at a certain moment and occasion, but can they actually judge future development? Moreover, Crombie (2001) suggests that skills such as reading and writing cannot be acquired before a child enters school, so the IQ-discrepancy definition fails to a great extent to give chances for early identification and intervention. To put it simply, “researchers who argued forcefully against the IQ-reading discrepancy criteria view such a discrepancy as based on an outdated and indefensible construct (IQ) which does not differentiate between the reading skills of different groups of poor readers and which has no obvious implications for differential teaching strategies” (Elbeheri and Everatt, 2009; p.29).

In 1994, the Research Committee of the Orton Dyslexia Society (currently known as the International Dyslexia Association) has defined dyslexia as the following: “Dyslexia is one of several distinct learning disabilities. It is a specific language-based disorder of constitutional origin characterised by difficulties in single word decoding, usually reflecting insufficient phonological abilities. These difficulties in single word decoding are often unexpected in relation to age and other cognitive and academic abilities; they are not the result of generalized developmental disability or sensory impairment. Dyslexia is manifested by variable difficulty with different forms language, often including, in addition to problems with reading, a conspicuous problem with acquiring proficiency in writing and spelling" (Lyon, 1995; p.9).

The opening sentence aims at showing that dyslexia is a part of other learning disabilities, and that the terms 'dyslexia' and 'learning disabilities' are different. (Lyon, 1995). Yet, it should be noted that despite dyslexia being distinct from the general term 'learning disabilities', 80 per cent of the population with learning disabilities is influenced by reading difficulties (Lerner, 1989, Lyon, 1995). Not to mention that quite often students with dyslexia face comorbid deficits, like attention problems (Shankweiler et al., 1995, Shaywitz et al., 1994), mathematical (Fletcher and Loveland, 1986) or/and spelling and writing difficulties (Lindamood, 1994), which should not be missed when designing an intervention programme. Still, Lyon (1995) argues that since attention and mathematical difficulties are distinct from the cognitive difficulties involved in reading, including them in the definition "would not be empirically sound and would limit its focus and its application to research and clinical practice" (p.10). Spelling and writing have, however, been mentioned in the last sentence of the definition as difficulties linked with dyslexia, and have been associated with phonological deficits in literature (Bruck, 1988, Fowler and Liberman, 1995, Lindamood, 1994).

The heritability of dyslexia is also stressed in this definition, as well as phonological processing skills considered the primary cause of reading and spelling difficulties (Nijakowska, 2010). Yet, many researchers say that the focus should be on the symptoms rather than the causes of dyslexia in order not to limit further research or encourage circular arguments on causes of dyslexia (Uppstad and Tonnessen, 2007). This definition also makes use of the notion of discrepancy between intelligence and reading ability, and characterises deficits in reading as "unexpected". The strengths and limitations of the discrepancy theory have been discussed above.

A more thorough definition, aiming to encompass all aspects of dyslexia as mentioned above, and also compensate for misconceptions about dyslexia of previous definitions, is that presented in the Rose Report (2009). Dyslexia is viewed as a learning difficulty, mainly manifested in inaccurate and non-fluent word reading and spelling. The definition of the Orton Dyslexia Society, presented above, and Vellutino et al. (2004), Hulme and Snowling (2009) also refer to the relation of dyslexia with such difficulties. The report also mentions deficits in phonological awareness, verbal memory and verbal processing speed, and ample research supports this view (Vellutino et al., 2004, Snowling, 2008). The important role played by phonology in learning to read has long been emphasized by contemporary studies of cognitive psychology (Snowling and Nation, 1997, Snowling, 2000), and decoding and encoding processes of single words have been reported as reliable indications of reading disorders (Ott, 1997, Reid, 1998), and at least at a primary level, learning to read depends on such processes.

Another strong point of this definition is that in contrast to definitions that have been described as negative, such as the discrepancy definitions which rely on exclusionary criteria (Krasowicz-Kupis, 2008 cited in Nijakowska, 2010), the particular definition comments that dyslexia “occurs across a range of intellectual abilities” (Rose, 2009; p.30) and indeed research has shown that children of all intellectual levels, but with poor reading and spelling, underachieve in tasks asking them to manipulate words and phonemes (Fletcher et al., 1994, Stuebing et al., 2002). Additionally, it is stressed that dyslexia “is best thought of as a continuum” with “no clear cut-off points” (Rose, 2009; p.30). To illustrate dyslexia may vary due to the degree of severity (from mild to severe) (Snowling, 2008), and it often becomes hard to assess whether a child does or does not have dyslexia (Goswami, 2008). Not to add that other factors, such as its origin and the time of diagnosis, may lead to account for different dyslexia symptoms (Markou, 1993).

This definition, in comparison to the Orton Dyslexia Association definition, explains that children with dyslexia may experience disorders in other areas like motor, memory, attention, organization difficulties (Castles and Coltheart, 1993), or mathematical difficulties (Ott, 1997), and as mentioned above, it is crucial to take them under consideration when applying intervention, otherwise intervention may not be appropriate for an individual, for instance, a student with motor difficulties may feel embarrassed to learn through a multisensory technique asking him to use his body due to his age-inappropriate movement. Finally, the definition stresses that the severity of dyslexia symptoms can be eased when implementing efficient intervention (Fuchs and Fuchs, 2006, Compton et al., 2006). This is an implication for teachers to design intervention, and depending on the way children respond, redesign it so as to meet their needs. It is expected, of course, that some children will improve sooner than others.

Yet, even though this definition seems to work, Nijakowska (2010) is cautious about defining dyslexia based on its symptoms as it is a dynamic phenomenon with constantly changing symptoms that “can be influenced by methods of teaching, remedial instruction and compensation abilities” (p.8).

2.5.1 Theories about Dyslexia

Various theories of dyslexia have been proposed so far, and research in developmental and educational psychology, behaviour genetics and neuroscience (Grigorenko, 2001) has stressed that both defining the syndrome and identifying its etiology is complicating, these issues are “still hotly debated” (Ramus et al., 2003; p.841). For the purpose of this thesis I am going to critically analyse only the most dominant theories around dyslexia.

The phonological deficit hypothesis

The phonological processing system involves the way speech sounds are perceived, coded and used (Hatcher and Snowling, 2002). According to Ecalle et al. (2009) and Ramus et al. (2003), students with dyslexia have difficulty with representing, storing and/or producing speech sounds. Reading becomes easier for children who can understand the mappings between graphemes and phonemes (Rozin and Gleitman, 1977). In fact, children with dyslexia experience many difficulties when they come to learn how to use the grapheme-phoneme schema, and therefore often cannot decode unknown printed words. In addition, many researchers hold the view that developmental dyslexia appears as a widespread difficulty in phonological processing and particularly at the level of phonological awareness. For example, students with dyslexia can neither identify nor handle the sound structure of any word (Ecalle et al., 2009). Magnan et al. (2004) declare that learning to read requires a system combining the areas of orthography and phonology. It is widely believed that the vast majority of students with dyslexia have a deficiency regarding the second area of this system, which in other words means that they are not able to make connections between printed and spoken words easily (Snowling, 2000). In fact, learning this correspondence along with mastering the alphabetic principle are important factors in learning to read an alphabetic script, like Greek or English, and the way reading is developed depends on how these sounds are stored, represented or retrieved (Snowling, 1981, Bradley and Bryant, 1978, Brady and Shankweiler, 1991).

In support of the phonological-deficit theory, it has been shown that students with dyslexia have difficulties with tasks asking them to identify, segment and manipulate speech sounds (White, 2000, Goldsworthy, 2000), and also that they have verbal short-term memory and automatic naming problems. Not to mention that according to the work conducted by Galaburda et al. (1985), at a neurological level, and functional Magnetic Resonance brain research (Paulesu et al., 2001, Shaywitz et al., 2002) an inherited, left perisylvia brain dysfunction in phonological difficulties may play an important role in forming phonological difficulties. Yet, those criticizing the phonological theory of dyslexia mainly suggest that dyslexia is a more complicated phenomenon, having its basis on sensory, motor, learning processes rather than a phonological deficit alone (Ramus et al., 2003). As Ramus et al. (2003) explain, this theory fails to address motor and sensory problems that pupils with dyslexia may have, for instance, Snowling (2000) acknowledges the presence of such problems but more as a sign of dyslexia rather than a cause of it.

The visual theory

Stein and Walsh (1997) view dyslexia as a set of visual deficits giving rise to difficulties such as processing letters and words in a text. As Singleton (2009) explains the "*cooperation*" between the magnocellular and the parvocellular system "enables us to perceive a stationary image when we move our eyes across a scene or a page of text" (p.45). According to the visual theory, children with dyslexia magnocellular pathway may be collectively disorderly (Ramus et al., 2003). Cornelissen et al. (1995) showed that pupils with dyslexia cannot perceive moving stimuli as fast as their peers without dyslexia. Eden et al. (1996) showed that particular critical areas of the visual cortex, typically activated by moving stimuli are not activated in the case of learners with dyslexia. Contrast sensitivity has been found by Evans et al. (1994) to be one of the problematic domains in students with dyslexia magnocellular functioning. Yet, according to Skottun (2000) who assessed 22 studies of magnocellular processing; only 4 could lead to the conclusion that dyslexia is linked to magnocellular deficiencies. This theory also fails to explain why students with dyslexia may be clumsy, may have poor handwriting and automatic (for example, reading) skills. In an attempt to bridge this gap the automaticity/cerebellar theory, presented below, was proposed.

The automaticity/cerebellar theory

As Nicolson et al. (2001) explain, the cerebellar theory argues that learners' with dyslexia cerebellum are partly dysfunctional, leading to various cognitive deficits. The cerebellum being responsible for regulating muscle tone, balance and co-ordination of movement, can play a key part in motor control and as a result in speech articulation; therefore, a dysfunction in articulation could imply problematic phonological representations (Ramus et al., 2003). Additionally, cerebellum controls the automatisation of various overlearned tasks such as writing, reading, driving or typing. Thus, as Ramus et al. (2003) explain, difficulties with automatisation probably mean difficulties in acquiring the grapheme-phoneme correspondence. Several studies have shown that learners with dyslexia may perform poorly in tasks requiring them to use their motor skills (Fawcett et al., 1996), in dual tasks exhibiting a poor sense of balance (Ramus et al, 2003), and in tasks where they are asked to estimate time (Nicolson et al., 1995). In addition, through brain imaging studies, it has been found that those with dyslexia cerebellum demonstrate anatomical, metabolic and activation differences (Nicolson et al., 1995).

Yet, the cerebellar theory is not without flaws since it falls short in explaining why individuals with dyslexia also have sensory problems. The argument put forward by its supporters is that there are different dyslexia sub-types that could be attributed either to the cerebellar or the magnocellular, and explain that phonological deficits stem from deficits in cerebellar while they look like magnocellular deformities (Ramus et al., 2003). Another limitation of this theory is that it relies on an old-fashioned opinion where phonological representations are viewed as connected to articulation of speech (Ramus et al., 2003), and as Liberman and Mattingly (1985) have observed, this view has been refuted because it has shown that even people with dysarthrosis had a normal phonological development. Not only to add that motor deficits, when linked to dyslexia, have been reported to be present in cases where people apart from dyslexia also have attention-deficit/hyperactivity disorder (ADHD) (Denckla et al., 1985).

The magnocellular theory

A theory trying to encompass all theories mentioned above is the magnocellular theory. Stein and Walsh (1997) suggested that this theory addresses the visual, auditory and tactual deficits individuals with dyslexia might have, as opposed to the visual theory which deals solely with the visual dysfunction. The cerebellum being the head ganglion of the magnocellular systems plays a part in the formation of binocular and inner speech, and since receiving a great amount of input from various magnocellular systems, might be influenced by a magnocellular dysfunction (Ramus et al., 2003). In a similar vein, Hari and Renvall (2001) pointed out that the magnocellular theory could explain all known expressions of dyslexia, auditory, visual, motor, tactual, and as a result, phonological. In support of this theory, a connection has been found between abnormalities existing in the medial and lateral geniculate nucleus of the brains of individuals with dyslexia (Galaburda et al., 1994), and simultaneous visual and auditory deficits that a number of them exhibit (Van Ingelghem et al., 2001).

Even though scientific research identifies auditory problems, this applies only to some subgroups of people with dyslexia, rendering thus itself to a great amount of criticism (Marshall et al., 2001, Rosen and Mangari, 2001). Moreover, the visual dysfunctions in individuals with dyslexia are noticed in a wide array of stimuli and are not restricted to those involving only the magnocellular system (Amitay et al., 2002, Farrag et al., 2002). More strikingly, scientific studies support that auditory problems cannot be considered a cause of phonological deficits (Bishop et al., 1999, Marshall et al., 2001).

From the aforementioned it could be concluded that the phonological theory does not put forward a sufficient explanation for the sensory or motor problems a group of individuals with dyslexia may face, while the magnocellular does not provide an explanation why these problems may be absent in a high number of individuals with dyslexia. Finally, the cerebellar theory addresses both matters insufficiently.

However, recent studies have connected dyslexia with deficits in phonological processing, and is now being considered as the most fully developed and generally supported theory of dyslexia as it can address research findings to the greatest possible extend (Frost, 1998, Snowling, 2001, Pennigton et al., 2001, Ramus, 2001).

2.5.2 Etiology

Addressing the causes of dyslexia is not simple, and a multitude of theoretical and scientific views have tried to provide an explanation about dyslexia, revealing this way its multidisciplinary character and different etiology perspectives. Medicine, genetics, biochemistry, education, language and psychology are only but a few sciences that have dealt with this issue.

Thorough research (Lerner, 1989, Shin and Ross, 1998, Markou, 1993) has pinpointed a number of possible reasons causing dyslexia. Its inherent nature has long been emphasized, and dyslexia could be attributed to a genetic component existing in families. Boys are in a greater danger of dyslexia in comparison to girls, with a ratio 4:1.

As far as the neurological view on etiology is concerned, it has strongly been suggested that connections between cerebral hemisphere function and dyslexia exist (Thomson and Watkins, 1998). Pennington & Smith (1987; cited in Markou, 1993) and Lubs et al. (1996; cited in Brooks, 1997) referred to the genetic etiology of dyslexia even though the involvement of the actual genes has not been identified as yet. Additionally, difficulties could be associated with brain dysfunctions because of errors in foetal brain development; during the first stages of pregnancy; when the foetal brain turns into a compound organ, the nerves cells, neurons, might not be adequately structured or connected, thus not helping information to be delivered among various parts of the brain.

Contemporary research on cortical hemisphere function consents with the view that the left hemisphere can be accounted for language and linguistic processing, while the right hemisphere is concerned with more spatially oriented types of skills. The left hemisphere has been characterized as the analytical, logical and sequential part of processing information, whereas the right is linked "with perception of spatial relations, depth perception and form perception" (Thomson, 1990; p.72). Problems in relation to the left hemisphere that have been reported as leading to dyslexia may include the following: i) a shortage in cerebral dominance, the functions of the two hemispheres (for example, the left being responsible for linguistic processes) are not discernible (Thomson, 1990), and "interference in the left-hemisphere functioning by the right hemisphere" favours "the right hemisphere at the expense of the left" (p.74), and consequently makes the absorption, storage and transmission of linguistic information between them problematic; ii) examinations, conducted after death, showed that there are distinctive discrepancies in the cluster of big cells in the area of the brain that could be accounted for processing visual and auditory information, thus leading students with dyslexia to slowly process exhaustive information (Galaburda, 1987; cited in Osmond, 1995).

Shin and Ross (1998) have pointed that the “whole-word” teaching method to reading could be blamed for dyslexia. To the opposite end, a phonetic approach to reading, where students are taught the names and sounds of letters first, is found. Yet, since there are irregular languages like English, where simply following phonetic rules does not imply successful reading, cultivating students’ phonological awareness should be the main aim, especially in the early years of schooling.

Shin and Ross (1998) have also discussed the psychological dimension of dyslexia that could be attributed to a lack in social relations, loss of a loved one, or regular school changes. Yet, judging from my personal experience, it is quite often to see children experiencing the above problems to underachieve academically and present symptoms similar to those which students with dyslexia exhibit. Dyslexia also affects children that have no social problems, have not suffered family bereavement, and have a stable school environment.

In addition, Frith (1997) introduces a causal modelling diagram applied to dyslexia. According to this model of the definition of dyslexia, there are three different levels involved in the explanation of all apparent reasons as to why children fail to learn to read. The behavioral level is the lowest level, where specific impairments are the result of poor literacy skills because of gaps in the child’s society in literacy. The cognitive level is the second level, at play when specific deficits are the result of a poor learning of the writing system, although Frith (1997) clarifies that this is based on a phonological deficit hypothesis as well as the dysfunction of two or more cognitive functions. At the cognitive level, students with dyslexia experience difficulties in processing the phonological features of words (Snowling, 2000). On the top level of Frith’s modelling diagram is the biological level, which involves the potential genetic brain abnormalities. Moreover, Frith (1997) elaborates on how several environmental factors may influence the causal pathway of the abovementioned three levels.

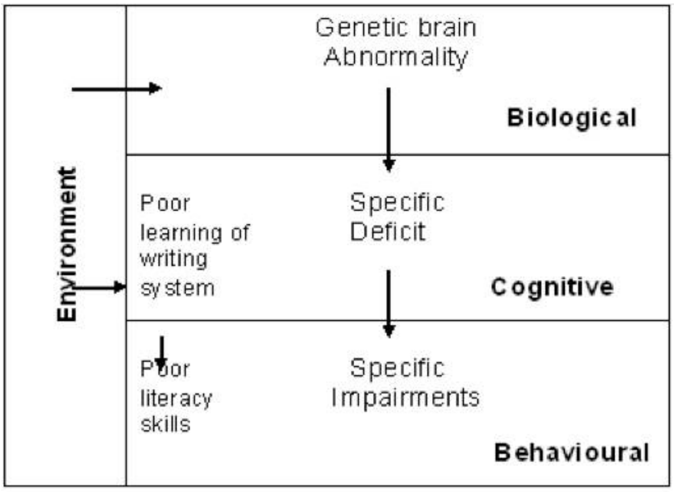


Figure 2.1 A causal model of dyslexia (Frith, 1997)

2.5.3 Main Difficulties

At this point I will discuss the main characteristics of dyslexia as have been described by the literature. However, we must bear in mind that individual difficulties may vary since not all individuals with dyslexia exhibit the same symptoms.*Reading*

As Reid (2005) argues, students with dyslexia have difficulty with the *decoding* process. They find it too hard to segment words into their components and transfer “a word from a decoding strategy to a visual (sight word) strategy” (p.3). Not to mention that since pupils with dyslexia lack a vocabulary of sight words they have to decode almost every word; not an easy task for them to perform as their phonemic awareness, their ability to identify different sounds and syllables, is poor. As a result students’ with dyslexia reading *fluency* is affected (Reid, 2005). In their effort to read they may rely on context. Yet, so as to use context effectively students have to have developed a level of fluency and therefore understanding (Reid, 2005). Due to their fluency and decoding problems they also have *comprehension* difficulties. Finally, sequencing problems result in disordering letters or parts of the words, for example “aliffiated” for “affiliated” (Reid, 2005).

Spelling

Reid (2005) has identified difficulties in spelling for students with dyslexia in the following domains: i) cannot cope with spelling rules; ii) phonological mistakes, for instance, representing the sound “ph” by using the letter “f”; iii) using letters or a series of letters out of sequence; iv) cannot distinguish between letters with similar sounds, for example “s” and “z”; v) cannot correctly use word endings, “ie” instead of “y”; vi) puzzle or omit vowels.

Writing

Pupils with dyslexia have difficulty when asked to write long pieces of work, and their work is usually “rambling and poorly organized” (Reid, 2005; p.6).

Speech development

According to Ott (1997), they are likely to jumble words, have poor articulation and hesitant speech, poor rhyme awareness and use of syntactic structures, and forget names of objects.

Memory-Sequential-Organizational problems

Children with dyslexia exhibit short-term memory deficiencies and cannot easily keep to memory lists; and also long-term memory problems that could be attributed to bewilderment during the learning process, or deficient organizational skills. Due to the latter it gets difficult for them to organize their time, equipment for learning and homework appropriately (Reid, 2005). Accordingly, children with dyslexia may also experience difficulties in following instructions (Ott, 1997).

Motor skills-Handwriting

Often children with dyslexia may have poor co-ordination skills and perform poorly on tasks such as tying shoelaces, hopping and skipping (Ott, 1997). Learners with dyslexia also show inconsistency in their writing style, and even the “slope and characteristics of the writing style can vary within the same sentence” (Reid, 2005). Capital and small letters are not used correctly, and an odd writing grip or sitting position might be adopted (Reid, 2005).

Laterality

Children with dyslexia may also have directional confusion, for example, which is the right or left, this leading to additional problems like following directions, understanding concepts up-down, top-bottom (Hornsby, 1995).

Yet, literature has also mentioned strengths that can be associated with students with dyslexia. Shaywitz (2004) comments on students with dyslexia as having curiosity and imagination levels that are really high, and their brilliant comprehension of stories when told or read to them. As a result, they may develop "a surprisingly sophisticated listening vocabulary" (Shaywitz, 2004; p.125). In addition, Hornsby (1995) has argued that children with dyslexia may be more mature in comparison to their peers. Shaywitz (2004) also points out that pupils with dyslexia can develop skills such as reasoning and creativity, and do perform quite well in tasks that require using these skills.

2.5.4 Dyslexia Debate

It is widely believed by many psychologists and teachers that dyslexia is barely a myth. Some debates exist as to whether dyslexia does indeed exist as a condition, or whether it merely reflects individual differences among different readers. It may very well be that the term "dyslexia" is not functional because the difficulties people with dyslexia are up against are so wide-ranging, as Elliot (2005) has argued. Thus, it is not reasonable to classify students as having dyslexia or not since the same treatment will be used for the cultivation of their reading difficulties. Also, poor readers are poor readers regardless of whether they will be labelled as students with dyslexia or without dyslexia. Elliot (2005) continues by saying that the phonological difficulties of children with dyslexia are present also in poor readers without dyslexia, and that environmental factors play a significant role in reading skill acquisition (Nicolson, 2005). On the other hand, Nicolson (2005) asserts that dyslexia cannot be a myth since 50 per cent of the variance in dyslexia is genetic, which means that dyslexia has a clear and distinct basis.

Moreso, there is no complete consensus as to how dyslexia can be diagnosed. Many children with dyslexia show difficulties outside the literacy domain, and there are overlaps between ADHD, specific language disorder and dyslexia in terms of secondary symptoms shown. Elliot (2005) points out that it is necessary for a diagnostic category to be exclusive, to be of value. In contrary, Nicolson (2005) believes that secondary symptoms are informative to the same extent as primary symptoms, and “may lead towards the development of classification systems based on underlying causes rather than manifest symptoms” (p.658).

Elliot (2005) pinpoints that children with low intelligence can be supported in the same way as children with reading problems but of higher intelligence. The effectiveness of support depends on the suitability of the interventional approach and its right implementation. To this end, he argues that either every child with poor reading ability has dyslexia, or none of them have. However, Nicolson (2005) says that this assertion confuses the etiology with the treatment. For instance, for educational psychologists, the key issue is the cause of the reading disability and the reason why they do not learn to read. For an academic psychologist, the key issue is the underlying cognitive or neurological factors that lead to reading problems. Therefore, an educational psychologist focuses on the treatment and the cause of reading disabilities, whereas an academic psychologist focuses on the etiology. The two different perspectives might lead to a disagreement of what dyslexia actually is, what the difference is between dyslexia and reading disorders, and if dyslexia is a myth or not. It is obvious that any successful approach to dyslexia requires collaboration between both groups in terms of ‘formal’ and ‘pedagogical’ diagnosis and treatment.

Elliot (2005) says that in the absence of clear evidence, there is no particular teaching approach that is more suitable for a dyslexic subgroup than for other poor readers. “At the current time, splitting poor readers into two groups - dyslexic sheep and ordinary poor-reading goats - has little practical value for dealing with literacy problems. Rather than pouring resources into dyslexic assessments, we would at the current time, be wiser to target all poor readers at the early age for interventions” (p.729). Nonetheless, Snowling (2005) asserts that “to gather everything under the umbrella of dyslexia helps neither theory nor practice” (p.730).

2.6 Dyslexia in Cyprus

I mainly focus on the situation in Cyprus, since the research was undertaken in that particular country. Therefore, it would be useful to explore what the current conditions are regarding dyslexia in Cyprus. First of all, I would like to delineate that no special schools for moderate learning difficulties operate in Cyprus. Therefore, all students with dyslexia can be found in mainstream schools. Some of them have already been diagnosed as students with dyslexia, but some of them are still characterised as ‘lazy’ and ‘odd’ students.

In the early 1990s, Cyprus had no policy on dyslexia in any area. The Ministry of Health was responsible for remediation of dyslexia rather than the Ministry of Education and Culture. The educational system provided specialised education for only two special needs groups - for the blind and for the deaf (Apostolides, 2004).

Interestingly, Apostolides (2004) says that the majority of workers in the Ministry of Education had no idea what dyslexia actually is, as few people had ever heard of it, and fewer understood it. Some of the psychologists who worked on behalf of the Ministry of Education did not accept its existence. Also, there were no provisions for children with dyslexia in the educational system, no special provisions for examinations, and the state education evaluation system was over-stretched. Additionally, the bureaucratic procedures of the Ministry of Education did not allow radical changes, with the exception of the attempts of a few teachers who had trained in special education, or had sufficient knowledge to deal with dyslexia. The lack of knowledge, and also the scarcity of specialists in dyslexia, leads mostly to incorrect diagnosis. Children with general learning difficulties were considered as having dyslexia. The same happened for ADHD.

Conversely, the situation in private schools was relatively better than in state schools. A few qualified psychologists cooperated with private schools, but mainly conducted the diagnosis of dyslexia in an empirical way based on their experience, and not by using the appropriate procedures as suggested by special education and psychology. In addition, some private schools were more willing to offer assistance to students with dyslexia by providing remediation sessions by specialists, such as speech therapists, although it is interesting to say that a few students with dyslexia enter private schools in Cyprus because of the entrance examinations that do not apply in state schools (Apostolides, 2004). The most disturbing fact was “the ignorance of the population at large, which resulted in most dyslexic children receiving no sympathy and being branded as lazy or indifferent to learning, and with parents confused and not knowing where to turn for assistance. The main problems, however, were (and still are) with the lower income groups, who in general, are faced with desperate problems” (Apostolides, 2004; p.62-63).

After 1992, some improvements had been observed, when the Ministry of Education had started a sort of cooperation with the University of Cyprus. The University of Cyprus has a traditionally strong department for training primary school teachers. The programme of training consists of courses on special education including dyslexia. Therefore, young teachers have at least an understanding and basic knowledge of how they can deal with dyslexia, a fact that changed their attitude towards children with dyslexia in their classrooms (Apostolides, 2004).

In 1993, the Cyprus Dyslexia Association (CDA) was founded, and was registered as an official and recognized association in 1994. According to its regulations, the association aims to help persons of all ages who have dyslexia, to develop their educational, cultural and other capabilities. It seeks also to enlighten the public and the authorities with respect to dyslexia and to encourage officials to establish state policy on dyslexia. In addition, CDA intends to provide assistance to all the communities in Cyprus, irrespective of religion or racial group or community, and to foreign residences of Cyprus. Finally, CDA inspires to create a centre for diagnosis, remediation and research for Dyslexia (Cyprus Dyslexia Association, 2010).

As mentioned above, one of the objectives of CDA was the formation of a national policy on dyslexia. Apostolides (2004) states some attempts of the Cyprus Dyslexia Association towards this end. From the early years of its operation, CDA emphasised on providing information and education to the public and to officials, as well as obtaining the support and guidance of a few private and state sector specialists involved in the diagnosis and remediation of dyslexia.

One of the priorities of CDA is the policy development for dyslexia, which mainly intents to the provision of information on dyslexia for the public, teachers, the state bureaucracy and the political leadership. The policy highlights the need for education and training of teachers, psychologists and officials, the provision of diagnostic capability for dyslexia in both public and private sectors, the establishment of a legal framework for state policy, the establishment of an appropriate state budget for implementation of policy, the provision of guidance for those children with dyslexia and their parents, and the provision of welfare and support services. In addition, it focuses on the creation of social contact between students with dyslexia, the development of self-esteem by people having dyslexia, and finally the provision of remedial education (Cyprus Dyslexia Association, 2010).

Before 1999, the legislation for education of children with special educational needs was problematic and had never been put into practice (Phtiaka, 2002). After the Educational Act 113(I) of 1999 was passed, much improvement was observed. Before that, it would be interesting to explore the role of CDA towards the establishment of state policy on dyslexia. Apostolides (2004) states that the establishment of state policy on dyslexia was considered an urgent problem in view of the almost total lack of knowledge in the state system. This was due to the fact that the Ministry of Education did not have a comprehensive policy on special needs before 1999. CDA proposed a dyslexia committee within the Ministry of Education, under the Special Education Service of the Department of Primary Education with the participation of CDA in that committee. MoEC answered positively. The Departments of Secondary and Tertiary Education also participated, as did the Educational Psychology Service. Also, the participation of psychologists from the Ministry of Health influenced the discussion on dyslexia, due to their greater experience in dealing with the problem.

In 1999, the Law 113(I)/99 for the Education of Children with Special Needs (MOEC, 1999) was passed and followed by the publication of the regulations that govern the implementation of the Act (Angelides et al, 2004; Phtiaka, 2007). The enactment of the Law 113(I)/99 established the legal basis for dealing with dyslexia in the state education system, and has facilitated the development of private sector policies, but it is obvious that policy goes beyond legal aspects. Law recognizes dyslexia as a disability, and establishes a public sector system of diagnosis and committees to determine the classification of a disability as a special need, allowing for a liaison officer with schools for the fulfilment of the programme for each child, as determined by experts (MOEC, 1999).

The new law was not brought into operation until the 2001-2002 school year. The situation has been improved now but is still far from ideal. Further training on dyslexia and the enlightenment of teachers and school directors is required, and guidelines are needed for the education of children with dyslexia. Recently, a decision was taken following pressure from the CDA to permit oral examinations, while the law requires each child with dyslexia to demonstrate their knowledge during examinations.

Apostolides (2004) concludes that “many aspects have to be considered together but the key elements appear to be strong public support, enlightenment and education of all concerned, a strong membership base, regular formal and informal contacts with officials and politicians, persistence, patience and determination. However, policy on dyslexia is always uncompleted. It requires constant adaptation in order to adjust to new research findings, modern demands and experience as to which practices work best” (Apostolides, 2004; p.66).

2.7 Definition for the purposes of my research

In Cyprus, dyslexia is sometimes simply referred to as a “Reading Disorder.” It is one of many disorders referred to as *Learning Disorders* in the American Psychiatric Association's Diagnostic and Statistical Manual (DSM-V). The

DSM-V indicates a reading disorder exists when a score on an individually administered achievement test of reading, writing, or mathematics is substantially below expectations for age, schooling, and level of intelligence (American Psychiatric Association, 2013).

The school system and government did not establish any criteria to be used to qualify a child as having dyslexia. The Educational Law 113 (I)/1999 does not provide any definition for dyslexia, but only defines the regulations and conditions under which students with SEN will be treated in the educational system. Usually the diagnosis requires the individual administration of a standard IQ test, such as the Wechsler or Stanford-Binet and individual administration of achievement tests such as the Wechsler or Woodcock-Johnson Achievement tests. Evaluations are performed by the District Committees which consist of a licensed psychologist or school psychologist, special teacher, clinical psychologist, speech therapist, social worker and other specialists. Parents may obtain their own independent evaluation and to have this information considered in the determination by the school.

Accurate diagnosis and psycho-educational testing by a licensed psychologist is essential for an effective treatment plan. However, most insurers do not cover diagnostic or treatment services for these specific developmental disorders since they are “educational in nature”, and they specifically preclude psychologists and others from billing for educational services or IQ assessment. Evaluators vary in experience, and how comprehensive of an evaluation which is performed. Therefore, it is usual to label a student as having dyslexia who under different conditions or a different evaluation might be identified as a student with poor reading skills.

The Cyprus Dyslexia Association avoids giving any clear definition about dyslexia beyond the general information about what it is and how it can be recognized. In terms of recognition, CDA published a check list for parents and teachers that can be used in order to identify dyslexic-type difficulties in their children. According to CDA, a child can be diagnosed as having dyslexia if they encounter:

- Difficulty with word retrieval or naming problems, frequently using words like ‘stuff’ and ‘that thing’ instead of the actual name
- Confusion with before/after, right/left, over/under, and so on
- Difficulty distinguishing between similar sounds in words; mixing up sounds in multisyllabic words (auditory discrimination) (for example, aminal for animal, bisghetti for spaghetti)
- Takes longer than average to complete written work
- Reading at a level well below the expected level for the age of the child
- Problems processing and understanding what they hear
- Difficulty comprehending rapid instructions
- Trouble following more than one command at a time
- Problems remembering the basic sequences, such as counting to 20, the days of the week, or the alphabet
- An inability to sound out the pronunciation of an unfamiliar word
- Seeing letters or words in reverse (b for d or saw for was), although seeing words or letters in reverse is common for children younger than 8 who do not have dyslexia, children with dyslexia will continue to see reversals past that age
- Difficulty with spelling
- Trouble learning a foreign language
- Difficulty with rhyming words, such as knowing that fat rhymes with cat
- Difficulty recognizing words that begin with the same sound (for example, bird, baby, and big all start with b)
- When the child surprises us, because in other ways they are bright and alert (Cyprus Dyslexia Association, 2010).

It is obvious that there is no clear definition of what dyslexia actually is in the Cypriot setting, and there is no special status for dyslexia. That is to say, each student that has been defined as having dyslexia might not be diagnosed as a student with dyslexia by different specialists, different district committees, or in different countries. Since there is no general consensus about the definition of dyslexia or any official definition adopted by the

MoEC, for the purposes of my research, I based the choice of students on the initial diagnosis of the District Committee.

Finally, it is worth noting that the dominant definition of dyslexia in Cyprus is influenced by DSM-IV definition which states that dyslexia is a specific learning difficulty of reading (and maybe writing), where the child exhibits an important deviation in their reading skills from what is expected of their age, literacy and intelligence (K.E.NE.D.Y, n.d.).

2.8 Dyslexia and Mathematics

Dyslexia has been seen in terms of difficulties relating to reading and spelling. However, it constitutes a constellation of difficulties. According to Joffe (1983), written language and mathematics share many common features.

Mathematics is an important and integral part of the curricula, but many students face difficulties. One of the reasons for these difficulties lies in the nature of mathematics per se. Mathematics is a subject where the student can build on previous or existing knowledge to acquire new knowledge (Gagatsis, 1997). Chinn and Ashcroft (1995) argue that mathematics has an interrelating/sequential/reflective structure, and they go on to explain that it is a subject where one learns the parts; the parts build on each other to make a whole; knowing the whole enables one to reflect with more understanding on the parts, which in turn strengthens the whole. Knowing the whole also enables one to understand the sequences and interactions of the parts, and the way that they support each other so that the ‘getting there’ clarifies the stages of the journey. Therefore, gaps in learning the different parts, or difficulty in conceptualizing how the parts make a whole, may result in poor achievement in mathematics (Symeonidou, 2008). Some gaps and deficiencies in the early stages of understanding can create a failure in processing the speed of mathematical problems in subsequent stages. Certainly, each child displays different strengths and weaknesses that lead to different levels of success or failure (Gagatsis, 1997).

Evans and Goodman (1995) argue that the performance of a child, in a particular time, is a complex process in which many factors interact. There are three main factors. The first factor refers to the characteristics of the child, and includes the poor image of himself as a mathematician, the way of learning, poor language skills (including reading), the dyslexic-type difficulties, lack of mathematical experiences at home, a different cultural background, gender differences, and difficulties in calculations.

Students' beliefs about mathematics as well as beliefs about themselves as learners have also been emphasized in recent years. For example, believing in their ability to solve time-consuming mathematical problems, believing in the importance of increasing their maths ability, and believing in the usefulness of mathematics in everyday life, are all related to the motivation to learn to solve problems in mathematics (Mason, 2003).

Investigating beliefs is important since they are behind students' attitudes toward classroom activities and performance. In particular, students with low achievement may be unaware of their implicit, maladaptive representations about mathematics, and be less able to modify them, and therefore these beliefs contribute negatively to their learning and achievement. After these beliefs have been assessed, adequate educational interventions should be planned and implemented in the classroom to gradually change inexperienced representations about the nature and acquisition of knowledge in mathematics, which can be very resistant to transformation. Changes to maladaptive beliefs can then positively affect motivation towards mathematics (Mason, 2003).

The second factor refers to characteristics of the teaching method, namely the pedagogical approach. Gifford (2006) points out that the potential negative attitude of a child towards learning or even assessment circumstances may cause failure to learn.

The third factor refers to the characteristics of the object of study. It is about the relative image formed by students for a subject (for example, mathematics), which is heavily influenced by the attitude and ideology of the teacher in this subject (Evans and Goodman, 1995). Teachers have a remarkable influence on students' construction of their beliefs through the ways in which they present the subject matter, the kinds of task they set, assessment methods, procedures and criteria. It can be legitimately speculated that in order to modify students' inexperienced beliefs about mathematics, teachers should emphasise and greatly value students' understanding of concepts, effort that increases ability, control over the learning process and problem solving skills. Given that teachers' beliefs, as reflected in their practice, influence students' beliefs, it appears evident that pre- and in-service teacher training should include activities aimed at making them manifest, and encourage teachers to analyse and reflect on their own beliefs about mathematics, and different ways in which it can be approached in the classroom (Mason, 2003).

2.8.1 Dyscalculia

Many researchers use the term 'dyscalculia' to describe the specific difficulty in numeracy (Luculano et al., 2008). The term refers to the attenuation of specific parts of the brain which are the basis of mathematical skills. *Dyscalculia* refers to specific learning difficulties in mathematics (Chinn and Ashcroft, 1995, Luculano et al., 2008). It is a contested term as researchers have not yet reached a consensus regarding its definition. According to Poustie (2000), children's conditions may result from developmental or acquired dyscalculia; the former resulting from a specific learning difficulty in numeracy/mathematics, a condition that is present from birth, and the latter referring to all kinds of learning problems in mathematics caused by various factors, including developmental and acquired dyscalculia. Mazzocco (2007) approaches the issue using a different terminology. She explains that dyscalculia (which she also refers to as mathematical learning disability) is a biologically based and behaviourally defined condition. She distinguishes dyscalculia from 'mathematical difficulties', which are considered to be difficulties of environmental, and not biological, aetiology.

Conversely, many researchers believe that the term 'dyscalculia' is unnecessary (Pritchard et al., 1989) as learning disabilities and learning difficulties can occur simultaneously (Miles, 1992). According to Pritchard et al., (1989) the difficulties that affect reading and writing affect, in a similar way, their performance in mathematics, in the case of students with dyslexia. They argue that students with dyslexia face more difficulties than students without dyslexia in learning to link objects, events, relationships, etc., with the correct names. According to Joffe (1983), the rationale for the attenuation of some parts of the brain may prove unfounded, since there is no area of the brain that specializes only in reading and spelling. There are different parts of the cortex of the brain that have to do with symbolic types of information, perception, translation and integration, including the written language, but not limited to these. If this is so, malfunction in one of these areas will affect a range of functions, especially if they have common elements. Both the written language and school mathematics have many common elements: both are universal languages that represent arbitrarily concepts using symbols.

According to Gifford (2006), dyscalculia is a problematic area in terms of its definition and identification. Especially for educators, the term is considered to be problematic, not only because of its complexity, but also because it has origins from scientific disciplines, such as neuro-psychology, applying different methodologies and theoretical viewpoints than mathematical learning theories. Hence, some of their implied theories come into conflict with learning theories.

The same author refers to three main implications deriving from the adoption of mental model for dyscalculia. First, the fact that these students answer wrongly does not mean that they face severe difficulties; secondly, such difficulties may be due to socio-cultural causes; and thirdly, if dyscalculia is considered with its neurological causes, it should occur differently in different cultures, with different teaching methods and linguistic structures (Gifford, 2006).

Why I am not focusing on dyscalculia? I am not focusing on dyscalculia for four reasons. First, it is a contested term that refers to difficulties in arithmetic only, but not difficulties that are literacy based. Second, it is a new term that cannot be met easily or frequently in Cyprus. Third, there is likelihood for co-morbidity of dyslexia and dyscalculia which makes the intervention more complex. Fourth, a student with dyscalculia might not face any difficulty in reading, which is a key notion for my research project. On the other hand, the main difficulty in dyslexia is poor reading skills, which may cause barriers in understanding word-based mathematical problems as discussed above.

2.8.2 Difficulties in Mathematics

People with dyslexia encounter difficulties with representing and accessing the sound of a word, thus it is not easy for them to remember that word or the meaning of it. Similarly, the core problem in mathematics for students with dyslexia is based on those parts of the subject which call for memorizing ability. In other words, a weakness at immediate recall of number facts may be one of the limitations (Steeves, 1983). A lack of the available number facts for immediate use is caused by retarded or deficient 'automatization' (Ackerman et al., 1986).

The specific difficulties of students with dyslexia in mathematics can be diagnosed with the WISC Arithmetic sub-test which may represent a kind of compromise between their high reasoning ability and typical dyslexic weaknesses (Miles, 1992). However, we must be careful because any potential arithmetical retardation in early school years may be associated with developmental dyslexia but not necessarily so (Critcley, 1970 in Miles, 1992). Students with dyslexia encounter difficulties mainly in place value, problems in writing the correct number of noughts, and in putting commas in the correct place. In addition, there may be an inability to visualize numbers, of memorizing multiplication tables, or retaining a series of digits in the memory for a sufficient time (Critcley, 1970 in Miles, 1992). Similarly, Pritchard et al. (1989) explain why many students with dyslexia, regardless of their school age, still use their fingers or make notes (working out) on paper when they do calculations. Researchers suggest that the requisite number fact is not immediately available to them by any other means; therefore they are obligated to use different and more childlike strategies. This is a typical 'compensatory strategy' of students with dyslexia (Pritchard et al., 1989).

Although research in the field of dyslexia and mathematics is scarce (Miles and Miles, 1992), few available research attempts confirm the assertion that the main problem in mathematics, in the case of dyslexia, comes from inadequate immediate memory. Webster (1979) asked students with dyslexia and students without dyslexia to recall strings of seven non-rhyming consonants and strings of seven digits. Students without dyslexia outperformed their peers with dyslexia in an activity that demands high levels of adequate immediate memory which seems to be an essential condition for mathematical progress. Since students with dyslexia are known to be weak in this area, these paradigms do not constitute a surprise. Moreover, Miles (1983) found that some students with dyslexia remain weak at exercises related to subtraction and that the great majority have distinctive problems with multiplication tables.

A lack of automatisation explains the reason that students with dyslexia encounter difficulties in multiplication tables, or difficulties in recalling words in the case of language. “The ability to respond ‘in one’ to a mathematical sum is in that case similar to the ability to recognize a word or phrase ‘in one’ when reading or to set it down with no hesitation when writing. In the same way having to work out a product (for example 9x8 = 10x8-8 = 80-8 = 72) is like having to deduce a word from its component letters; both are examples of a ‘fall basic’ strategy for use when immediate responding is not possible. In the case of both literacy and numeracy it is, of course, a great advantage in the long run if a large amount of automaticity can be achieved, but it is important in both cases that alternative procedures should be available for use when necessary” (Miles, 1992; p.14).

An additional difficulty is the fact that they easily lose their place when reciting tables (Miles, 1992). There is also evidence that the difficulties experienced by students with dyslexia over ‘left’ and ‘right’ affects mathematics too. For instance, the three of the four basic operations, addition, subtraction and multiplication require to be started on the right, opposite to writing across the page in European languages that require to be started on the left. Conversely, operation of division requires to be started on the left but involves all the other operations that are started from the other way around. “Now unless dyslexics have an adequate understanding as to what is involved, so that whether one starts on the left or the right is simply something to be remembered there is considerable risk that they will go wrong” (p.17).

Furthermore, students with dyslexia encounter difficulties in memorising sequences and make mistakes in the numbering and writing of numbers (Douklias et al., 2010). For example, they may write 1000300604 instead of 1364. Reversals of numbers are common mistakes, e.g. 1257 instead of 1752, as well as confusion with maths symbols, e.g. 6 x 8 = 14 (instead of 48) (Markou, 1993).

When students with dyslexia attempt subtractions or additions, they do not follow the common route as everyone else, but conversely they follow complex logical reasoning as a highly sophisticated person could do. Such a way of thinking impedes the ability of giving instant answers, increasing considerably the risk of error, and is a time-consuming procedure (Miles, 1983).

On the other hand, Steeves (1983) asserts that students with dyslexia can be extremely successful mathematicians. There is a view that about 10 per cent of students with dyslexia are likely to be really successful in mathematics, 30 per cent exhibit no particular difficulty, and 60 per cent encounter greater difficulties related to mathematics, though these proportions seem to be simplistic. Miles and Miles (1992) aptly points out that “all dyslexics have difficulties of some kind with mathematics, as part and parcel of their problems with language and memory, but that there is considerable variation in the extent to which these difficulties are overcome” (p.8-9). The overall evidence suggests that all or most students with dyslexia do indeed have difficulty with some aspects of mathematics, but that in spite of this, there is a likelihood of success.

2.8.3 Orientation

Orientation problems afflict children with dyslexia even more in the case of mathematics. This is because while in reading and writing they manage to overcome some of the difficulties by learning to read and write from left side to the right, but in mathematics this becomes more complicated as the direction right-left or left-right depends on the operation. Pollock and Waller (1994) characteristically say that "children with orientation problems needed to learn to read from left to right. Addition, subtraction and multiplication begin from right to left. Suddenly, division reverses the direction: from left to right" (p.116). This proves to be complicated.

Furthermore, errors in the position of digits cause more problems than errors in place of letters in written words. For example, the teacher can easily understand that ‘gril’ is ‘girl’, but not that 1438 is 1348. The difficulties in language create confusions in the meaning of words related to orientation in space, for example, right and left, far away, and so on. This explains the difficulty in forming geometric shapes by following basic instructions (Gagatsis, 1997). Interestingly, students with dyslexia are divided into two groups as far as the ability of orientation in space is concerned. One group includes those who have difficulties related to language. The problem is basically a weakness in terminology and memory. The second group is characterized by more severe difficulties and problems with time and space (Pollock and Waller, 1994).

2.9 Mathematics in the Cyprus curriculum

When choosing this subject, I found it useful to review the curriculum for teaching mathematics in primary schools in Cyprus. Therefore, in this section, I present the aims, objectives and curriculum of mathematics as outlined in the curricula of the Ministry of Education and Culture of Cyprus.

It is worth noting that the Cypriot educational system is very centralized (Angelides et al., 2004). The Ministry of Education and Culture defines the curricula and syllabuses. Also, the MoEC issues the textbooks which the teacher is obliged to use, while they have the freedom to adapt their teaching to the needs and peculiarities of students (Angelides et al., 2004). Nowadays, the Ministry is promoting educational reform through the implementation of the New National Curriculum (NNC) that will give the teacher more freedom to use the textbooks and materials as outlined in the curriculum (MoEC, 2012). Although the NNC put emphasis on the integration of new technologies in mathematics, the use of computers for differentiation of instruction is still somewhat limited due to restricted resources, limited knowledge and the reluctance of teachers to integrate new technologies in their instruction, either because they are not aware how to do so, or because they consider ICT as wasting valuable time for preparation and implementation (Demetriou, 2009, Mavrou, 2005, Vrasidas, 2014).

It is also worth mentioning that there is only one curriculum for all students and for students with special educational needs and difficulties in mathematics. For the case of students with learning difficulties, the existing curriculum is amended in collaboration with the special needs co-ordinator, parents, teachers and the district special education committees (Demetriou et al., 2007). The NNC (MoEC, 2012) does not have an exclusive section for students with learning difficulties, which falls in line with what Phtiaka (2010) suggested, in that students with special educational needs do not need a curriculum with different or reduced content, but rather that our aim is the formation and implementation of a common curriculum for everyone. Nevertheless, Symeonidou and Mavrou (2014) point out that the NNC do not take into account the students with learning difficulties in the desirable extent.

Curricula

According to the Cypriot curriculum, mathematics is an important part of everyday life. The design of the curricula of Maths seeks not only to develop basic mathematical skills of students, but also to cultivate mathematical thinking in a way that helps the understanding of the structure of mathematics and the parallel cultivation of positive attitudes towards the subject. The mathematics' curriculum includes the general purpose of the module, the general targets for all grades of primary and secondary school and the syllabus for each grade separately (MEC, 2012). The NNC is based on four principles: a. The mathematical notions should be explored in a way that will attract the interest of the students; b. The curricula gives emphasis on mathematical problem solving tasks; c. New technologies are an integral part of mathematics; d. All students must gain experience through a good quality mathematical program.

The problem solving is a hallmark of effective curricula (Schoenfeld, 1994). The target is to enable students to use flexible ways in solving mathematical problems by dealing with mathematical concepts and design steps that need to be followed in order to solve the problems. The problem solving involves reflection not only of the process followed by the students but also the concepts used to solve the problem. Solving problems develops the ability to understand and promote the exploitation of the structure and data of an ailing situation. It develops the imagination and creativity of the students.

The NNC suggests the interdisciplinary approach of problem solving with different units of mathematics, and mathematics with other sciences. Problem solving can also be used in teaching processes in multiple ways: as an introduction to mathematical concepts, as a means for exploring ideas and the application of skills and knowledge, and as a means for evaluating the abilities of students (MoEC, 2012).

2.10 WMPS and dyslexia

It is obvious that solving a mathematical problem requires the involvement of higher cognitive and (abstract) deductive strategies, perception, attention and memory (Babbitt & Miller, 1996). Solving mathematical word problems is perhaps the most complex cognitive process in the subject of mathematics. According to the Cypriot mathematics primary school curriculum (MoEC, 2012), dealing with mathematical problems requires the mobilization of knowledge and skills and promotes student’s creativity. In order for students to be enabled to solve a problem, they must firstly understand it, then devise and implement a solution plan, and finally check their answer. The comprehension of the problem relates to the ability of students to identify the given data and the question. Only when they can distinguish information will they be able to devise a plan to solve it. Textbooks contain problems that embed several strategies of problem solving, such as reasoning, selecting the appropriate operation, reverse route, estimating and checking, making a drawing, creating a table and discovering patterns. Textbooks help students to develop their ability to prepare a draft for solving the problem (MoEC, 2000).

In the final stage, pupils check the reached answer, by taking into account the given data and the problem's question. This helps in ascertaining the reasonableness of the answer. Students should engage in activities that require them to monitor their answer. For example, students may be asked to judge whether the result seems reasonable, if there is another solution, if there is another way to obtain the answer, or whether the solution verifies the problem (MoEC, 2000).

The general objectives for solving mathematical problems are that students are able to identify the key elements of problems and solve word problems of a single operation, to solve problems using various strategies, monitor and evaluate the answers and use problem solving in cases of an interdisciplinary approach, both within and outside the discipline of mathematics (MoEC, 2012).

According to Polya's (1945) model, problem solving in mathematics consists of four stages: understanding the problem; solution plan; execution of the plan; and evaluation. Krulik and Rudnick (1987) describe an additional WMPS model which consists of five stages: understanding the problem; investigation of the problem; choice of strategy; problem solving, and checking the solution.

For understanding the problem, the description of its status, the visualization of the problem and the identification of the question and given data are required. This understanding can be achieved through communication (careful reading, identification of problem data, analysis and synthesis of the problem) and through the representation (pictures, diagrams, tables, graphs and mathematical symbols) (Carson, 2007). When students comprehend the problem successfully, they should then investigate the problem which involves the organization of the data, the determination of possible absence of data, the construction of a solution plan, and the creation of a catalogue or table (Krulik & Rudnick, 1987).

After the investigation, students have to select the appropriate solving strategy. Primary school students should develop some strategies for solving problems that are useful and generalizable for solving many kinds of mathematical problems. Through these strategies, students develop their ability to analyse unknown problems, develop their capacity to deal critically with problems and their solutions, develop their capacity to expand solved problems, reach generalizations, and develop positive attitudes towards mathematical problems (Krulik & Rudnick , 1987).

Some of the strategies are as follows: reverse route or reverse path, creating an organized list, the strategy of testing and verification, the representation of objects (simulation), creating a table, finding a pattern, creating a drawing, simplification of the problem, exclusion, reasoning, construction of an equation, and brainstorming. After selecting the appropriate strategy, the student should apply the strategy and execute the necessary operations. At the end, they must be able to check the answer, extend and generalise it.

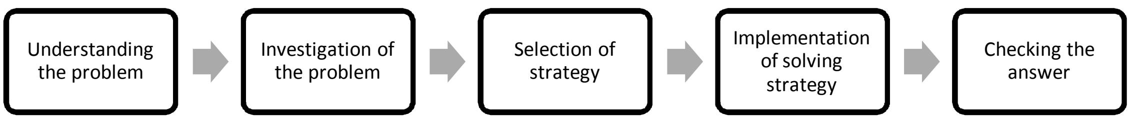


Figure 2.2 5-step model for WMPS of Krulik and Rudnik (1987)

However, there are word problems that cannot be solved with simple, step-by-step procedures. Mason (2003) calls them anomalous problems:

> Some problems may be anomalous when compared with those that can be solved in a routine way. You may encounter something that you have not dealt with before, a situation where you do not know how to proceed, so

> thanks to reasoning you can try to understand it. We should reason, and through reasoning it is easier to find the solution (p.80).

Interpretation seems to be crucial in those cases.

> Mechanical procedures do not always give solutions, that is, they are not good for all problems. There are problems for which you have to use procedures which are different from those you have learned in the classroom. It is necessary to reason on a problem, to reason on the text to understand what you have to do. Many times there are different ways to solve the same problem. We should be able to interpret problems not just read their texts. Sometimes we solve them in the usual way and the result does not come out and we are disheartened (p.80).

Garofalo (1989) points out different kinds of students' beliefs affecting mathematical performance, for example, the difficulty of a mathematical problem is due to the size and quantity of the numbers; all problems can be solved by performing one arithmetical operation, and in rare cases, two. The operation to be performed is determined by the keywords of the problem, usually introduced in the last sentence or in the question, thus it is not necessary to read the whole text of the problem; the decision to check what has been done depends on how much time is available (Mason, 2003).

But what about solving word mathematical problems for students with dyslexia? Mathematical problems are nothing other than short texts containing information and data, and a question which essentially determines how someone will act to solve it and give an answer. If the problem is not worded to be understandable, then the degree of difficulty increases. For many students, the reading of the instructions and details of the text is the most serious stumbling block. For the student with dyslexia, in particular, the deciphering of words demands so much energy that the chances of any understanding of the actual text are greatly reduced, and such understanding may at best be faulty (Demetriou, 2011, Symeonidou, 2008).

Miles (1992b) says that the greatest difficulty encountered by students with dyslexia in mathematics lies in tackling mathematical problems, because of their severe lack of language, meaning that it is not easy for a student with dyslexia to understand the text of a given mathematical problem, particularly in the language that teachers and mathematicians usually use in these texts (Miles, 1992b). They face problems with less everyday objects and unfamiliar words such as dimensions instead of size (διαστάσεις instead of μέγεθος in Greek), numerator, isosceles, etc. The vocabulary in these problems consists of technical terms which have different meanings in everyday life, for instance, the words *add, even* (number), *division* (operation and games). When they read a problem, they may not understand the meaning, or not comprehend what sort of operation is needed because they may not focus on the right keywords or right areas of the problem.

It is a matter of fact that language of mathematical problem texts are often so concisely compressed that every word becomes meaningful in solving them (Malmer, 2000). Many students with reading difficulties can, on the other hand, be very good at solving problems, but most of the time students with reading difficulties can solve mathematical problems after the problem has been expressed in a simpler form. In many cases, working with a classmate who has good reading skills can be beneficial (Malmer, 2000). Many assignments are particularly suitable for working in pairs. This form of collaboration provides students with opportunities to discuss problems together and reason things out, including important elements in the learning of mathematics. In test situations it may be wise for students to have an audio version of the text on CD-ROM or as a software read-aloud facility (Malmer, 2000).

Students with dyslexia may face similar difficulties in reading a mathematical problem to those that they address in reading any text. Apart from difficulties in reading, additional difficulties arise in comprehension and understanding. If a student with dyslexia is unable to read or understand the problem, then it is obvious that they will not be able to solve it. The successful solution of the problem requires understanding. Any ambiguity, misreading or misunderstanding will lead either to an incorrect solution or no solution at all. The abandonment of the effort is common in the case of students with dyslexia, who often underestimate their abilities and leave the tasks uncompleted (Gagatsis, 1999).

Apart from difficulties with understanding, which lie in reading any text, mathematical problems involve a further difficulty which is equally important. After understanding a problem, it then needs a solution. Students with dyslexia encounter difficulties in choosing the appropriate strategy to solve the problem, as well as difficulties in selecting and implementing a suitable instrument that will lead to a solution. However, many students with dyslexia have difficulties in the next step. That is to say, if they understand the problem and choose the right strategy and appropriate action, they are then likely find it difficult to pose the equation or implement the operations in order to find the solution (Babbitt and Miller, 1996).

In the next stage, I will discuss the potential of ICT in supporting students with dyslexia, and then the potential of ICT in supporting students with dyslexia in WMPS. Before that, there is a need to define what the term ICT means.

2.11 Information Communication and Technology

Contemporary pedagogical approaches are adapted to the individual characteristics and needs of pupils. The differentiation in teaching is realised by the use of *special materials and equipment*. ICT tends to be covered by the general term '*special materials and equipment'* (Hardy, 2000). The initial term *Information Technology* (*IT)* contains several items of electronic materials and equipment: a whole range of hardware and software associated with computers. Later, the word *communications* was added to the term as a result of the considerable influence of networks, in addition to their ever the increasing usage in communication (Hardy, 2000). "ICT is a useful phrase for summarising the myriad of ways in which microchip technology has permeated many aspects of everyday life, in education, leisure, work and home" (Florian & Hegarty, 2004; p.2). On the other hand, Smith (1999) simply points out that IT is the subject, whereas ICT is the term used to refer to the tools.

In this thesis, by referring to ICT resources, I mean the available computers and educational software in the school, or additional internet tools used for the creation of WBLEs.

2.11.1 ICT in the Cyprus Educational System

Until the 1980s, educational technology efforts in Cypriot schools were limited to the use of traditional audio visual equipment, and some educational radio and television programming. Advanced ICT has been introduced in Cyprus's educational technology scene since the early 1990s, although technological infrastructure was very limited (Vrasidas, 2002). At the end of the 1990s, the Pedagogical Institute began to offer optional IT training programmes for teachers (Hadjithoma and Eteokleous, 2007).

MoEC has established objectives in six areas for primary education: equipment, the acquisition and development of software, the skills of teachers and students. In the primary level, the movement among European education systems is to integrate ICT as a tool for learning (Vrasidas, 2002). During the academic year 1993–1994, the Ministry of Education and Culture established a pilot programme to introduce computers and related technologies into the classroom (Information Technology Group, 2000).

Nowadays, every classroom in all Cypriot schools is equipped with at least one computer, with full high-speed internet access, a colour printer and a scanner. Every school has at least one computer cluster in a dedicated classroom which is available for all students and teachers. ICT has been included as a compulsory part of the curriculum for either primary or secondary students in Cyprus (Vrasidas, 2014, Demetriou, 2009). However, the majority of in-service teachers have not trained in how to introduce ICT into their teaching, as in-service teacher training in educational technology used to be optional until relatively recently. Therefore, there are many registered teachers in primary schools that are asked to integrate technology into their teaching without any training on how to use technology. Vrasidas (2002) argues that only teachers who have been trained in the use of technology will be able to successfully integrate ICT in their classrooms and guide their students towards becoming technologically literate, and capable of using technology to access information, collaborate with others, communicate with peers and construct knowledge.

The integration of ICT in education deals with the fact that the Cypriot Public Educational system is very centralized (Hadjithoma & Eteocleous, 2007), with bureaucratic procedures that render the system inefficient in many areas (Vrasidas, 2002). For instance, when there is a need for any change in the curriculum, lengthy bureaucratic procedures are required in order for it to be completed. Another important issue for the integration of ICT in education is the lack of strategic planning. In addition, it is widely believed that teachers need constant training and support on the integration of ICT in their teaching, therefore, the lack of in-service teacher training and support seems to be an additional issue that the MoEC has to struggle with (Vrasidas, 2002).

One of the main principles of the New National Curriculum (MoEC, 2012), is the better integration of new technologies in the learning process. According to Eurydice (2011), Cyprus is on the list of countries with the most developed ICT infrastructure, in comparison with other European countries. However, despite the good infrastructure in terms of new technologies in Cypriot mainstream schools, the majority of teachers do not use it in the way that one could expect. Although the idea of development and change is generally accepted by teachers, the adoption and integration of new technologies in their instructions are not in line with the rhetoric of reform. The reasons remain almost the same: lack of time, inadequate IT skills of teachers and students, a scarcity of suitable software and so on (Vrasidas, 2014).

2.11.2 ICT and special education in Cyprus

Watkins (2003) says that beyond any common platforms for discussion and debate in the European framework for the implementation of new technologies for the inclusion of children with SEN in the mainstream classroom, there are not any specified policies, other than the general practices for the use of ICT for the general schooling population. Watkins

(2003) includes Cyprus in the countries that have not adopted any special needs education ICT policies that include statements and objectives in five areas: infrastructure (hardware, software and internet facilities), support for practice, training, co-operation, research and evaluation. In Cyprus, ICT is an element of general educational policy. It is embodied within the school curriculum that applies to all pupils, including those with SEN, and is included as a particular constituent of national legislation and policy for pupils with SEN (Watkins, 2003).

Though the introduction of ICT in education is very high on the agenda of the Cyprus Educational System, nevertheless, policy regarding ICT and special education is at a very early stage in Cyprus (Mavrou, 2005). There are two basic axes of that policy: firstly, the supply to special schools, special units and resource rooms in mainstream schools, with at least one computer for each classroom, or a computer cluster for special schools (MoEC, 2002); and secondly, the provision of assistive technology hardware and software for individuals according to reports and assessments of specialists (MoEC, 2003). The second axis refers to the identification and assessment procedures of the Law 113(I)/99, as any other provision for students assessed as having SEN (Ministry of Education and Culture, 2004).

According to the MoEC (2002), one of the reasons for the supply of at least one computer for each classroom in primary schools is the enhancement of the support of children with SEN. Also, at the beginning of each school year, the MoEC provides schools with an extra budget based on the number of integrated students with SEN in each school. The budget is dedicated for the purchase of educational software and equipment for both special education and even speech and language therapy sessions (Mavrou, 2005). The sense of this policy aims to support students with SEN in small groups, or individual learning processes, out of mainstream classroom settings, and most likely prepares them for their inclusion in general classrooms (Mavrou, 2005). Nevertheless, this philosophy on one hand reduces barriers for accessing learning, but on the other hand excludes students with SEN from being part of the mainstream classroom, thus it does not fall in line with the philosophy of inclusion (Symeonidou and Mavrou, 2014).

It is widely believed that using ICT to compensate for the difficulties of students with SEN while working in the mainstream classroom, allows physical access to learning, cognitive access with a multimedia approach, on-going assessment and development of self-esteem, acceptance and inclusion (Blamires, 1999, Rahamin, 2004). The current policy of the Cypriot MoEC does not support the idea of e-inclusion, but merely the access to learning out of the classroom setting. According to Blamires (1999), ICT is not just about access, it is about engagement and inclusion, even if achieving more affective targets of education, especially for inclusion, is a more demanding task. However, Mavrou (2005) points out that “using ICT in classrooms to promote inclusion is even more difficult in educational systems such as the Cypriot, where resources are quite limited for each mainstream classroom” (p.3).

2.12 Differentiation in a single-computer classroom for students with SEN

Teachers need to face up to the challenges that arise from the diversity of their students, and employ a variety of approaches in order to adapt their teaching to their particular needs. A differentiated approach to teaching encompasses all attempts to remove any obvious barriers for the learning process while at the same time provides a variety of approaches for students in order to meet their needs (Demetriou, 2009). “SEN children present the additional challenge that they may not be able to use the most widely accepted methods used in the classroom-reading and writing. They may, however, arrive with an extra resource–a teacher assistant or a support teacher who should be able to help teacher in a number of ways such as preparing materials beforehand and helping in the lesson” (Franklin & Litchfield, 1999; p.116).

The valuable tool for teaching differentiation could be the future potential for ICT. Higgins and colleagues (1999) claim that the wide range of SEN challenging teachers in the classroom does not make the teaching process non-straightforward, but intentional. They go on to say that individual children will need educational programmes suited to their needs. This implies that teachers should provide different support systems and activities, as well different kinds of access to the various hardware and software at their disposal (Smith, 1999). The right implementation of new technologies in the educational procedure can bring about very positive and worthwhile results to the whole student population, and in particular for students who have additional learning difficulties or disabilities, and are part of the ordinary classroom (Demetriou, 2009). It can bring forward motives for learning and can take into consideration the ideal environment and style of learning for every student individually.

As mentioned above, every single classroom in all schools in Cyprus, is equipped with at least one computer with full high-speed internet access, a colour printer and a scanner. Every school has at least one computer cluster in a dedicated classroom which is available for all students and teachers. ICT has been included as a compulsory part of the curriculum for either primary or secondary students in Cyprus. However, the majority of in-service teachers have not trained on how to introduce ICT into their teaching, since in-service teacher training in educational technology is optional. Therefore, many teachers that have been asked to integrate technology into their teaching without any training on how to use the technology.

The model of a single-computer classroom faced, and still faces, various forms of criticism. Mavrou (2005) states that not much research has previously taken place, but, from her experience and point of view, the introduction of ICT in classrooms has created mixed feelings of both enthusiasm and fear within primary school teachers. Nevertheless, Cypriot teachers struggle to implement ICT in their instruction, and there is generally a great effort put in to developing ideas and the most effective ways and efficient application of the single-computer model. Kasoulides (2001) discusses the *"prospect of a restriction",* that is to say, the use of the restricted resources in teaching in a more efficient way. His suggestion could be generalized for the case of Cypriot primary schools with the single-computer model. He suggests the use of computers for supporting children with SEN in the mainstream classroom, similarly with Demetriou (2009), who suggests the use of ICT for differentiating the teaching for students with learning difficulties. Yet, in practice there is generally much use of computers for working in groups of students, due to the relative scarcity of equipment at schools (Mavrou, 2005). Thus, students usually have to work in groups on computers due to scarcity, rather than each student having an individual computer to use.

Given the above briefly described educational settings of Cyprus, a consideration regarding ICT and inclusion has emerged - could we suggest a way of using the single computer in the mainstream classroom in order to more effectively include children with special needs, by increasing their classroom involvement and peer interaction? Mavrou (2005) suggests the use of the single-computer model, for collaborating learning in pairs or groups, with the participation of integrated child with SEN in these groups. She examines whether the collaboration of disabled and non-disabled children is effective regarding the socio-emotional perspective of inclusion (Crook, 1994). Particularly, Mavrou (2005) studies the types of verbal and non-verbal interaction in respect of the social and affective sides of collaborative learning (i.e., social acceptance, task involvement, inclusion), which are generated in computer-based collaboration of disabled and non-disabled children working in pairs in mainstream classrooms in Cyprus.

Vygotsky (1978) formulated the theory of human development. According to this theory, interactive and socio-cultural learning depends on “adult guidance” or “collaboration with a more capable peer” (Vygotsky, 1978, p.86). He poses one of the strongest grounds of the theory and practice of collaboration which can be generalised for collaborating learning in the classroom. Mavrou (2005) makes an analogue linking of the non-disabled peer as the “capable” student, which allows us base this on the Vygotskian theory for collaboration of disabled children with their non-disabled peers. Mixed ability pairs consist of a child with SEN and a child without SEN, and operate within one another’s proximal zones of development (Vygotsky, 1978). Thus, the interaction between two students influences their development, and therefore disabled children would most probably gain more from this experience than from working individually. Consequently, Mavrou (2005) suggests a model which moves the ideology of inclusion from a theoretical level to practical level, especially in the field of socialization and interaction with peers between the benefits of inclusion.

Moreover, according to the Piagetian view of social-arbitrary knowledge development, concepts of morality, values, and acceptance, develop through interaction. As a consequence, in collaboration of disabled and non-disabled students, the latter will develop skills of social acceptance, morality and values, especially related to disability, mostly through interaction with their disabled peers. Similarly, computer assisted learning has been identified as a promising way to adapt instruction to individual differences (Xin, 1999), and increases potential to meet individual needs as well as enhancing on-task social interactions of heterogeneous groups of students.

Studies such as those of Putnam et al. (1996), Xin (1999), Gillies and Ashman (2000), Demetriadis (2001), Mavrou (2005) and Solomonidou et al., (2004) are examples of research which support the view that students with SEN working together with their peers are motivated, more involved in tasks, and more accepted in their classroom community. However, research in this area deals mostly with more general collaborative learning approaches involving children with learning difficulties, and focuses more on achievement and cognitive development, marginalising in a way the affective and social aspects of such a collaborative condition (Crook, 1994, Dillenbourg, 1999). Further research and more empirical investigations in this field seem to be necessary, especially in the light of the rapid technological and other educational advances that constantly influence education (Mavrou, 2005).

Mavrou (2005) elaborated an empirical study in a mainstream school in Cyprus. She examined the interaction (verbal and non-verbal) between disabled and non-disabled students on collaborative computer-based tasks. Two pairs of students consisted of one child with SEN and one child without SEN respectively, and worked on collaborative computer-based tasks created by the researcher, using open-ended software (Clicker4 and ClozePro). Interestingly, she found that the collaboration helped students with SEN and increased their participation in the computer-based tasks, even though they did not have any previous training, and were not involved in any presentations or discussion of the basic principles of the collaboration. Training and experience in collaborative learning is very important for the successful implementation of any kind of collaborative learning, especially for students with SEN (Gillies and Ashman, 2000).

> Limited but not disregardful the results of the two Case Studies presented are optimistic for the use of ICT in collaborative learning for promoting inclusion. ICT is a way to promote interaction among students with special needs and their classmates in the mainstream settings. Interactions that yield involvement, participation, acceptance and motivation of disabled students, enhancing the right to education and inclusion (Mavrou, 2005; p.18).

Solomonidou et al. (2004) investigated whether the type and special characteristics of software, as well as the type of instruction method, influence the behaviour of Greek students with ADHD symptoms. Although Solomonidou et al. (2004) implemented both individual and collaborative learning with the use of computers for students with ADHD, this implementation did not take place in the mainstream classroom, but rather in segregated settings in favour of the experiment. Nonetheless, the findings are very interesting and show both advantages and disadvantages of individual or collaborative learning by using ICT for students with ADHD, and also show the suitability of several ICT applications, as well as educational software, for these populations. It was found that specific characteristics of the educational software used by pupils with ADHD symptoms stimulated their attention more than pupils without ADHD. The findings of Solomonidou and colleagues (2004), support the literature suggesting that ICT can indeed have a positive effect on users with ADHD problems. However, they strongly suggested that this effect is succeeded and expanded if the appropriate software environment is used.

Xin (1999) examined the effects of collaborative learning in mathematics to integrated students with SEN and their peers in the USA, with the use of computer-assisted instruction. Students were allocated into two groups: whole-classroom learning, and group-collaborative learning. Educational software was designed to support students learning several mathematics skills, such as problem solving, application, computation and concepts. He found that children with SEN, in groups with the assistance of computers, outperformed children who worked in the whole-classroom settings with the assistance of ICT. In terms of social outcome as a result of the cooperation, the researcher did not find any statistically important differences between the two learning settings. Yet, students with SEN expressed their preference to be included in the mainstream classroom when they were embraced and accepted by their fellow-students. Xin (1999) proved what Davidson (1994) and Mavrou (2005) stated, that collaborative learning promotes integration of students with and without SEN through positive peer interaction and healthy team cooperation.

Additionally, according to Xin (1999), computer-assisted instruction provides individualized instruction permitting learners to monitor their speed on a moment-by-moment basis, supplies immediate feedback through which learners can monitor their response accuracy on each question on the screen, and also provides immediate reinforcement to motivate continuing on-task behaviour - evidence that agrees with Solomonidou et al. (2004).

Computer-based instruction has the potential to meet the individual needs of each student, and boost the on-task social interactions of a diverse group of students. Also, the combination of computer assisted instruction and collaborative learning instruction confirms that pairs or groups of students working together reaches enhanced learning outcomes in mainstream classroom environments (Light and Blaye, 1990). Mevarech (1993) also argues that a cooperative social context can benefit both high and low achievers, and develop their individual accountability and attentiveness, although his research focused mainly in mainstream classrooms without students with SEN.

Xin (1999) concludes that computer assisted structure and collaborative learning strategies may improve students' performance either they have SEN or not.

> When learning situations are structured cooperatively, regular and special education students can work together in pairs or teams. Students support and help each other to encourage themselves to accomplish their learning tasks. They learn to accept different views from their team members, understand, and learn from each other. They also learn to play a role of an active collaborator within teams. This learning experience may motivate students with and without disabilities in their academic achievement and social skill attainment in schools (p.67).

The results of the Xin's (1999) study point out that a computer assisted collaborative learning approach can help teachers to structure the integration of each student as they work toward their academic attainment and social relationships between their fellow students in the mainstream classroom.

2.13 Dyslexia and assistive technologies

Until recently, there has been a tendency to either disregard or question the ways in which students with SEN can improve their learning with the use of ICT in education. Many hold the view that people with dyslexia can improve their learning by using computers without inhibiting other learners. The suggested ideal solution seems to be the use of multiple media employing several senses aiming to achieve an improved comprehension of the information presented. The plethora of benefits that have arisen from multiple media means that there is an ever-growing consensus among researchers of educational technology that learning materials should be designed for all types of learners and learning styles, including children with dyslexia, rather than being allowed to simply reflect the tutor's preferred style of teaching (Beacham, 2002).

Olson, Foltz and Wise (1986) initially adopted a computer training model for the remediation of dyslexia. They created a talking computer system in order to support children with decoding difficulties, which they described as *"reading with orthographic and segmented speech feedback" (ROSS).* ROSS provides children with stories on the computer screen. Children can see and listen to the words they do not recognise by targeting words with the mouse. Olson and Wise (1992) argue that their program is effective and that speech support enhances the ability of phonological decoding and word recognition. However, this particular intervention has not been successful among those with dyslexia with significant impairments in phonological awareness (Hulme and Snowling, 1997).

Over the years, a large number of programs have been developed to reinforce particular teaching points. Software could be valuable for an adjustment to individual needs, provided that the speed of presentation and response can be altered, the display is clear, the length of the game can be changed, the sound level can be shifted, the program saves the settings, it encourages the learner to work independently, and the word lists can be edited. The program's reaction when the pupil makes a mistake is also a substantial parameter (BECTa, 2000).

The computer-based intervention for dyslexia is mainly based on the principle that the implementation of computer programs can improve the learning experience for children with dyslexia. In addition, the use of technology in special needs education can counterbalance the negative effects endured by students with dyslexia by providing them with the support they need in their phonological learning deficits (Cammarata, 2006).

> Research suggests that dyslexic pupils are more likely than most of the population to use ICT when they leave school and so it is important that they are equipped with the necessary skills that they will need in future life. This principle of consistency also pertains to software, where industry standard software should be used. This ensures that the pupils will already be familiar with it in the future and know best how to use it to suit their needs. This gives them equal access (Keates, 2002; p.16).

Research usually advocates the multi-sensory methods of teaching for children with dyslexia such as integrated visual, aural, tactile and kinaesthetic modalities, as consolidations for the learning experience. This approach demands well-structured, sequential and cumulative lessons which are difficult to arrange without the aid of assistive technologies, and without the implementation of computer activities making the learning procedure more fun. Phonics-based multi-sensory teaching seems to be extremely crucial and effective, especially for primary school pupils. There is a large amount of software that supports displaying the difficulties of students with dyslexia with writing as a result of cognitive and short-term memory weaknesses. Writing may be the hardest challenge that students with dyslexia are up against because it has heavy demands on cognitive processes, especially on the memory. “The use of word processing enables the dyslexic child to produce a greater amount of better quality written work because it reduces memory load and facilitates self-correction; for example, the use of spell checker. A *talking word processor,* which will repeat back the text that the child has entered, enables dyslexic children to become much more independent when writing, as they can problem-solve their own mistakes. Examples of recommended talking word processor programmes include *Inclusive Writer, Pages, Write:Outloud,* and *textHELP! Read and Write”* (Singleton et al., 2003; p.10).

There are many interesting and useful computer programs for learning and support of pupils with dyslexia of all ages on the market. Usually, when the range of choice is so high, teachers are faced with the problem of trying to decide on the most adequate and appropriate piece of software amongst the hundreds advertised in the educational software catalogues. Some software aims to enhance the study skills of a person with dyslexia, while other seeks to develop the phonological processing skills. Similarly, some software may focus only on the development of auditory and visual memory, or on the developing of phonic decoding skills (Keates, 2002). Teachers are usually interested in obtaining more information about this software, and contemplate on its usefulness before acquiring it for their teaching purposes. Some software is available to download from the web as free or demo versions. McKeown (2000) advises teachers to not consider labels advertising programs suitable for dyslexia, visual impairment and so on, since for the most part, they turn out to be useless. Rather, teachers should consider the individual needs of their students in order to choose the best assisting software available. In other words, teachers should be able to generalise and apply the information to their own situation. For example, the individual needs of people with dyslexia often differ from one child to the next, since one child may have difficulties in particular aspects of writing or spelling, whereas another child may face problems with reading (McKeown. 2000).

Ecalle et al. (2009) state that "recent advances in computer aided learning environments offer new support in the task of reading acquisition. Digitized and high-quality synthetic speech is incorporated in programmes focusing on phonological awareness and issues related to letter-name and letter-sound knowledge, phonological decoding, spelling, and support for word decoding and comprehension while reading and writing stories" (p.5). The computer-based intervention is mainly based on the principle that the implementation of remedial computer programs can enhance learning experiences for children with dyslexia. Moreover, the use of technology in special education can counterbalance the adverse effects endured by students with dyslexia by providing them with the required assistance as far as their phonological learning deficits is concerned (Cammarata, 2006).

Furthermore, according to the cognitive approach of dyslexia, people with dyslexia lack the mental resources in order to process the phonetic features, both in the visual and auditory modes. According to Magnan et al, (2004) and Ecalle et al. (2009), the computerized interventions essentially facilitate the association process between these two units. There has been a considerable amount of evidence demonstrating that the number of computer-aided learning supporters constantly rises. Computer-based approaches for the remediation of dyslexia are techniques which are exceptionally ground-breaking, innovative, promising and flexible. They are distinguished by a variety of dynamic characteristics, particularly for enhancing phonological awareness (Magnan et al., 2004). In addition, "the qualities of computers that are relevant to instruction in phonemic awareness included digitized speech and high-quality graphics, immediate feedback and game-like presentation to maintain child interest" (Mioduser, Tur-Kaspa, & Leitner, 2000, cited in Magnan et al, 2004; p.132).

Evidence also supports that a child with dyslexia needs to be taught on an individual basis or within a small group, where the teaching will be differentiated and adjusted to its special educational needs. In accordance to this, Wise and Olson (1995) argue that computer-based interventions allow individual training, but do not replace the interactive relationship between teacher and student. Nevertheless, the computer provides the child with accurate further feedback directly, as well as the print exposure "that is needed to improve fluent and flexible word recognition in the individual child, whilst releasing the tutor so that he/she can directly train another child in phonological and decoding skills" (p.175). Hawkridge and Vincent (1992) argue that the provision of personal computers, or generally of ICT, must be set according to the needs. "The aim of ICT in SEN settings could be considered to be meeting the individual needs of pupils with SEN via *an appropriate personal technical infrastructure.* The provision of appropriate technical infrastructure requires a consideration of the key principles of learning and teaching, as well as the identification of individual learning styles and approaches" (Watkins, 2004; p.164).

Nowadays, more contemporary technological equipment, such as tablets, can be used for the facilitation of the learning process of students with dyslexia. The touch-screens make navigation easier and more game-like. Many applications and web-based learning environments can be run through tablets at the same time, with no large investment in additional devices or software (Gasparini and Culén, 2012).

2.14 ICT, dyslexia and mathematics

"This chapter will be out of date by the time this book is published" (p.263) as Rooms (2000) masterfully claimed in a chapter in an edited book on educational technology. Technology advances at a swift pace. A rapid technological development is noted across several domains. These changes influence the use of ICT in education to a great extent (Hitchcock, 2001). ICT constitutes the ultimate tool for the best access to the curriculum for every learner (Loveless and Ellis, 2001). Therefore, I will not review the available software and educational programs available for students with dyslexia in the field of mathematics, since they continually change on a regular basis, but I will discuss the general role of ICT in supporting these populations in teaching mathematics in the mainstream school.

Briggs and Pritchard (2002) highlight the need to use ICT daily in mathematics lessons. ICT can enhance good mathematics teaching but is not a panacea. It should only be used if it supports good practice in teaching mathematics in particular lessons. Thus, any decision about using ICT during the instruction of mathematics must be related to the learning objectives and the subject. In addition, ICT can be used if the teacher or student can achieve an objective in a more effective way with the use of ICT, than without it, otherwise there is no need to use ICT if there is no any additional value in the subject of mathematics. At this stage, I will review the additional value of ICT in mathematics, and will focus on the value of ICT in WMPS for students with dyslexia.

According to the National Council for Educational Technology (1997), ICT can support learning in mathematics through continuous feedback, the observation of patterns, the exploration of data, opportunities to teach and guide on the computer, instead of the opposite and the development of visual imagery. As far as feedback is concerned, the computer can give impartial and non-judgmental feedback that can help students to learn, since feedback constitutes a part of the learning process. According to Clements (2000), among the unique contributions of computers is the fact that they provide students with an environment for testing their ideas and providing feedback. In fact, feedback is crucial for learning, and technology can supply this feedback (NCTM, 2000). Computer-assisted feedback is one of the most effective forms of feedback, because “it helps students in building cues and information regarding erroneous hypotheses”; thus it can “lead to the development of more effective and efficient strategies for processing and understanding” (Hattie & Timperley, 2007; p.102).

The literature suggests a plethora of uses of ICT in mathematics. For instance, it can help students to practice and consolidate number skills and can explore, describe and explain number patterns; students are able to take their first steps in mathematical modelling by exploring, interpreting and explaining patterns in data as well as experiment with and discuss patterns in number and shape and space; develop logical thinking and learn from immediate feedback; make connections within and across areas of mathematics; develop mental imagery and write simple procedures (TTA, 1999).

Much has been written about the benefits of computer-assisted instruction in special education, but relatively few studies have produced conclusive findings related to math instruction for students with dyslexia. Much of the mathematics and computer research has involved investigating software programs designed to provide practice with computation skills. For example, extended practice using computers has been shown to support increased automaticity in basic mathematics tasks for students with dyslexia. Several other researchers have been interested in comparing simple drill-and-practice software programs to more lively game formats for building acquisition and fluency skills. Some studies have revealed that both practice formats are effective, whereas others have suggested that drill-and-practice programs are better than game programs (Babbitt and Miller, 1996).

There is a large number of software and educational programmes that can be used for supporting students with dyslexia, with difficulties in mathematics in the mainstream classroom. Teachers should consider the particular needs of the learner when planning and teaching any lesson. The same occurs when the teacher plans to incorporate new technologies in the instruction. Briggs and Pritchard (2002) classify the various software as a tutor, a simulator, or a tool. “A tutor teaches something; a simulator puts the user in a different context of some sort, perhaps imaginary, or perhaps a construction of a real situation; and a tool is a means by which a job might be completed more easily” (p.23).

An additional way to classify software is based on content. Thus, it is possible to classify most software as either content free or as content specific. Obviously, content-free software does not have any specific content. This kind of software can be used for certain activities such as constructing graphs, communicating, writing, drawing and other jobs that could not be carried out without the help of new technologies. Examples of content-free software are several drawing and graphic programs, web browsers or search programs in general, multimedia design programs such as webpage creation tools, desktop publishing programs, hypermedia programs and the well-known logo (Briggs and Pritchard, 2002). Content-specific software focuses on a particular subject. Such programs are written and designed to encourage the learning of particular mathematical topics, introducing ideas and skills, practicing and reinforcing and problem solving (Briggs and Pritchard, 2002).

Within the complexity that characterizes problem-solving activity, D'Amore and Zan (1996) identify the involvement of three interrelated discrete variables, as follows: the subject who solves the task; the task; and, the environment in which the subject solves the task (Kolovou et al., 2008). Where early generation software simply imitated paper-and-pencil tasks, recent research shows that suitable tasks in rich ICT environments can also bring about higher-order problem solving (Kolovou et al., 2008). For example, Bennet and Persky (2002) claimed that technology-rich environments tap important emerging skills. They offer us the opportunity to describe performance with something more than a single summary score. Furthermore, a series of studies indicated that the use of ICT facilitates the assessment of creative and critical thinking by providing rich environments for problem solving (Harlen and Deakin, 2003).

Beyond the assessment of students' cognitive skills in WMPS, ICT can help us to teach cognitive and meta-cognitive strategies (Way and Beardon, 2008) following a five-step problem-solving model, suggested by Krulik and Rudnick (1987) as described below. ICT can be used to prompt and cue cognitive processes that will help students successfully perform each of these steps (Babbitt and Miller, 1996). Programs that incorporate text, graphics, sound, animation, and video, hold promise for the development of sophisticated problem-solving software (Babbit and Miller, 1996). For example, Miles (1992b) suggests the picture drawing, the re-writing of the question in their own words, making notes of given and asked details, and labelling a drawn picture, as useful strategies for WMPS, that can be accommodated more easily with the use of ICT.

2.14.1 Teaching Problem Solving to Students with Dyslexia

At this point I will explore the teaching approaches to WMPS for students with dyslexia, and how the use of ICT can facilitate it, especially those populations.

A variety of strategies have successfully been used to teach problem solving. It is interesting to note the similarities across the strategies. The most critical components among these strategies seem to be reading the problems carefully; thinking about the problem via self-questioning or drawing, visualizing, underlining, or circling relevant information; determining the correct operation or solution strategy; writing the equations; and computing and checking the answer (Babbitt & Miller, 1996). However, there is a disagreement about the effectiveness of teaching problem solving programmes, although recommendations regarding problem solving are not clear (Gifford and Rockliffe, 2012). For example, Yeo (2003) found that teaching contextualized problems is not an effective approach, while Willey and Holliday (2007) concluded effective outcomes of the Realistic Mathematics Education scheme for students with dyslexia.

Another example of a popular teaching approach for solving word problems has been the keyword method. Students are taught to look for certain cue words (for example, *how many more, altogether, less)* in their word problems. They are taught that these keywords frequently indicate the operation that they should use to solve the problem. However, this approach has been criticized because the keywords do not always cue the appropriate operation; thus, student errors are likely to occur. Current research on problem-solving approaches for mathematics indicates that students need to learn to attack word problems in a systematic and strategic manner (Babbitt & Miller, 1996).

Using the computer to teach problem solving to students with dyslexia

According to the Principles and Standards of the National Council of Teachers of Mathematics (NCTM, 2000), technology supports decision-making, reflection, reasoning, and problem solving.

Currently, computer programs and applications that incorporate text, graphics, sound, animation, and video hold promise for the development of sophisticated problem-solving software in which mathematics instruction can be enhanced in several ways (Babbit and Miller, 1996). Multiple representations of information in a variety of formats have been found to result in better retention and retrieval (Paivio, 1971). In addition, facilities which give the user instant access to multiple resources (for example, synthesized speech, definitions of terms, mathematical diagrams) on a need-to-know basis.

Because research on the development of effective problem-solving technology for students with dyslexia is limited, it seems that a viable approach to increasing contributions in this area would be to apply what we know about effective problem solving instruction to the development of relevant computer software. Such an approach would provide a foundation for further study and refinement of current knowledge (Babbit and Miller, 1996).

The teaching of cognitive and meta-cognitive strategies has been advocated to remediate poor problem solving performance among students with dyslexia. New technologies can be an effective tool for supporting the use of specific cognitive and meta-cognitive problem-solving strategies. For example, in Babbitt's and Miller’s (1996) six-step problem-solving model, the student is taught to (a) read the problem, (b) understand the problem situation, (c) choose a solution strategy and solve the problem, (d) check to make sure that the question is answered, (e) check the reasonableness of the answer, and (f) consider applications and extensions of the problem. ICT can be used to prompt and cue cognitive processes that will help students successfully perform each of these six steps.

Given the difficulties faced by students with dyslexia in WMPS and the facilities that ICT can provide for the accommodation of such tasks, a question arises whether the student with dyslexia is able to understand and solve a mathematical problem by selecting and applying solving strategies, and following the five-step problem-solving model suggested by Krulik and Rudnick (1987), as described above. What can ICT do to facilitate these difficulties? The following table is an attempt to correspond the stages for WMPS with the difficulties encountered by the students with dyslexia and the role that ICT can play in each stage.

Table 2.1 5-step model for WMPS and the role of ICT

Stage of Problem Solving	**Dyslexic type difficulty**	**The role of ICT**
Comprehension: careful reading	Reading Difficulties	Simplified restatement of the problem. Audio version of the problem. Links to synonyms. Links to simplified definitions. Text with pictures, replacement of difficult or key words with a picture. Saying the problem in simpler way in own words.
Comprehension: problem data (question, information, numbers)	Difficulty in finding given information and question of the problem	Tools for grouping given details and questions. Capability of different labeling of given details and questions. Representation of data with images, sounds, drawings, diagrams, graphs, mathematical symbols. Visualization of the problem, concept mapping.
Investigation: Organisation of data	Difficulty in organizing given information. Weaknesses in choosing useful details	Tools for grouping given details and questions. Capability of different labelling of given details and questions.
Investigation: Design of solving plan	Difficulty in organisation, weaknesses in memory	Examples, auxiliary indications.
Choice of suitable strategy	Weakness of memory, weakness in recalling strategies, unawareness of	List with various strategies with explanations and examples that facilitate short-term memory, feedback.

	problem solving strategies	
Problem Solution	Weakness in implementing problem solving strategies	Explanation of strategies, visualization of strategies, implementation by using diagrams, pictures, tables, drawings, etc.
Checking the solution	Weak self-esteem, reduced likelihood for checking the answer	Feedback, positive encouragement, re-representation.

2.15 Summary

The purpose of this chapter was to present a review of the conducted literature in the areas covered by this study. The literature review started with the provision of general information about the Cypriot educational system, where this study focuses on. After a brief discussion about the notion of inclusion, information about special and inclusive education in Cyprus was provided through a brief historical review, which then leads to the current situation. An extensive literature review followed concerning dyslexia as a developmental disorder. Several definitions were provided and discussed, as well as theories about dyslexia, the etiology, and the main difficulties encountered by people with dyslexia, according to the literature. Then, the current situation in Cyprus in terms of dyslexia was discussed, which was useful in the selection of the definition adopted for the purposes of this study. Afterwards, the connections of dyslexia with mathematics were reviewed, and the difficulties of students with dyslexia in mathematics were presented.

Next, the place of mathematics in the Cypriot national curriculum was reviewed and followed by the presentation of the main difficulties of students with dyslexia in WMPS. After the provision of a brief definition about ICT and the review of the position of ICT in the Cypriot educational system, the chapter continued with a review of the use of ICT in special education in Cyprus, and the role that new technologies can play for differentiation, especially for students with SEN, and the potential of using the single computer in the mainstream classroom for this purpose. Afterwards, an overview of the use of assistive technologies for dyslexia was presented. Such reviews lead to the connection of dyslexia and WMPS with ICT, and the approaches towards WMPS with the use of new technologies for students with dyslexia that concluded the chapter.

The following chapter deals with the research methods, ethical considerations and instruments chosen for data collection.

Chapter Three
Constructing the Methodology

3.1 Introduction

The purpose of this chapter is to describe the aim of the study, and justify the research paradigm and approach by making connections with the peculiarities of conducting research with students with SEN. The issues of research design, validity and reliability, along with more ethical concerns, are also addressed. Then, the data collection instruments adopted in this study and the justification of their choice is reviewed. Finally, a short evaluation of my role as participant observer and interviewer, with respect to the validity of the findings, will be provided.

3.2 Aim of the study

Given the limited ICT resources available in the mainstream classroom, the difficulties of students with dyslexia in WMPS, and the potentiality of ICT in facilitating and counter-balancing the disadvantage of children with dyslexia in several aspects of their school life, this research aims to explore the potential of using restricted facilities of ICT for supporting students with dyslexia with difficulties in word mathematical problem solving in Cypriot mainstream classrooms and on an individual level. The research questions of this study were presented at Chapter One.

3.3 Situating the study within the research paradigm: qualitative research

My research project is a qualitative inquiry. Qualitative methodology typically involves an interpretivist approach to phenomena. An interpretive approach to research is undertaken in order to understand various phenomena from the perspective of the participants involved (Elliot et al., 1999, Merriam, 2002). It is characterized by the researcher's efforts "to understand the meaning people have constructed about their world and their experiences;

that is, how do people make sense of their experience?" (Merriam, 2002; p.4-5). Participant meaning is an integration of conceptions of what is real, and the manifestation of the particular phenomena of reality. Hence, qualitative researchers "are interested in how people make sense of the world and how they experience events" (Willig, 2001; p.9).

In contrast, quantitative research explores events from the outside and from the prism of empirical concerns based on social reality, but with little reference to the meaning of the observations for the researched subjects or their lived experience of the situation (Corrie and Zaklukiewicz, 1985). Qualitative procedures are often held from the inside point of view, especially for research in social world settings such as schools. Case study constitutes an example of this kind of research which involves interviewing, observation and documentation analysis in natural settings from the inside view (Gerring, 2007, Yin, 2009).

Special conditions and difficulties arise because of the particularity of research in special educational needs settings. Disability, per se, creates specific conditions for research, and special problems in the design, execution, evaluation and interpretation of such research (Schindele, 1985). The nature of special educational needs and the complexity derived from peculiar requisites compel the researchers to undertake a qualitative research and choose a case of child or children to study; the well-known *Case Study*. The limited potentiality of the generalizability of case studies may perpetuate these limitations, but still even their weakness to produce generally or universally applicable outcomes, this kind of research seems to be the most popular amongst researchers in education (Rose and Grosvenor, 2001).

Patton (1990) suggests the conditions that must be fulfilled in order to use qualitative methods in case studies. For instance, in special education a research project based on an individual interventional programme must emphasise individualized outcomes. We use qualitative methods when detailed and in-depth information is needed about certain clients and programmes, or in the case that the focus of our research is on diversity among special characteristics, idiosyncrasy and unique qualities exhibited by individuals. Also, when no standardised instrument is available in order to measure programme outcomes in terms of validity and reliability, qualitative methods of research seems to be more suitable. The nature of the conditions for qualitative methods in research, as suggested by Patton (1990), makes them more suitable for the research undertaken in the field of special education, where the subjects are unique, sample sizes are usually restricted, the diversity across different categories of SEN is broad, and even further widened within them (Mertens and McLaughlin, 1995).

Finally, research in the field of inclusive education mainly focuses on the holistic analysis of problems in policy and practice. It analyses and describes the experiences, attitudes, and thoughts of individuals that can mainly be explored by qualitative methods. Qualitative research stimulated the development and improvement of specific interventions in the field of special education that are responsive to the cognitive and motivational understandings of students, parents and professionals. They illustrated the cultural values, institutional practices and interpersonal interactions that affect practices in inclusive education (Peck and Furman, 1992).

The only quantitative method used in this study was the use of descriptive statistics for the analysis of test scores for the whole-classroom case study.

3.4 Case study

According to Mertens and McLaughlin (1995), the case study is one type of ethnographic research. It involves intensive and detailed study of one individual or a group as entity (Bassey, 2002, Yin, 2009). Case studies have played a significant role in special education research because they emphasize on the individuality which is a core notion in this field.

> Unlike the experimenter who manipulates variables to determine their causal significance or the surveyor who asks standardized questions of large, representative samples of individuals, the case study researcher typically observes the characteristics of an individual unit –a child, a clique, a class, a school or a community. The purpose of such observation is to probe deeply and to analyse intensively the multifarious phenomena that constitute the life cycle of the unit with a view to establishing generalizations

> about the wider population to which that unit belongs (Cohen & Manion, 1989; p.124-5).

3.4.1 Why case study?

One of the reasons I chose the case study as the methodological design of my research is that I implemented an educational programme in the classroom and individually, a fact that limits the size of the sample since it is not affordable in terms of time and resources to implement the same programme in more than two or three classrooms. In addition, the case study helps in focusing on the individuality of the case, and observes the characteristics of this individual unit (mainstream classroom or individual). Therefore, such observation allows probing deeply and analysing intensively the multifarious phenomena that constitute the lifecycle of the mainstream classroom, and individual students–before, during and after the implementation of the educational programme, with a view to establishing generalizations about the potential impact of the use of limited ICT resources for differentiation of the instruction in WMPS for students with dyslexia in the Cypriot context.

3.5 Ethical considerations

In any piece of educational research, researchers must always bear in mind the ethical principles that refer to the protection of human rights. Particularly in the field of special education, the rights of human subjects must be taken carefully into consideration due to the significant vulnerability of populations considered as having SEN. However, McNamee (2002) points out that little attention had been paid to applied ethics in educational research.

In this section, I will discuss several issues deriving from ethics in research in special and inclusive education. The review will be helpful in understanding and identifying the key issues that researchers should consider in this field of research, and the responsibilities of the researcher to participants involved in any piece of educational research.

3.5.1 Research in Inclusive education

Foster (1999) states

> Good quality research, which develops our theoretical and empirical knowledge of the world of education, is important, and if researchers are seen to conduct their activities unethically, then this research is less likely to get done and will not be given the consideration it should receive. Research, as with any other activity in a humane, open and democratic society, should be conducted within a framework of values (p.1).

But what does occur when conducting research in inclusive education? Inclusive education has had a strong ethical component since its inception because "it was developed largely from a commitment to the ethical requirement that all individuals be provided with access to a decent public education, regardless of how they might differ from the general population with respect to various skills, abilities and powers that affect school performance" (Mertens & McLaughlin, 1995; p.83-84). When conducting research in inclusive education, common methodological and ethical dilemmas become more complex, especially when the researcher focuses on vulnerable groups of children or youth (Valentine et al., 2005). "Research in inclusive education can raise complex ethical issues and the researcher needs to be aware of these and the ethical and legal responsibilities that arise from current research practices" (Sheehy, 2005; p.1). In fact, research in inclusive education usually aims to capture and understand the aspects of good practice. Since this field of research encompasses risks and threats because of its peculiarity per se, Nind and colleagues (2005) highlight the need to take into account the potential unforeseen ethical and methodological dilemmas produced by the context of the research from the beginning.

Beyond the ethical component of inclusive education per se, many ethical issues derive from any research attempt related to this field. For instance, the principles of consent, anonymity, protection of privacy, the right of the subjects of research to be informed of the purposes and nature of the research, and the right to independently make the decision on whether they wish to participate or not, become more complicated in special educational research. In the case of students with impairments or SEN, it is not always easy to request consent for participation in the research. There is a perceived likelihood that these children will not understand the purpose or the nature of the research, even if it has been explained sufficiently. Limited understanding and communication embeds the ability to give their real consent and understand the purpose of the research. Such notions are discussed in more detail below.

3.5.2 Ethical Practices

Rights of participants with SEN

Participants have some rights and the researcher has to take these rights into account at any stage of any piece of research (Le Voi, 2006). Included in these rights is the right of the subject to be informed of the purposes, processes, intended outcomes, and nature of the research, and the right to independently make the decision on whether they wish to participate or not (Masson, 2005). According to Lewis and Proper (2004), researchers should establish the value of their research to people with learning difficulties. In order to do this, they need to be clear about the aims and purposes of their research. They need to answer several questions, such as how the research will be useful; how it will contribute to the lives of people with learning difficulties; whether the research will bring about change; whether the participants could be harmed in any way through involvement (Tisdale, 2004).

Informed Consent

The most crucial notion of ethics in social sciences is the principle of consent (McNamee, 2002). All codes of ethics and statements of ethical principles place informed consent at the centre of ethical research activity, while most research institutions require informed consent in writing and approval from the institutional ethics committee before conducting the research (Burgess, 1989). Homan (2002) argues that informed consent constitutes a widely recognized moral obligation to respect the interests of the participants, which can be expressed in four elements; two of them are related to the process of informing and the remainder are related to the voluntariness. It is ‘informed’ because all relevant aspects of what is to occur or might occur are made known to the participant, and the subject must be able to understand this information. On the other hand, ‘consent’ implies that the participant will be given the chance to make a rational and mature judgment, and that the agreement to participate in the research should be voluntary, free of coercion and undue influence (Homan, 1991; p.71).

Confidentiality and Anonymity

Confidentiality and anonymity constitute a challenging issue in conducting research in special or inclusive education. According to Morris (1998), children and young people with learning difficulties are more vulnerable to abuse in research. In these cases, researchers need to be ready for many possible outcomes that can arise, and the same time they must ensure that their responses remain confidential.

One of the most crucial notions of conducting research in the social sciences, and especially with children with SEN, is confidentiality. It refers to the respect of the privacy of subjects and their families (Howe and Moses, 1999). Beyond the privacy, procedures are needed to keep data confidential. Nevertheless, Barnes (1979) asserts that “confidentiality is at risk from the very moment when the scientist is told or allowed to see something that would normally be hidden” (p.145).

A practical way to assure confidentiality is to anonymise the individuals. *Anonymity* is an additional principle and challenge of ethics in educational research. Although confidentiality and anonymity have similarities in terms of definition, the latter refers mainly to the need not to reveal information that traces back to the identity of the participant. Lewis and Proper (2004) state that some special conditions in a particular case make the discovery of the identification of participants easy. “Minority populations, which are heterogeneous in their characteristics, make it harder to make this promise. Moreover, provision may be bespoke or individual to a region making individuals easier to locate. Innovative projects are, by their very nature, likely to be unique and consequently highly identifiable along with the particular individuals who are part of them” (Lewis & Proper, 2004; p.7).

Alike, Lewis (2005) asserts that it is not easy to sustain anonymity when there are small and easy identifiable samples. For example, a child with dyslexia in a primary school in Cyprus is readily and effortlessly identifiable by just mentioning the name of the school, or by providing information that leads to school identification by the reader. Thus, it is important for the researcher to not reveal that information in order to protect the participant.

Ethical issues about this study

In this project, the participants were students with dyslexia, other than the teachers and special education teachers. Hence, it was important to consider ethical issues from the early stages of the research project, since it involves students, and particularly students with SEN. From the beginning of the research I had to take provisional decisions about the nature of the research, and the methodology, bearing in mind the ethical aspects of conducting research in inclusive education.

Firstly, it is important to note that the methodological approach that I implemented was *case study*. However, the case study features social life, therefore ethical issues are inescapable (Simons, 1989). This kind of research must be conducted bearing in mind the publics ‘right to know’, but also the individual’s ‘right to privacy’. In other words, the researcher not only has obligations in accessing data but also has obligations relating to their release.

Although the procedure of obtaining authorization for conducting research in schools is bureaucratic, there are some hierarchical steps that the researcher cannot escape. The first step was to obtain approval from the organization that I belong to. Thus, an application to the Ethics Committee of the University of Leeds was submitted. Research undertaken within an institution, such as in this case, needs to be approved by the institution’s Ethics Committee. If more than one institution is involved in the research, then the researcher has to apply to both committees; for instance, the university’s Ethics Committee and the School of Education. Applications to Ethics Committees cover areas such as the vulnerability of subjects, informed consent, risk assessment and confidentiality.

Therefore, after I obtained the approval from the committee (Appendix C), I contacted the Center of Educational Research and Evaluation of the Ministry of Education and Culture of the Republic of Cyprus, in order to gain permission for undertaking this research in mainstream schools in Cyprus. Permission was granted for two school years in a row (Appendix D). When I received authorization from the Ministry, I then contacted the schools that I wanted to work with. I explained the principles of the research project to the Head Teachers of the schools, asking their approval for accessing their particular institution to carry out my research. It was essential, before I started collecting data, to gain access and permission from all the relevant stakeholders beyond the Head Teachers, such as the staff, parents, and of course the children. I asked the Head Teacher to put me in contact with teachers, parents and children, and allow me to have access to the personal data of those children held by the school (Appendix A).

Once I obtained permission from the schools' Head Teachers, I then sought informed consent of the participants. The last stage of consent is the most crucial, since it is impossible to undertake any research without asking the participants who constitute the protagonists of the research. To begin with, the children, the parents, and the staff of the school had to be made aware of the implications of the research. This means ensuring that they knew that they had a choice as to whether to participate in the research or not, that they had the right to withdraw at any time, that they knew what their role in the research was, they knew what would happen to the data generated from the research, and they were made aware that it may be published (Greig et al. (2007). Furthermore, they were informed about the research's purpose, who was undertaking the research, why it was being undertaken and who was sponsoring it. However, I should not assume that once participants authorized their consent, that this meant that they were willing to give any information that they were being asked. Similarly, if access had been gained via a gatekeeper, this did not mean that all people within those settings were willing to be participants by proxy. I had to obtain their consent, each time I approached someone new for interview, observations and so on (School of Education - University of Leeds, n.d).

However, as previously discussed, according to the regulations, in the case that children are the subjects of the research, the researcher should ask the parent or legal guardian to give the consent on behalf of the child. Therefore, I composed an official letter explaining the purpose, aims, data collecting methods, and the procedure of my research project (Appendices A, B1 & B2). I sent the letter to the students' parents, asking them to sign and return it, in the case they agree and give consent for the participation of their child (Appendices D1 & D4). Nevertheless, I needed to recognize the rights of the individuals who could have agreed or disagreed to their involvement in research. Thus, I had to ask the students for their assent to participate in the research, beyond the parental consent. In order to reach this, I explained in simple and understandable language the aims and purpose of the research, the methodology that I was going to follow, their rights as participants, and my obligations to them as a researcher.

Finally, participants had the right to be informed about the outcomes and findings of the research in which they participated. I simplified the outcomes and made them more accessible. The figure below shows the steps followed from obtaining approval from two different ethics committees to the conduction of the research, and the information of the participants about the findings.

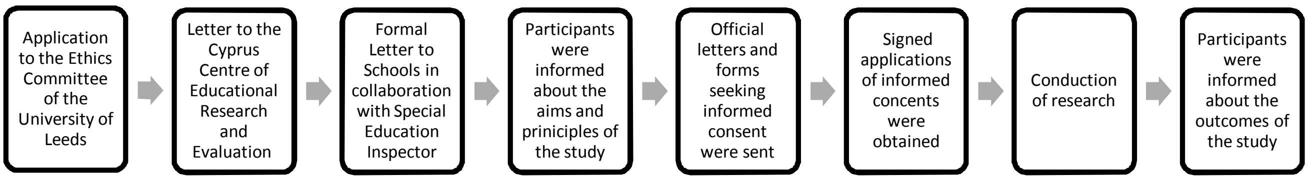


Figure 3.1 The steps followed for the conduction of an ethical research

In the following section, I will present the chosen instruments for the collection of data for the three different case studies of this project. The rationale for the selection of such instruments, how and when they were used, as well as some issues referred to in the literature concerning each tool, will also be discussed. In addition, the notions of validity and reliability will also be discussed.

3.6 Choice of methods

Different research methods have been chosen to suit the purpose of the study. Unlike quantitative methods, the qualitative methods, particularly observations and interviews, are direct methods that will provide close contact with the subject, events, and behaviours being studied, and therefore can enable achieving a 'real life' picture (Grosvenor and Rose, 2001, Campbell et al., 2004).

The designation of appropriate data collection methods is an outcome of a description of what constitutes the required data. Data consists of information that addresses and answers the research questions. Data approaches or methods must supply the means to do so. A consideration of the types of data required to answer research questions is a prerequisite to the selection of the suitable methods to collect it. There must be an agreement between data requirements and data methods. By bearing these in mind I chose to approach each one of the three different cases as case studies and the main instruments for data collection were observations, screen recordings, tests, and interviews before, during and after the implementations.

3.7 Rationale for the instruments used in the mainstream whole-class implementation

This section presents discussions concerning data collection tools, requirements and methods.

3.7.1 Interviews

The interview is an oral method of data collection in which at least two persons are involved. During the interview, the interviewer (the person who poses the questions) attempts to gather information about the thoughts, opinions, beliefs and ideas of the interviewee on a particular topic. Apart from these, interviewers can gather information on issues related to behaviour, feelings, attitudes and even demographics. Generally, the interview aims to collect any information related to the purpose and research questions of the research. Interviews were chosen for this study because more than any qualitative methods, they can allow pure information transfer, particularly when a good rapport is established with interviewees, and questions are posed in a good manner (Kitwood, 1977; cited in Cohen et al., 2010).

The interview was used as one of the main tools for data collection in this research. Interviews were conducted before the implementation of the interventional program, in order to obtain data necessary for the design of supportive educational software based on the specific educational needs of students with dyslexia. Also, interviews were conducted after the implementation of the interventional program in order to obtain data that lead to finding answers to the research questions.

The format of semi-structured interview employed in this study was hierarchical focusing. The objective of hierarchical focusing of research questions is to gain the required data while influencing, as modestly as possible, the interview's responses. Basically, it emphasizes the use of an open-ended and non-directive approach to interviewing. The interview agenda is developed as a hierarchical outline of major areas, with its branches consisting of general to specific inquiries. The point is that after the initial general question, the researcher should avoid an introduction of new, prepared questions until the respondent's expressions have been explored fully by using their terminology. The challenge is to match the respondent's language with the appropriate items of the interview outline, and to integrate these two features as further prompts and probes, thereby attempting to cover additional branch inquires. New questions were regulated by the items of those branches of the interview guide which have not been addressed. The development of a hierarchically arranged guide of interview questions would be related to the general research questions.

The interviews were conducted with three students with dyslexia, three teachers of mainstream classrooms, and the special needs teachers of each school. Especially for the whole-classroom implementation, some other students were also interviewed (Appendix E).

3.7.2 Observations

Observation was also a good source of data for this study. Its directness is very useful and helped in realizing the difficulties of students with dyslexia in WMPS, the potential of ICT during the implementation of the interventional approach, and any potential changes and developments after the implementations. Therefore, observations were conducted before, during and after the implementations of the computer-assisted interventional program.

Observation is one of the most direct sources for collecting data. It is an action that involves the researcher in the process of the problem's investigation, and helps in structuring the theoretical solution of the research. It is based on principles and follows a certain path towards attaining the objectives of the research. During the observations, everything related to study was recorded; for instance, movements, reactions, facial expressions, conversations, etc. The researcher decides upon the type of behaviour that he will observe, and devises a plan for the recognition, classification and registration of such behaviour (Papanastasiou and Panastasiou, 2005).

A major problem of observation is the observer himself. The observer can be the biggest advantage and the biggest disadvantage. The advantage is that the observer can correlate the observed behaviour with the variables of the research. The disadvantage lies in the fact that the observer may be wrong in this association, and therefore the given information may not correspond to reality. If the observations are not video recorded, there is a threat that the observer may omit several significant events for research outcomes (Papanastasiou and Papanastasiou, 2005). In this study, video recording was not used due to the unwillingness of the participating teachers. Nonetheless, all the sessions were audio-recorded.

An additional disadvantage is the time required to conduct observations. Due to the long period of time required for in-depth observations, the researcher is forced to limit the number of subjects for observation, which reduces the reliability of the results. Apart from the time, the researcher decreases the number of variables because of problems that occur when the researcher focuses on many variables (Papanastasiou and Papanstasiou, 2005).

The observational method of participant observation was used before, during and after the implementations of the whole-classroom case study. The activity of participant observation involves the researcher observing the naturally occurring behaviours of participants. I sought to observe and take notes of participant talk, actions and reactions in regard to the phenomenon under investigation. Also, pair and group work with computer software enabled students to articulate and explain their strategies and solutions (Wegerif and Dawes, 2004), provided there was a classroom culture in which students were willing to provide explanations, justifications, and arguments to each other that helped in observing behaviours, and ways of thinking and interaction between students, both with and without dyslexia, during the implementation of the program.

In the case of the two individual case studies, I acted as participant observer. In this type of observation, the researcher participates fully as an equal member in all group activities, while the team's members are informed about the presence and the aim of the researcher. However, during the observations as participant observer, the participants might deliberately hide some types of behaviour from the observer. This is a disadvantage for this type of observation. Also, the participation of the observer can cause a diversification of the behaviour of the participants.

The recording of data was based on free observation. In free observation, the researcher observes the subjects of the research for some time, and compiles the information later. However, this involves disadvantages because the researcher records a great deal of information that is usually unnecessary, and thus becomes difficult to be grouped and then analysed. I used free observation before, during and after the implementation of the computer-assisted program. Free observation helped in realizing the classroom's climate, the general interactions between peers and the class teacher, and the level of participation and general difficulties of the students with dyslexia during the instructions.

During the implementation of the computer-assisted instruction, audio recording was conducted. This choice was due to two main reasons. First, audio recording allows the exact recording of what is taking place, and therefore no problems arise in the reliability of the information used in the research. Second, participant observation does not allow the researcher to record his observations to the extent permitted by non-participant observation (Papanastasiou and Papanastasiou, 2005).

3.7.3 Screen Recordings

Beyond the observations and interviews, it was useful to keep records about what was happening on the computer screen while students with dyslexia were working on the computer. The rationale behind this came from a feeling that much of the information was presented on the computer screen, the feedback and procedure that was followed by the students, thus, it was essential to keep screen records. Screen recording gave the opportunity to re-visit the attempts of students on the computer, both audibly and visually, and to produce these resources with minimal effort and cost, which could not be done during the implementation.

Screen-recording packages capture the visual display and include audio recording. A software package known as BB-Flashback3 was used, which enabled the recording and editing of on-screen activity with associated audio (Bonnington et al., 2007).

Interviews, observations and screen recordings were combined to allow the production of richer data.

3.7.4 Pre-Tests and Post-tests

Tests are objective instruments for data collection. In some experimental designs, tests are administered before and after applying an interventional program or interventional instruction to determine the possible changes. Although the study is not based on the experimental design, two tests were administered, one before and one after the implementation of the interventional program, only for the participants in the case of whole-classroom implementation. The initial test (pre-test) assessed the understanding in solving mathematical problems and potential problems, or weaknesses, of students with or without dyslexia. After the implementation of the interventional program, a post-test was administered which re-evaluated understanding, skills in using cognitive and meta-cognitive strategies in WMPS.

Pre-tests and post-tests were administered to all students of the classroom whether they were considered as having dyslexia or not. Therefore, assessment of the level of the classroom as regards WMPS and comparisons between their performances before and after the interventional program were enabled.

The tests consisted of 4 WMPs, involving different solving strategies and levels of difficulty (Appendix F). The pre-test and post-test were the same. The advantage of using the same test before and after the implementation of the interventional programme was to ensure the equality of the two tests, therefore ensuring that the same variables and any potential change are measured, because of the implementation of the programme, which increases the validity of the test and proves the level of the effectiveness of the programme (Papanastasiou and Papanastasiou, 2005).

3.8 Validity and reliability

To ensure the quality of this qualitative study, the validity or trustworthiness, and reliability or credibility are considered. Various methods are used in triangulation and with various participants: students with dyslexia, students without dyslexia, mainstream classroom teachers and special education teachers. In all stages of the study and cross-sectionally, observations were conducted, and interviews and tests were carried out. These stages ensured that data was collected from a wide variety of sources and participants, so that it can be triangulated, and the trustworthiness of research is ensured.

Mertens and McLaughlin (1995) and Yin (2009) suggest the triangulation as a valuable strategy that can enhance credibility in qualitative research. Triangulation involves verifying the collected data from several methods, instruments or sources for the reliability of evidence across the resources of data (Yin, 2009). If the data collected using different methods do not agree, then we cannot be reasonably confident that we are approaching the true situation, and therefore have to be cautious (Gillham, 2000). Of course, “that does not mean that one set of data or any of them is wrong but that the picture is more complicated than we expected” (Gillham, 2000; p.13).

However, there are some threats to the credibility of case studies which I had to take into account. The events that took place during the interventional approach likely affected the outcome (Gillham, 2000). One of these was instrumentation, especially where the main instrument was observation (Mertens & McLaughlin, 1995). In observational studies, the researcher serves as the data collection instrument. But it is obvious that a human instrument does not always perform the same, thus, potential changes observed on the depended variable would be due to the nature of the instrument, and not the effect of the independent variable (Moyles, 2002). The same occurs with interviewing, especially when the participants are children defined as having SEN (Gillham, 2000). Audio recordings of observations, screen’s capture recordings and interviews assisted this situation.

An additional feature of research is the notion of external validity or generalizability (Yin, 2009). External validity refers to the extent to which findings can be applied to another situation (Mertens & McLaughlin, 1995). Nevertheless, generalizability is mainly used for large scale surveys. Although case studies are not very representative, they can tell us much more than simply idiosyncratic understanding, beyond the cases that were explored in this study. That is to say, theory arisen from a case study research can be transposed beyond the original sites of study. “Where case studies generate new thinking, that thinking has a validity that does not entirely depend upon the cases from which it is drawn” (Hodkinson & Hodkinson, 2001; p.11). In the terms of the generalizability of case studies, Corrie and Zaklukiewicz (1985) state, “while the study of several cases may increase the extent to which general statements are possible, a single case can also encompass generalization when repeated instances are found of the phenomena that forms the focus of interest” (p.127). It is a matter of fact, thus, that findings of case studies can reveal the reality in other similar settings, situations or circumstances. However, heterogeneity of the populations with learning difficulties may incommode the generalization of the outcomes, but still the case study of the implementation of particular interventional approaches may produce outcomes that apply to similar settings or circumstances. This argument allows researchers in the field of special education research to make suggestions based on their research findings.

Guba and Lincoln (1989) link the external validity of positivist research with transferability in qualitative research. They argue that in qualitative research, the obstacle of transferability depends on the reader and the degree to which they will determine the similarities between the receiving context and the study. “The researcher’s responsibility is to provide sufficient detail to enable the reader to make such judgment. Extensive and careful description of the time, place, context, and culture is known as thick description” (Mertens & McLaughlin, 1995; p.55).

Bassey (2002) prefers the term ‘trustworthiness’ instead of the terms ‘validity’ and ‘reliability’. The term ‘reliability’ especially turns out to be impractical for case studies which explore a particular case and therefore are not open to exact replication. ‘Trustworthiness’ constitutes a substantial characteristic of case studies which refer to the question of whether something really means what we claim it means (Bassey, 2002). Several factors and facts may threat the trustworthiness of case studies; for example, the multiple-treatment interference which happens if subjects receive more than one treatment during the study (Papanastasiou and Papanastasiou, 2005). The problem that arises in this situation is the fact that we are not sure which of the treatments has caused the change, or if the combination of treatments has influenced the result. In the field of special education, it is not possible to separate the effect of several treatments, therapies and interventions received by children with SEN. For this reason, it would be better to take into account the influences of other interventional programmes that are common in dyslexia, such as speech therapy, since any supporting sessions cannot be stopped in favour of the research for moral reasons.

3.9 Evaluation of my role as participant observer and Interviewer

Iacono et al. (2009) highlight the key role of the researcher in data collection due to subjectivity in the data collection, which is probably one of the main disadvantages of case research. However, some bias may arise from the influence of the researcher's beliefs over participants' behaviours and the impact of the researcher's beliefs. This complicates the procedure since the researcher needs to set up rigorous processes to ensure the validity of findings (Darke, Shanks & Broadbent, 1998). In this section, my role as participant observer and interviewer with respect to the validity of findings will be evaluated.

As far as my role as interviewer is concerned, various issues were taken into account in order to ensure the validity of findings. The question here arises as to what methods I followed as an interviewer in order to guarantee that what we think was measured through the questions asked actually what was measured. The main strategy followed for the validation of interview measures was to minimize bias to the extent that was possible. According to Cohen et al. (2010), "the sources of bias are the characteristics of the interviewer, the characteristics of the respondent, and the substantive content of the questions" (p.150). In essence, an effort was made to eliminate the influence of my attitudes, opinions and expectations as the interviewer in the posed questions. An emphasis was put on perceiving the responses of the interviewer in his own image, and not any desired-by-the-researcher image. In addition, any bias in seeking particular answers supporting predefined notions and any misconceptions of what the interviewees were saying were avoided. Also, attempts were made to ensure that the interviewees did not misunderstand any of what was being asked during the interviews.

The features of hierarchical focusing of the interview schedules helped to boost the validity of findings since the initial questions were non-directive, unbiased and open-ended. Closed questions were only introduced when the answers were very short and laconic, and therefore the interviewees needed more direction, but nonetheless answered unbiased questions. Especially, in the case of interviewing children, efforts were made to establish trust, overcome reticence, avoid formality, avoid any assumptions such as 'children know all the answers', overcoming any issues which arose from children's hesitance to talk, posing the questions at the right position, using understandable vocabulary, and bearing in mind the receiving and giving of non-verbal cues.

In addition, an attempt was made to move beyond what I wanted to hear in the responses, and attention was given to keep on point and avoid any chance for the respondents to see the interviewer as an authority (Simons, 1982; McCormick and James, 1998). According to Polkinghorne (2007), "participants will be more open to sharing their experienced meanings if they trust that the interviewer is open to accept their felt meanings without judgment" (p.481).

Finally, suggestions of Kvale (1996) about the skills that the interviewer should develop were taken into consideration. According to the author, the interviewer should conduct an informed conversation, structure the interview's stages to be clear to the participant, use clear and understandable terminology, allow plenty of time for the respondents to answer at their own pace, be sensitive and empathic, check the validity, reliability and consistency of the responses with the right questions and be capable in clarifying, confirming or modifying the comments of the respondent with the respondent himself (p.148-149).

Similarly, a brief evaluation of my role as participant observer before, during and after the implementations with respect to the validity of findings is provided here.

The potential lack of objectivity is referred to as the biggest disadvantage of participant observation. In this case, the researcher is more a participant than an independent observer while the under observation multifarious phenomena constitutes the subject of research. "The notion of participant observer does presuppose a degree of emotional detachment from the subject matter, the clear objective of the researcher being the conduct of the research" (Iacono et al., 2009; p.42).

Cohen et al. (2007) argue that the close involvement of the observer in the classroom may influence his judgements. According to Cohen et al. (2007), participant observation has to be accurate in terms of its internal validity verifications. Some techniques were employed in order to minimize potential threats of internal validity, ensure the representativeness of the observed events, and cross-check the validity of their interpretations when the main tool is participant observation. Notes were taken but mainly after the observations. For instance, there is a threat for the participant observer who focuses on present to be unaware of important events of the unexplored past. I avoided this threat, since I exploited the awareness of the special and classroom teachers who were present from the beginning of the school year for the interpretation of the observed events. The teachers had the privilege of being present and observing important antecedent events that I was not in a position to observe during my visits. In addition, many of the students might not have been representative in respect with the purpose of the study, therefore the main focus of the participant observations was paid on the group of the students with dyslexia and the students with dyslexia per se.

Also, my presence in the classroom and my participation in some activities during the instructions, may have brought about different behaviours. This is an additional threat to the internal validity of findings as a result of my role as participant observer. Again, this was avoided with the involvement of teachers in my attempt to record and interpret the observed events. The teachers were more able to ensure the types of which appeared odd and altered, probably because of my presence in the classroom. Finally, I tried not to 'go native', thus I avoided any kind of attachment with the focus group, any other group of students or even individual students. This ensured that no particular group or individual student was seen adequately objectively.

Fox (1998) refers to confirmability which is also known as objectivity and intra-observer reliability, which means that the observer who is the main instrument in participant observations has no in-built bias. However, "in a naturalistic paradigm, we have to accept that observer bias is a fact of life:

we all have values and we cannot wholly avoid allowing these to colour the way we interpret data in a qualitative analysis" (p.21). In order to minimise bias, I needed to recognise my bias at first. Fox (1998) suggests the useful role of informants to remind an observer of his potential biases. For this purpose, colleagues and supervisors were asked to offer alternative readings of the observation notes, as well as the audio recordings and computer screens' captures, and feed back any areas where my interpretations might have been biased. As mentioned above, the teachers' awareness was employed in several observed events in order to minimise the influences of my bias.

In addition, some ethical dilemmas. as anticipated. occur in participant observation. The subjects of the research should be investigated in a covert manner; while the participants should be informed of the nature of the investigation (Iacono et al., 2009). In my case, the participants were informed of my role, but the students considered me more as a teacher than an investigator of their behaviours. This helped to reduce any potential impacts on their behaviour because of my presence which was based on building a relationship of trust. It also helped in reducing cases of reluctant students or teachers participating in the project.

As mentioned above, my role as participant observer was somehow a disadvantage in comparison with non-participant observers, since my participation in classroom activities either before, during or after the implementations, prevented me from keeping detailed notes on time. However, this was overcome with the use of audio recordings and the computer screen capturing during the implementations. This allowed effortless revisits to the observed sessions.

3.10 Summary

The purpose of this chapter was to justify the adopted research approach by taking into account the aim of this research. Given the nature of the research questions and qualitative research paradigm in particular, the case study was selected for the project. Based on its purpose, the study is classified as predominantly descriptive with the case study approach being the main research method adopted as the project attempts to explore the extent that computer-mediated instruction can help students with dyslexia in solving WMPs in real classroom settings, or individualized settings in the mainstream school. The main adopted data collection techniques include interviews, observations, computer screen recordings, and tests. The issues of research validity, reliability and generalizability, along with more ethical concerns, were also discussed. The next two chapters (Chapter Four and Chapter Five) are dedicated to the description of the methods followed for the design and conduction of the implementations. The methods followed for the analysis of data will be described in Chapter Six.

Chapter Four
The work scheme of the whole-classroom implementation

4.1 Introduction

The purpose of this chapter is to describe the procedure followed for planning, designing and developing the work scheme for the whole-classroom implementations, which constitutes the first case study of this project. Emphasis is placed on the steps taken to design the WBLEs, and the principles taken into account for this purpose. The second part of this chapter focuses on the implementation of the work scheme by providing information about the school, the classroom, the participants, the structure of the six implementations, and the role of the teachers during the implementations. The chapter starts with a short section outlining the initial research design and subsequent amendments.

4.2 Designing the work scheme

4.2.1 Initial design and subsequent amendments

At this stage, a short section outlining the research design and subsequent amendments was provided. According to the initial design of this research project, the initial plan aimed at conducting three different case studies in three different mainstream classrooms in three different schools with three different students with dyslexia included. After the first case study, I realised that conducting of two more whole classroom implementations was almost impossible. The design of the WBLEs and whole classroom implementations were substantially time-demanding and produced a large amount of data which made the process of the transcription and translation of interviews, and observation notes and subsequent process of the data analysis more complicated. In addition, according to the initial design, the individual sessions with the student with dyslexia in the first case study would be conducted in parallel with the whole classroom implementations. The student with dyslexia would be given the opportunity to use WBLEs for WMPS as homework. Those word mathematical problems would be corrected the following day in the mainstream classroom with the teacher. Nonetheless, as mentioned above, the student's daily programme, as well as that of their mother, as well as the last amendments on the teacher's and school's schedule, prevented me from continuing with the parallel individual sessions at the student's home. Only one individual session was conducted with the student with dyslexia which was used for the evaluation of the WBLE. Therefore, the conduction of two more individual implementations with two more students with dyslexia was decided on instead.

It is important to note that the subsequent amendments on research design did not affect the initially posed research questions.

The figure below outlines the initial research design and subsequent amendments. The description of the procedure follows for planning, designing and developing the work scheme for the individual implementations will be provided in Chapter Five.

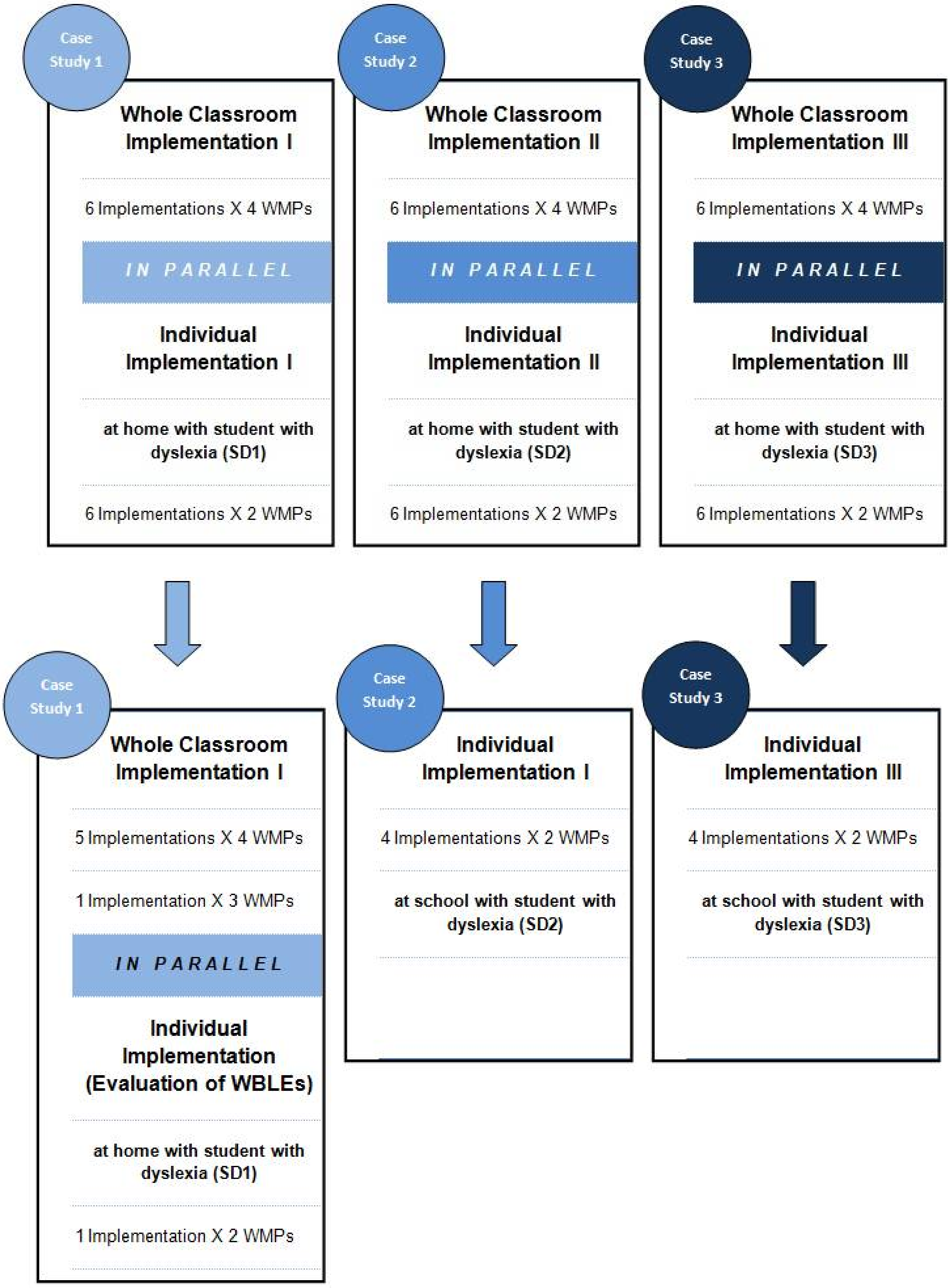


Figure 4.1 Initial Research Design and Subsequent Amendments

4.2.2 Plan, design and development

For the plan, design and development of the whole-classroom implementation of the project, I visited the chosen school more than 30 times. I also attended additional meetings with the class teacher (outside school and not during working hours also) for the interviews before and after the implementation of the program and the design of WBLEs.

The first time I visited the school, I had meetings with the headmaster, the class teacher, and the student with dyslexia. The meeting had an informative and negotiating character. I needed to clarify many details to the headmaster of the school, who gave more emphasis on the approval from the Ministry of Education and the procedures for gaining informed consent from the students' parents.

The teacher was positive from the first time we met. The first meeting was held in a friendly climate. She asked about several things, but her major concern was the amount of teaching time that was going to be affected. I secured that the program would be designed and based on her bi-weekly and monthly programming, which somewhat relieved her, but she still had this concern until the completion of the implementation of the program.

The teacher gave me the opportunity to introduce myself to the students of her classroom. I explained who I was and what I wanted from the students, who were then given the opportunity to ask questions. Their first reaction was positive, especially when they heard that we were going to work on the computers. I provided the students with an information sheet for their parents, with the form of informed consent attached, as well as an information sheet for the students, with an additional form of informed consent. I gave the same form to the student with dyslexia (so as not to cause any discrimination), but I contacted that student's mother separately on the same day, and provided her with a different and more-detailed information sheet, and signed consent form.

In cooperation with the teacher, we arranged a meeting with parents for the following week, so that parents had the chance to see a presentation about the research project, and then ask me any questions that they might have. A week later, I had 22 signed forms from the parents, and 23 signed forms from the students. Only one student had not brought the signed informed consent from his parents. Hence, we could not continue at this stage, since we had not thought of how to handle this exception. Nonetheless, I explained to the teacher that this was not a problem, and the student could participate in the lesson, however, I would not have the right to interview or record him, and therefore the student would not be a participant in my research project, but at the same time he would be a normal student of the classroom. The teacher insisted on seeking advice from the headmaster of the school as well as the educational inspector of the school on this situation. In the meantime, however, the parents of this student decided to sign the form after all, and so this problem was solved immediately.

However, another problem arose. The class teacher declined the use of any kind of video recording means during the lessons, before, during and after the implementation. After negotiations, I managed to convince her to use just audio recording, but automatically I lost the benefits that would have derived from video recording.

The research design was based on the case study approach, and the procedure was held in three stages:

During the first stage, data concerning the attributes, weaknesses, and attitudes of students towards the use of the computer and mathematics were collected. This took place in March and early April 2012. I visited the school five times in order to observe the students and the teacher during the instructions. Seven 40 minute observations were held during several lessons in the mainstream classroom. I also interviewed the student with dyslexia, the class teacher, the special education teacher of the school, and five other students of the classroom.

In addition, a pre-test was administered to all students of the classroom whether they were considered as having dyslexia or not. I was, therefore, able to assess the level of the classroom as regards WMPS. These lead to the identification of the particular characteristics of the students, elements that helped in the design of the learning environments on the computer, with the cooperation with the class teacher.

At the same time, we started the design of the WBLEs. Each learning environment was designed a week before its implementation. The cooperation with the teacher was not only held with face to face meetings. We communicated via Skype, using landline telephones, and cell phones. The WBLEs were designed on Weebly, a tool for websites creation. More information about the design and creation of the WBLEs will be provided in the next section of this chapter.

During the second stage, the implementation of the differentiated instruction with the use of the computer took place in the school's computer lab. The program was implemented from April to May 2012, in which nine 40 minute sessions (three 80 minute sessions, and three 40 minute sessions) were held. All of the sessions were audio recorded, and detailed observation notes were taken after each session. In addition, the computer screen of the group of students with dyslexia was captured during the implementations.

Students worked in groups of three and sometimes four. The initial design was to work in pairs with the use of the computer, but it was not possible because there were only ten available computers, and only six or seven out of the ten computers were operative. Instead of solving WMPs with the use of paper and pencil, students used the designed web-based learning environment which guided them to follow the various stages for WMPS, from the stage of understanding, to the stage of choosing the appropriate strategy, and then reaching the solution. The learning environment on the computer provided continuous and immediate feedback to students, while the teacher and I provided additional feedback to the groups. Students were sitting in groups, not only because of the limited number of available computers in school's lab, but also because of the benefits deriving from the collaborating learning.

The first four times that the program was implemented in the computer lab, students were free to sit in the group of their choice. This was an approach of the class teacher, as she promised that students could work on the computers with their particular friends. The negative consequence of this approach was the fact that no mixed-ability groups were formed. Therefore, some groups were weak and doomed to fail while other groups were stronger. After the first four times we asked the students to change seats and the teacher (who knew their abilities better than me) decided on the changes to make between the groups.

The student with dyslexia was sitting with his friends during the first four implementations. After the swaps, he was a member of a more balanced group. Onwards, I will refer to this group by using the phrase *'the target group',* and the pseudonym *Peter* instead of the phrase 'student with dyslexia'. It is important to mention that after the first time of the implementation, the target group used my laptop. The main reason for this was the fact that the operative computers were few, so it was impossible to create groups of three students, but also because it was important to record the screen of the computer while the students of the target group were working on it. It was not possible to record the screens of the computers in the lab because we needed to login as administrators of the computers. Also, the teacher was not willing to install any software on the computers due to their vulnerability. A software package called BB-Flashback3 was used, which enables the recording and editing of onscreen activity with associated audio (Bonnington et al., 2007).

During the third stage, data was collected for the evaluation of the program and the record of any potential changes in terms of attributes, attitudes towards WMPS, participation during the instruction, and so on. I administered the post-test which was the same as the pre-test. I interviewed four students of the classroom, Peter, and the class teacher. In addition, five 40 minute observations were held during the instruction of mathematics.

The described procedure is figured below.

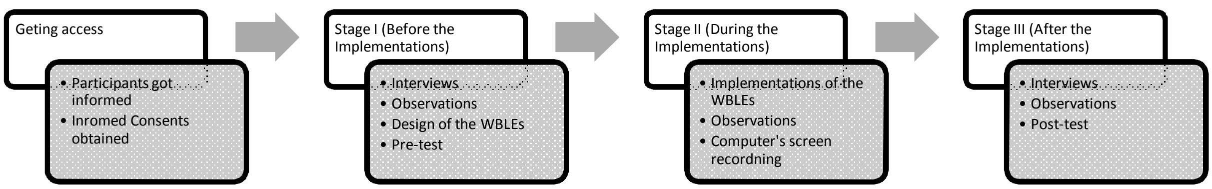


Figure 4.2 The work scheme for the whole-classroom implementations

4.3 Web-based learning environments

In this point, I will describe the process followed for the design of the WBLEs, and the main principles taken into account for the design of dyslexia-friendly learning environments.

A Web-Based Learning Environment refers to a learning environment (LE) which involves learners' interaction with web-based computer programs designed for particular learning content. When it comes to designing any sort of learning environment, the designer ought to have a pedagogic and design rationale in terms of the way that learners will learn through their WBLE, and take into serious consideration the characteristics and needs of the recipients of their learning environment, as well as the content that they will be learning prior to designing.

The design of the web-based learning environments for the purpose of this project was a lengthy procedure. For the design of the WBLEs we used Weebly. Weebly is a web building tool designed for 'non-techies', and offers a simple step-by-step website developing process that anyone can use to its fullest potential. Its editing interface allows users to easily and quickly "drag and drop" content into the currently open web page, which Weebly considers its flagship feature. Consistent with this design are also a blog editor, a simple method of implementing and customizing its library of themes, and a policy of no forced advertising on even free accounts' websites. Pro accounts include further capabilities, such as the adding of in-site audio or video content, and more features (Weebly.com., 2012). A pro version was used because it was not possible to imbed audio content with the free version.

In addition to Weebly, we used other programs available on the computers of the school, such as MS Word and Paint. The pictures and animations were taken from Google images. Copyright-free images were preferred, but in case there were no suitable copyright-free images, we used images by referencing the sources.

The design of learning environments was based on the five steps of WMPS, as suggested by Klulik and Rudnik (1987). We created different pages for each of the five steps (understanding the problem, investigation of the problem, choice of strategy, problem solving, and checking the solution). Navigation buttons were placed in the right bottom edge of each page for easy navigation of the WBLE. Each implementation contained four WMPs taken from the student's Maths textbook. The last implementation consisted of three WMPs. Individual implementations consisted of two WMPs per session. The designed WBLEs are provided in a CD attached to this thesis.

During this stage I will discuss the issues we took into account in order to design the web-based learning environments for this project. The figure below shows the eight principles.

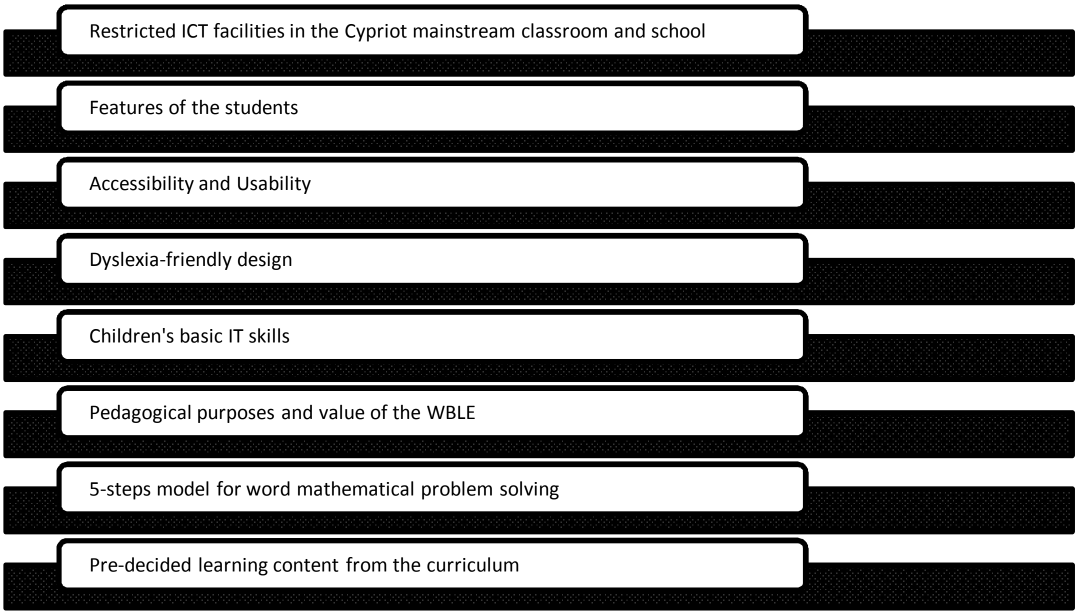


Figure 4.3 The eight principles for the design of the WBLEs

First, the web-based learning environments were designed by taking into account the restricted ICT facilities in the Cypriot mainstream classroom and school. This is the reason that it was decided to use Weebly to create the learning environment as a group of web-pages. Weebly is a free-to-use tool for web creation, which does not demand advanced knowledge of computer use. It does not involve programming languages, and its logic is based on drag and drop elements from the tools list to the under-creation web page.

Second, the features of the students were taken into consideration. The learners that would learn with the WBLE were 10-years-old native Greek speaking Cypriot students, and non-native Greek speaking foreign students in the mainstream classroom. Students in this classroom had mixed abilities, both boys and girls, and some of them might have had additional learning difficulties because of the lags in the language. According to Gifford and Rockliffe (2012), the individual strengths and weaknesses of students with difficulties in mathematics should be taken into account, as different teaching strategies may better fit in accordance to such difficulties. However, some authors argue that most students can benefit from effective strategies, and “the content of teaching program should depend on individual assessment” (p.7).

Third, the WBLE was designed to be accessible and usable. In terms of making the WBLE accessible, we took into consideration the principles of universal design. This would be succeeded by offering the users the opportunity to customize the learning procedure according to their own needs. For example, we had aural representations of all text in the WBLE, and also provided all pictures and links with alternative text. Thus, the learning environments were designed in a structured and consistent manner. Therefore, on each page we tried to not have more content than an ordinary computer screen can display, so scrolling up and down was not always necessary. In addition, each external link could be opened in a new window, so the primary page was not leaving the browser. That helped for the deduction of disorientation issues.

Fourth, the design should have been dyslexia-friendly. Since the protagonists of the research project were students who have been diagnosed as having dyslexia, the learning environments should have been designed by bearing in mind the particular characteristics of the students. A game-like design was used, based on Mayer’s multimedia principle, which refers to individual preferences in terms of the use of animation, auditory narration and text (Mayer, 2001). We tried speech out technologies but none of them worked properly in Greek language. It was then decided to accompany every text with attached audio recordings. The recordings were made with my voice. All important information, WMPs and instructions could be listened to, as computers cannot read or interpret graphic images. In addition, we tried to contain clear graphics and distortion-free text. Clear, simple, and consistent graphic navigational icons were used and flashing text avoided. Also, there was no variation in fonts, distracting sounds or many animations, and textured or patterned backgrounds. The background was black and the text yellow, with the chosen font easily readable (white background and black text colour in the first WBLE). Black background and yellow text were chosen in order to achieve a good contrast. The paragraphs were kept short where possible, and a small amount of text was used in each page. The text was left-justified, as it is very hard for people with dyslexia to read paragraphs where all lines are centred, or which are right-justified. A consistent layout and format was used throughout the site, as it helps to have navigation aids laid out consistently on every page. It is broadly accepted that sites which are designed to be easy for people with dyslexia are also easy for others to use and navigate. Market research shows that most people find it more difficult to read on a computer screen than from printed sources, so students without dyslexia will appreciate the dyslexia-friendly format (Dyslexia the Gift, 2012).

Fifth, we took into account the fact that by that age, children have basic IT skills and are able to manipulate the World Wide Web. In the interviews, observations and discussions with the students, the classroom teachers and special education teachers of the schools, I discovered that these learners were extensively exposed to ICT in their everyday life, mainly as they were born in an era where computing and the internet are expanding rapidly into the world. Therefore, it was not necessary to dedicate additional time for training in basic IT skills.

Sixth, we took into account the pedagogical purposes and value of the WBLE. The main purpose of the WBLE is to: “teach in such a way as to produce the most learning for the least teaching” (Papert, 1993). Therefore, students were actively involved in the process of their learning and were not passive recipients of informative knowledge. Since this WBLE involves mathematical problems, I adopted Papert’s (1993) perspective of teaching mathematics with the use of technology, and Vygotsky’s perspective of learning; individuals learn better when talking and doing, and then negotiating knowledge with peers through social interaction (Vygotsky, 1978). Therefore, we designed the WBLE by giving the opportunity to learners to first do and then discuss what they have done with their peers. In accordance to this, we took into account the principles of the Realistic Mathematics Education approach which is based on the idea of contextualised mathematical problem solving through the provision of visual and verbal access to mathematics. Hence, students develop their mathematical understanding through meaningful contexts (Dickinson and Hough, 2012). Visual and verbal access can be achieved with the use of the computer, and can be enhanced with collaborative learning, which helps students become involved in extended discussions and verbal reasoning (Gifford, 2006).

Seventh, I adopted Krulike and Rudnick's (1987) five-step model for WMPS in the web-based learning environment by contextualizing WMPs under real situation settings (Verschaffel et al., 1994). Additionally, it is suggested that computer manipulatives can help children learn, especially in situations where the mathematical concepts are abstract (Clements, 1999) such as this one that some children of this age still being at a concrete level of thinking (Piaget and Inhelder, 1969) cannot easily conceive. Therefore, we designed each step as a simulation of a contextualized real problem-based situation which makes sense in a child's everyday world. Each learner had the chance to read and listen to the WMPs, instructions and help, and share ideas, opinions and thoughts with the rest of the group within the interaction with the WBLE and group-mates. The rationale behind this action is mainly the fact that being socially interactive is a major characteristic of human nature and cannot be ignored, especially when it comes to educating young children. Vygotsky (1978) thoroughly explains that social interaction is vital for higher cognitive skills' development, and students' acquisition of certain ideas that they could not conceive otherwise on their own. Therefore, the main mean of knowledge acquisition was through interaction and collaboration. In this way students could negotiate knowledge and also, having in mind that the learners are different and come from different backgrounds and therefore have different ideas, some less able students can benefit and learn better from the scaffolding that they might get from their interaction with more able peers, and the other way around (Papert, 1999).

Eighth, the web-based learning environments were based on pre-decided learning content from the curriculum, due to not wanting to waste valuable teaching time which would cause deviation from the syllabus. However, there was a risk to just digitalize the WMPs of the textbooks without any additional value of the computer-mediated instruction. Since the design should have been attractive to students, we decided to create game-like learning environments. A game-like design increases motivation (Masson, 2005, Solomonidou et al., 2004). Since the WBLE was aimed at being used within a classroom (for mainstream classroom implementation), with specific learning objectives which refer to specific pre-decided learning content from a curriculum which the learners might not be interested in, the motivational considerations differ from those of a free access web-based learning material, where its entrance is chosen by the learners themselves.

4.3.1 Designing the WBLE

As mentioned above, the design of the web-based learning environments for the purpose of this project was a lengthy procedure. The design of learning environments was based on the five steps of WMPS, as suggested by Klulik and Rudnik (1987). Each implementation contained four WMPs taken from the student's Maths textbook. The last implementation consisted of three WMPs. The WBLEs were designed with the cooperation of the class teacher, and for their design we took into consideration the eight principles mentioned above.

The WMPs were chosen in cooperation with the teacher of the mainstream classroom. Bi-weekly programming of the teacher was followed and the problems were taken from the textbooks. The WBLEs were designed a week before their implementation. Six packages of WBLEs, including 23 WMPs, were designed with the cooperation of the teacher of the mainstream classroom for the purposes of the first case study. The first individual implementation and the first mainstream classroom implementation were used for the evaluation of the WBLE. An example of WBLE of a WMP translated in English is provided in Appendix F.

4.3.2 Piloting and evaluating the WBLE

Apart from the implementation of the program in the whole classroom, there was an additional supplementary part which was home-based. For this particular part of the project, only the Peter was selected, in order to investigate the potential of new technologies in WMPS for homework, especially for the particular student. Because of the large workload and the full schedule of Peter and his mother, it was not possible to implement an individual program for homework more than once. Therefore, I decided to use such individual implementation, for the evaluation of the WBLE. Also, the first mainstream classroom implementation was used for this purpose.

The evaluation of the WBLE was conducted within the multidisciplinary framework suggested by Nielsen (1993). The main issues within the evaluation framework are the usefulness of the learning environment which refers to its usability and utility. Usability includes the easiness to learn, efficiency of use, easiness to remember it, the provision of subjective pleasing, and the limited faults and errors. Utility refers to the added learning value and the pedagogical usability of the learning environments. In essence, we can talk about additional learning value when the learning environment provides organization of teaching processes, development of quality of teaching, development of learner’s skills and the development of educational ICT. Finally, pedagogical usability refers to the level that WBLE can support the organization of teaching and studying, the extent that can support learning and tutoring processes, and the development of several learning skills.

An additional core notion for the evaluation of WBLE is accessibility. It refers to the level that the web-based learning environment or any website can be accessible to people with or without disabilities. The design should go along with the Web Content Accessibility Guidelines (Foley and Regan, 2002).

The figure below presents the content of the term usefulness, as suggested by Nielsen (1993) and modified by Silius and Tervaraki (2003).

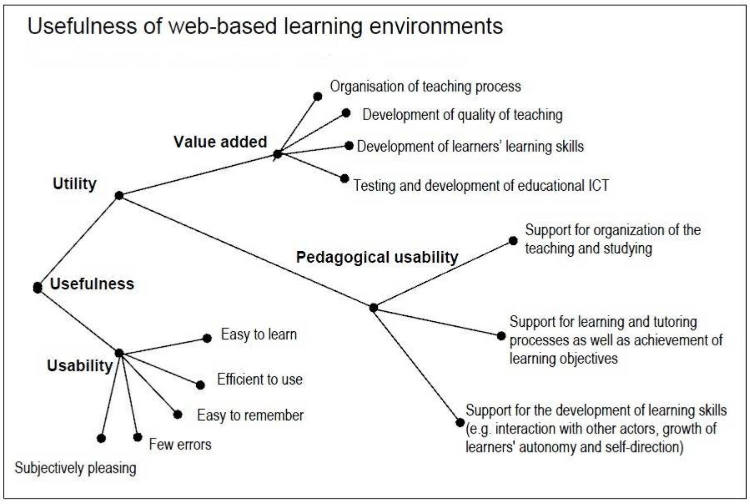


Figure 4.4 Evaluation of usefulness of WBLEs based on Nielsen (1993) and modified by Silius and Tervakari (2003)

Overall, I must admit that I was quite pleased from the comments that I received from both Peter and peers regarding the system's functionality. Their feedback helped to redesign the WBLE in a more suitable manner. For example, I noticed that WBLE was not running fast enough and its presentation was different when it was accessed from different internet browsers, such as Windows Internet Explorer, Mozilla Firefox and Opera, instead of Google Chrome. Also, some navigation buttons and links were not working properly. Therefore, the navigation buttons were replaced and the users were advised to use Google Chrome for running the WBLEs.

Generally, observations and feedback provided by the users helped in making improvements, especially in terms of accessibility and usability. The background colour and the colour of the text were changed in order to make it more dyslexia-friendly and accessible for everyone. Also, we worked to improve the quality of sound, and increased the number of available earphones. Therefore, more students had at least one earphone in order to listen to the WMPs, and the instructions. We also tried to make the WBLE more interactive by giving more chances to the users to discuss several choices. The provided feedback from the WBLE was enhanced, and the section of provided help was made more interactive.

4.4 Implementation of the work scheme

4.4.1 Outer context: School and surroundings

The school was chosen after gaining the advice of the special education inspector for the Districts of Limassol and Paphos. It was a public primary school in Limassol, the second largest town in Cyprus. It is one of the oldest primary schools of the town which launched its operation in the early 1970s. The school was chosen for this study, not because it was the most representative school of the town or the citizens of Limassol, but because it was one of the few schools where there was a student with dyslexia in the 5th grade, and his parents, the class teacher, and the headmaster of the school accepted to collaborate and participate in the research.

The school is divided into two levels: the lower and upper levels which consist of Grades 1 - 3 and 4 - 6 respectively. Each level had a different headmaster. The implementation took place during the school year 2011-2012. The school had a total of 288 students. The majority of students came from families with middle socioeconomic status, since the school is located close to an industrial area as well as the port of the town. In general, the west suburban area of the town is not very developed and there are many economic migrant workers and asylum seekers that live there. Therefore, a great amount of the students live in Cyprus as immigrants, hence they were not native speakers of Greek language.

4.4.2 More Information about the school

The school is included in the Educational Priority Zone, which is an institution that is applied to the Cypriot education, and is part of the "Plan for Educational Reform for the success of all children". According to this plan, the innovation of Educational Priority Zones derives from positive discrimination which occurs in the unequal treatment of inequalities, based on the priority needs of children.

4.4.3 Timetable

The detailed timetable of the school day is as follows:

Table 4.1 Timetable of Cypriot Primary Schools

7:45 – 8:25	Session 1
8:25 – 9:05	Session 2
9:05 – 9:20	Break
9:20 – 10:05	Session 3
10:05 - 10:45	Session 4
10:45 – 11:55	Break
10:55 - 11:35	Session 5
11:35 – 12:15	Session 6
12:15 – 12:25	Break
12:25 – 13:05	Session 7

It is important to note that all the implementations took place by the end of the school day. 40 minute sessions took place during Session 7, and the 80 minute sessions during Sessions 6 and 7, which are divided by the third break of the school day. The class teacher took the decision to make arrangements in the schedule, and dedicated only the last sessions of the school day for the implementation of the project. As she explained, she did not prefer conducting this exercise earlier in the day as she felt that this may waste valuable learning time. It is worth noting that students were not very cooperative during the last sessions of the day, especially after a full day of learning. It is obvious that the teacher underestimated the process and put the project outside the classroom’s priorities. I will discuss how this teacher’s approach affected the effectiveness and results of the implementations later on.

4.4.4 Ethos and climate of the school

From my visits to the school, I found a climate of humanitarian and democratic atmosphere with no climate of strict control or guardian. It was an open climate in which teachers collaborate together; they had the responsibility of their profession with the full support of the headmaster of the school, who did not seem to strictly control the teachers of the school.

This was obvious from the fact that the headmaster of the school explained to the class teacher her right to accept or reject her participation in the project. The school was operating under instructions, rules and regulations. The active involvement of the headmaster seemed to play an important role in creating a positive climate for the learning and development of healthy relationships between the members.

The syllabus for each subject and the curriculum were strictly defined by the Ministry of Education and Culture, and were therefore rigid and did not allow exceptions. As a matter of fact, the syllabus defined by the curriculum was excessive, which caused massive workloads for the teachers of the school. The latter gave the impression that their sole aim was to cover the requirements of the syllabus. Therefore, teachers often disregarded the goal of their instruction, a fact that affected teaching and learning. The strict curriculum lines were one of the main concerns of the teacher in taking the decision to participate or not in the project, because of her already massive workload.

4.4.5 Inner context: the classroom and computers' lab

Each classroom of the school was equipped with one computer, a colour printer and a projector. The school contained a computer lab. All implementations took place in the lab. Only ten computers were available in the lab and only seven were operative. In addition, a computer for the teacher was available. There were also three large colour printers and a projector connected to the computer of the teacher. The computers in the lab run on the Windows Vista operating system. Only two of those run on the Windows XP operating system. They were old computers with limited RAM and limited capabilities.

One of the reasons the available computers in the lab were very few was that the responsible teacher for the maintenance of the computers used to replace any out of order classrooms' computers with computers from the laboratory. The priority given to classroom equipment resulted in the transmutation of the computer lab to a store with a collection of faulty computers.

4.4.6 The participants

The main participants were 23 students attending the 5th Grade of a primary school in Limassol, Cyprus. The majority of the students were not native speakers of the Greek language, they did not have a good command of the Greek Language, and as a result they faced many difficulties derived from the lags in language acquisition. It was a multi-level classroom with students of mixed-abilities sited in groups of five to six students. The level of the majority of the students in terms of participation and performance was considered as low. More details on the level, participation and characteristics of the students will occur in the presentation of the results.

4.4.6.1 Student with dyslexia

One of the students had been diagnosed as having dyslexia and was included in the mainstream classroom. The student with dyslexia, a ten year old boy, was the protagonist in this first case study. For the purposes of the study I use the pseudonym 'Peter' when I refer to the student with dyslexia.

Peter was born in Limassol, Cyprus in 2002, to not very literate parents. Both of his parents are native Greek-speaking Cypriots. They are high school graduates and work as private retailers. His parents divorced when he was six years old, hence he lives with his mother, his sister and his grandmother in a house which is located very close to the primary school. Peter was diagnosed as having dyslexia when he was in the 3rd Grade of the primary school. I did not have the chance to talk with his 3rd Grade teacher as she had been transferred to a different school. According to his mother, the teacher noticed some learning difficulties and asked Peter's parents if they would give their consent to inform the District Committee for Special Education in order to send an educational psychologist to the school to assess the student. After the initial assessment, a team of specialists was composed by the committee (psychologist, special educator and a speech therapist). They decided to provide more facilities to the student in order to emphasize on his oral performance during the school year. They also took the decision to provide remedial teaching by withdrawing Peter from the mainstream classroom twice a week. Peter's father wanted to ask for appeal but his mother disagreed.

Typical features of dyslexia were recorded during the observations, before, during and after the implementation of the program. These features will be presented later on in the presentation of the results.

4.4.6.2 The teacher

The teacher was a 28-year-old female from Nicosia, who was appointed to this school for the first year of her career. She was a graduate of a Greek University and had continued her studies in the UK where she was awarded with MA in Inclusive Education. She had been working as a teacher with a contract for the past one and a half years. Since she was trained in the field of inclusive education, she was well informed about the theories and tendencies in that field, and this was one of the reasons that she accepted to collaborate with me, after I informed her about the subject of my research.

4.4.6.3 The special education teacher

The special education teacher was a 27 year old female from Limassol, who was appointed at that school from the beginning of that school year as a supply teacher for special education, as the permanent special needs teacher was on sick leave. She was a graduate of the Department of Special Education of a Greek university. She was not very experienced as a teacher as she had covered supply teaching periodically and her contracts were short-lasting.

4.5 Structure of the work scheme lessons

At this point, the followed work scheme of six whole-classroom implementations is outlined. Earphones were used in order for the students to gain access to the audio recorded instructions. As the available computers were few, 3.5mm audio splitters were used, that duplicated the available earphones.

4.5.1 Implementation 1

The first implementation took place on April 26th, 2012 during the last session of the school day. Sessions lasted less than 40 minutes. 21 students participated, while two students were absent. Only five computers were operative and thus available, out of the ten computers in the lab of the school. Students were free to decide where to sit. Peter decided to sit with his two closer friends. His group consisted of three children (three boys). One of them was a very able student so he was somehow the leader of the group. He was the one who took control of using the mouse and leading the group.

The remaining groups consisted of three, four and five students. The teacher and I preferred not to allocate roles for group members because the implementation was initially designed for pairs. We just asked them to indicate a responsible student for mouse handling. The WBLE consisted of four WMPs. It was designed in cooperation with the classroom teacher, and problems were chosen from the student's textbook. Students had to solve the WMPs in cooperation with their peers in groups. Feedback was provided separately for each group by the class teacher and myself and the computer.

4.5.2 Implementation 2

The second implementation took place on May 5th, 2012. 20 students participated while three students were absent. Only six computers were operative and thus available out of the ten computers in the lab of the school. Students sat in the same groups as the first implementation. Peter sat with his two closer friends, as he did the first time, so his group consisted of three children (three boys). The same student undertook control of the computer handling. The groups consisted of students with mixed abilities, both boys and girls.

This session took place during the last two sessions of the school day and lasted 80 minutes. After a discussion with the class teacher, we decided to dedicate more time to this exercise, as the students were not able to finish all the WMPs of the WBLE of the first implementation. We also decided to change the structure of the lesson in order to reduce the competition between the groups, and increase the level of participation and interest of the students. The students had time to solve the first WMP, and after this was completed there was a whole-classroom discussion concerning the solution of the problem. After this discussion, the children continued with the next problem and so on.

Again, the WBLE consisted of four WMPs. This was designed with the cooperation of the classroom teacher, and the students had to solve the WMPs in cooperation with their peers in groups.

4.5.3 Implementations 3 and 4

The third and fourth implementations took place on 16^{th} and 17^{th} May 2012. Twenty students participated, while three students were absent. Only six computers were operative and available out of the ten computers in the school’s computer lab. For Peter’s group I brought my laptop in order to increase the number of available computers. Therefore, with the addition of my own laptop, there were seven available computers for both sessions.

The target group remained the same. Some other students made swaps since there were more available computers for this session.

The sessions lasted 40 minutes each, therefore it was not possible to keep the structure of the second implementation where the available time was twice as much. Students had time to interact with the WBLE and collaborate in their groups in order to solve the provided WMPs. While the students were working on the computers, the teacher and I provided guidance, support and feedback to the students.

Once more, the WBLEs consisted of 4 WMPs. They were designed in cooperation with the class teacher and problems were chosen from the student’s textbook.

4.5.4 Implementations 5 and 6

The fifth and sixth implementation took place on 24^{th} and 25^{th} May 2012. Twenty-one students participated while two students were absent. Only six computers were operative and available out of ten computers in the school’s computer lab. A laptop was used for Peter’s group to increase the number of available computers to seven.

Students did not sit in the same groups as the first four implementations. This decision was taken in consultation with the class teacher, following the outcomes of the last two implementations. Mixed-ability groups were created. Peter was a member of a different group this time and responsible for computer handling. In essence, Peter's group consisted of three boys. The second boy, apart from Peter, was the most able student of Peter's group in the first four implementations. The other groups consisted of students with mixed-abilities, with both boys and girls.

Both sessions lasted 80 minutes. After the outcomes of the last two sessions, and after a discussion with the classroom teacher, we decided to dedicate more time to this exercise, as the students were not able to finish all the WMPs of the WBLE. We also decided to follow the structure of the lesson of the second implementation in order to reduce competition between the groups, and increase the level of participation and interest of the students. This structure was more functional and the outcome more promising since the students had more time to solve the WMPs, and then had the opportunity for whole-classroom discussion concerning the solution of each problem. After the discussion, the children continued with the next problem and so on.

The teacher took responsibility of coordinating the interval discussions. While the students were working on the computer, both the teacher and I provided guidance, support and feedback. The WBLE for the fifth session consisted of four WMPs, and the WBLE of the sixth session consisted of three WMPs.

After the completion of the last problem of the sixth WBLE, the students were given free time to play on the computer as a motivation and award of their achievement to complete the task within the time frameworks.

4.6 Summary

This chapter has provided a description of the procedure followed for planning, designing and developing the work scheme for the whole-classroom implementations. The steps followed for the design of the WBLEs, and the principles that the design of the WBLEs based on, were reviewed and figured out. The second part of this chapter focused on the implementation of the work scheme and information about the outer and inner context, the school, the classroom, and the participants were presented. In addition, the structure of the six implementations and the role of the teacher and the researcher during the implementations were provided. The next chapter will summarize the procedure followed for planning, designing and developing the work scheme for the two more individual case studies of this project. Information about the schools, the participants, as well as the structure of each individual implementation, separately for the two students, will be presented.

Chapter Five
The work scheme of the individual implementations

5.1 Introduction

The purpose of this chapter is to describe the procedure followed for planning, designing and developing the work scheme for the two individual case studies of this project. The second part of this chapter is divided into two sections and focuses on the implementation of the work scheme by providing information about the schools, the participants, and the structure of individual implementations for each case separately.

5.2 Plan, design and development

For the plan, design and development of the individual implementations of the project I visited two different schools, more than 10 times each. I also had additional conversations with the classroom teachers and special education teachers regarding the choice of WMPs, and the design of WBLEs before each implementation.

The procedure I followed was similar to that followed for the whole-classroom implementation of the project. In cooperation with the Special Education Inspector of the Districts of Limassol and Paphos, we found a few schools in Limassol with students with learning difficulties, with just some of them having been diagnosed as having dyslexia, and some of them not. After the communication I had with the special education teachers of each school, I decided upon two schools, with two fourth grade students who have been diagnosed as having dyslexia.

The first individual implementation took place between January and March 2013, and the second between April and June 2013. Similarly with the whole-classroom implementation, the first time I visited the schools, I had meetings with the headmasters, the classroom teachers, the special education teachers, and the students with dyslexia. The meetings took place separately and were of an informative and negotiating nature. I needed to clarify many details to the headmasters of the schools, who both put more emphasis on the approval from the Ministry of Education, and the procedures for gaining informed consent from the students' parents.

Both teachers and special education teachers were positive about the collaboration from the first time we met. Opposite to the opinion of the teacher of the whole-classroom implementation, teachers did not show any trace of concern as I clarified form the beginning that the implementations would be individually-oriented, and would take place outside the mainstream classroom. Therefore, their instruction and planning would not be influenced by the implementations.

The teachers took the initiative to contact the student's parents in order to obtain their written consent. Parents contacted me for more information, and so we arranged separated meetings. Parents had the opportunity to ask questions. Their reaction was positive, and they gave their written consent without hesitation. Both parents showed enthusiasm and excitement about the concept of the project.

Similarly to the whole-classroom implementation, the research design was based on a case study approach and the procedure held in three stages.

During the first stage, data concerning the attributes, weaknesses, and attitudes of students towards the use of the computer and WMPS were collected. That took place in January 2013 for the first individual case, and during April 2013 for the second case. The teachers of the mainstream classrooms, the special education teachers, and the students with dyslexia were interviewed before the implementations. Particular characteristics of the students were taken into account and helped in the design of the learning environment on the computer with the cooperation with their teachers. At this time, I also started designing the WBLEs. Each learning environment was designed a week before its implementation. The WBLEs were designed on Weebly (a web designing programme), and consisted of two WMPs each. Problems were chosen from student's textbooks in cooperation with the teachers.

The design was based on the principles and steps as described in Chapter Four, for the design of the WBLEs for the whole-classroom implementations. Examples of designed WBLEs are included in a CD attached to this thesis. Eight packages of web-based learning environments, including 16 WMPs, were designed with the cooperation with the teachers for the purpose of the two individual implementations.

At the second stage, the individual implementations with the use of the computer took place in the school's computers lab for the first case, and in the special education classroom for the second case. The first individual case took place in February 2013, and the second one in May 2013. Four 40-minutes sessions had been held for each case. All of the sessions were audio-recorded. The computers screens' activity was recorded with the use of a software package called BB-Flashback3.

Instead of solving WMPs with the use of paper and pencil, students used the designed web-based learning environment which guided them to follow the stages for WMPS from the stage of understanding, to the stage of choosing the appropriate strategy, and then reaching the solution. The learning environment on the computer provided continuous and immediate feedback to students, while I sat next to the students and provided additional feedback and guidance.

During the third stage, post-implementation interviews were conducted for the evaluation of the program, as well as to record any potential changes in terms of attributes, attitudes towards WMPS, participation during the instruction, and so on. The mainstream class teachers, special education teachers, and the students with dyslexia were interviewed.

The described procedure is presented in the below figure.

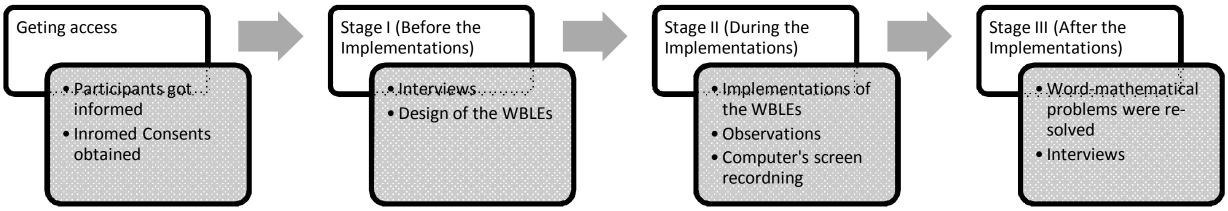


Figure 5.1 The work scheme for the individual implementations

5.3 Individual implementations

5.3.1 Individual Case Study I

5.3.1.1 Outer context: School I

The school is located in the Northern suburban area of Limassol, an area of middle socioeconomic status. The school is relatively new, opening in early 1990s. In the school year 2012-2013, 233 students attended the school, divided into 11 classrooms.

Each classroom of the school was equipped with one computer, a colour printer and a projector. Some classrooms were equipped with interactive boards, which were purchased using funds raised by the Parents' Association of the school. The school has its own computer lab, with 21 computers however, only 19 of them were operative. In addition, a computer for the teacher was also available. There were three large colour printers and a projector connected to the computer of the teacher. The computers in the lab run on the Windows 7 operating system, and were all relatively new.

5.3.1.2 The participants

The participants of the first individual implementation were the student with dyslexia, the teacher of the mainstream classroom, and the special education teacher of the school.

5.3.1.2.1 Student with dyslexia

The student with dyslexia was a 9-year-old boy, and the only student who had been diagnosed as having dyslexia in his class. For the purposes of the study I use the pseudonym 'Alexis' when I refer to this student with dyslexia.

Alexis was born in Limassol in 2004. His mother is not particularly literate, but his father is more literate, and works as clerk. Both of his parents are native Greek-speaking Cypriots. Alexis was diagnosed as having dyslexia when he was in the third grade of primary school. According to the special education teacher, the teacher of the mainstream classroom noticed some learning difficulties and asked Alexis's parents to give their consent to inform the district committee for Special Education, in order to send an educational psychologist to the school to assess the student. They decided to provide more facilities to the student, and emphasize on the oral performance of the student during the school year. They also took the decision to provide remedial education in special settings by withdrawing Alexis from the mainstream classroom twice a week.

Typical features of dyslexia were recorded during the implementations, and noted in the interviews conducted before and after the implementations of the WBLEs. These features will be presented in data analysis section in Chapter Eight.

5.3.1.2.2 The teacher

The teacher of the mainstream classroom was 46 years old at the time of research conduction. She is from Limassol and has worked at that school for the last four years. She was a graduate of the Cyprus Pedagogical Academy, with no postgraduate title. However, she is an experienced teacher and has worked as a teacher in schools in Cyprus for the last 24 years.

5.3.1.2.3 The special education teacher

The special education teacher has 10 years teaching experience. She graduated from the Department of Special Education of a Greek university, with a specialization in learning difficulties and mental impairments.

5.3.1.3 Structure of the Individual implementations

The first two individual implementations with Alexis took place on the 23rd and 30th January 2013, and the third implementation took place on the 7th February 2013, in the computer lab of the school. Only Alexis and I were present in the lab during these 40-minute sessions.

The fourth implementation took place on the 22nd February 2013 at Alexis's home. Alexis, his mother and I were present during these 40-minutes session, and used a desk in Alexis's room. This took place at Alexis's home in consultation with the class teacher and parents of the student. The reason that the implementation did not take place at the school was because of some changes in my schedule and some contingent obligations. My laptop was used for the last implementation, since no computer was available at Alexis's home. Also, there was no internet access, therefore, a backed-up version of the WBLE was used.

The WBLEs were designed in cooperation with the class teacher, with each one consisting of two WMPs taken from the student's textbook. The four sessions were audio-recorded and activity on the computer screens was captured. Alexis had the chance to solve the same WMPs in the classroom during Maths lessons, and some of them as homework, but they were discussed and corrected in the classroom the following day.

5.3.2 Individual Case Study II

5.3.2.1 Outer context: School II

The school selected for the conduction of the second individual case study was located in the North-Eastern suburb of Limassol, in an area of middle socioeconomic status with many immigrants. The school was new and first opened in the year 2000. In the school year 2012-2013, 282 students attended the school, divided into 12 classrooms.

Each classroom of the school was equipped with one computer, a colour printer and a projector. The school had a computer lab which contained 22 computers and an additional computer for the teacher in the lab. There was also a large colour printer and a projector connected to the computer of the teacher. The computers in the lab were relatively new and Windows 7 operating system was installed.

5.3.2.2 The participants

The participants of the second individual case study were the student with dyslexia, the mainstream class teacher, and special education teacher of the school.

5.3.2.2.1 Student with dyslexia

This student was a 9-year-old girl, and the only student who had been diagnosed as having dyslexia in her class. For the purposes of the study I use the pseudonym ‘Maria’ when referring to this particular student with dyslexia, for this case.

Maria was born in Limassol, Cyprus in 2003. Both of her parents are native Greek-speaking Cypriots, and neither of them particularly literate. Both of Maria’s parents work, and therefore Maria was brought up with the help of her grandmother. She has two older brothers and two older sisters. Some of them also receive remedial education in special settings.

Maria started receiving special education support from the first grade, having been diagnosed as having dyslexia during the third grade of primary school. According to the special education teacher, the mainstream classroom teacher noticed some learning difficulties and asked Marias’s parents for consent to inform the District Committee for Special Education. Similarly Peter and Alexis’s cases, they decided to provide more facilities to Maria, and to emphasize on her oral performance during the school year. They also made the decision to provide remedial education in special settings twice a week.

Typical features of dyslexia were recorded during the implementations, and noted in the interviews conducted before and after the implementations of the WBLEs. These features will be presented in the data analysis section in Chapter Nine.

5.3.2.2.2 The teacher

The mainstream classroom teacher was 39 years old at the time of research conduction. He was from Limassol and has worked at that school for the last three years. He was a graduate of the University of Cyprus, with no postgraduate title, and is an experienced teacher, having worked in Cyprus schools for the last 15 years.

5.3.2.2.3 The special education teacher

The special education teacher had 19 years teaching experience. She graduated from the Department of Psychology of a Greek university, with specialization in Educational Psychology. She has been a registered special education teacher in Cyprus for 16 years. In addition, she has worked as an Educational Psychologist for three years in Greece.

5.3.2.3 Structure of the Individual implementations

The individual implementations took place on the 7th, 14th, 21st and 28th of May 2013, in the special education classroom of the school. Only Maria and I were present during the 40-minute sessions. The WBLEs were designed in cooperation with the special teacher and the mainstream classroom teacher, and each WBLE consisted of two WMPs taken from the student's textbook. The sessions were audio-recorded and the activity on the computer screens was captured. Maria had the chance to solve the same WMPs with the special teacher after each implementation in the framework of the supporting lessons.

5.4 Summary

In this chapter, the work scheme of the two individual case studies was outlined. The first part dealt with the procedure followed for the planning, designing and developing of the two individual case studies of this project. In the second part, information about the schools, the participants, and the structure of the individual implementations for each case was presented.

Chapter Six
How the data analysis was conducted

6.1 Overview

This chapter details the procedure I followed for the analysis of data collected in the three different case studies of this study. At first, I discuss some theoretical aspects of the analysis of qualitative data. I then present the approaches followed for the analysis of data by providing information about the data analysis theories, and describing the steps associated with examples from the data.

6.2 Theoretical aspects of data analysis of qualitative data

The main objective of the stage of data analysis in research studies is to make sense of a huge amount of data. Different research approaches suggest the use of different analytical procedures in accordance with the philosophical positions underlying each approach. This makes the researcher's decision very difficult as to the best way to carry out data analysis.

Among the several analytic strategies such as grounded theory, phenomenology and ethnography, there are some common parameters which are described below.

- In general, qualitative analysis is conducted in two stages: the organization and then the interpretation of data. Nonetheless, the most of the time, one process is held simultaneously with the other (Tesch, 1990).
- The analysis process is inductive and iterative (Lichtman, 2006, Lacey and Luff, 2001). That is to say, the thematic categories emerge during the analytic procedure, although there are cases where thematic frameworks are combined and defined in advance.

- Particular elements that the researcher wants to study are extracted from the whole data, in a continuous process which involves revisiting the data, categorization and re-categorization.
- The organization of data helps the researcher to become more familiarized with them.
- Data are presented in charts or tables, which eases the progress of the interpretation.
- Interpretation of data is based on common patterns that occur in the data, which form the themes that will lead to the explanations and interpretations of the phenomena.
- Data are broken down into parts, closely examined and compared for similarities and differences (Strauss & Corbin, 1998; p.102)

Taking into account the above mentioned common patterns, and considerations about several analytic procedures, I decided to choose the 6-step model, as suggested by Braun and Clarke, (2006). However, I chose to use this model as the base and simultaneously enhance some of the steps with other strategies. This will make the analytic procedure of the data of this project more dynamic and flexible.

The approach suggested by Braun and Clarke (2006) comprises a systematic guide which facilitates the organization of data, the coding process, and the presentation and interpretation of findings. Their approach is listed in thematic analysis methods which focus on the identification, analysis and reporting of themes, in other words, patterns within the data. It is a method that “organizes and describes your data set in (rich) detail” (Braun & Clarke, 2006; p.76). According to the authors, thematic analysis is included in the category of “methods that are essentially independent of theory and epistemology, and can be applied across a range of theoretical and epistemological approaches” (p.78). “Through its theoretical freedom, thematic analysis provides a flexible and useful research tool, which can potentially provide a rich and detailed, yet complex account of data” (p.78).

One of the main reasons I chose thematic analysis is the fact that it does not require the detailed theoretical knowledge which occurs in grounded theory.

That is to say, it can offer a more accessible form of analysis, particularly for inexperienced researchers analysing qualitative data (Braun & Clarke, 2006).

It consists of six steps: 1) Familiarisation by reading the data, noting down initial ideas; 2) Generating initial codes by coding interesting features of the data; 3) Searching for themes by pulling together codes into potential themes; 4) Reviewing themes by checking if themes work in relation to coded extract and the entire data set, generating a thematic ‘map’ of the analysis; 5) Defining and naming themes through on-going analysis to refine the specifics of each theme; 6) Producing a report for final analysis (Braun & Clarke, 2006).

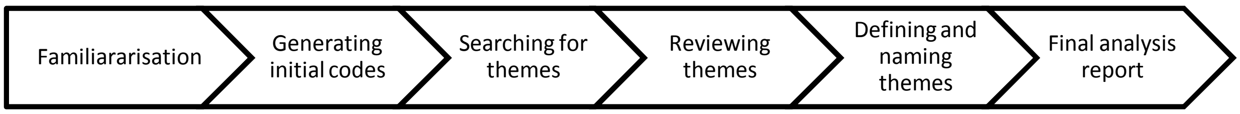


Figure 6.1 Six steps of thematic analysis

It is important to mention that the model suggested by Braun and Clarke (2006) suggests that the themes can be formed a priori, or emerge during data coding, in contrast to grounded theory where the themes exclusively emerge during data coding, while any pre-existed thematic category might be taken as an attempt to fit the data in an already existed theory. “Theory is emergent rather than pre-defined and tested and emerges from the data rather vice versa. Theory generation is a consequence of, and partner to, systematic data collection and analysis while patterns and theories are implicit in data waiting to be discovered” (Cohen et al., 2013; p.598).

At this point it is important to comment on the way thematic analysis works, and the level at which the themes are to be identified. In terms of the ways thematic analysis works, I chose mainly the inductive way, or ‘bottom-up’ (Frith and Gleeson, 2004). That is to say the chosen method was data-driven, meaning that I did not try to fit the process of coding into pre-existing themes. The coding scheme was not driven by my existent research conceptions, but theme identification was strongly connected to the data per se (Patton, 1990).

In terms of the level at which the themes are to be identified I decided to conduct the thematic analysis at the latent level which "goes beyond the semantic content of the data, and starts to identify or examine the underlying ideas, assumptions, and conceptualisations–and ideologies-that are theorised as shaping or informing the semantic content of the data" (Braun & Clarke, 2006; p.13). That is to say, the elaboration of themes involves interpretations beyond the mere description. The analysis here does not focus on the surface but goes beyond the participants' words.

Each step of the analysis is explained below, with some examples of how the data analysis was conducted. Furthermore, I explain any additional models used for the enhancement of the proposed model of Braun and Clarke (2006). It is also important to mention that analysis is not a linear process, but rather the researcher can move from one step to the next, or move backward through the phases, as needed.

6.3 Why I did not choose grounded theory

In this point, I explain why I did not choose grounded theory for the analysis of data. The justification will be made by providing some of the parameters of this branded method of data analysis.

The first reason is that "grounded theory does not force data to fit with a predetermined theory" (Cohen et al, 2010). Even if the theory generation of this project emerges from the data, it would be foolhardy to claim that the new theory is completely independent from other existing theories or literature references. No matter how much effort the researcher made for his mind to become "tabula rasa", it is inevitable that they will often refer to what they read in the literature during the coding process and analysis.

In addition, one of the elements of grounded theory lies in theoretical sampling. The researcher cannot pre-define the final sample size because the question is not the representativeness, but the quantity of data that will allow the theory to emerge. In this project, I needed to collect additional data during the second part of the project: the use of WBLE for individual implementation. Initially I justified the need for additional data collection on that particular part of the project, since the need emerged from the preliminary analysis of data. It is what the grounded theory pinpoints; the process of data collection is controlled by the emerging theory and that data collection continues until sufficient data have been gathered to create a theoretical explanation. Nonetheless, the case is not that simplistic. The grounded theory suggests the constant collection of data, even after the analysis started in order to reach data saturation which will help the new theory to emerge (Cohen et al., 2010). In the case of this project, I faced difficulties in reaching a satisfactory number of participants, not because there are no students with dyslexia in Cypriot schools, but because many of them have never been diagnosed as having dyslexia. Beyond the additional difficulties in finding teachers who were willing to participate and cooperate with me, beyond the possibility for parents not to give their written consent, the features of this project (case study-based) was prohibitive in reaching a saturation of data.

Moreover, the grounded theory as a method for data analysis falls short in recognizing the implied theories that inevitably direct research in its early stages (Silverman, 1993; p.47). For instance, data are theory saturated instead of theory neutral. The theory might be suitable in providing categorizations, but not apt in providing explanations of the phenomena (Cohent et al., 2010).

Also, Hodkinson (2008) points out that the number of researchers who “have used grounded theory in a complete and precise fashion is probably relatively small” (p.95). Hodkinson argues that each researcher has different understandings of the phenomena, therefore implements and uses the principles of grounded theory in their own way. Of course this goes for every method for the analysis of data, although grounded theory is much more complex in terms of its principles, making it risky for a novel researcher.

6.4 Why thematic analysis?

I will now discuss why I chose thematic analysis rather than any other method, and how this method benefits my study. Thematic analysis is not a complex method, and is a relatively easy and quick method to learn, and use, especially for novel researchers. According to Braun and Clarke (2006), thematic analysis is accessible to researchers with little or no experience of qualitative research, and can fit in any piece of qualitative research because of its flexibility (p.97). The benefits for my study will be that the results can be easily reached by those who are interested in the field. Also, this method allows my study's participants to become collaborators, since it can be seen as participatory research paradigm. In addition, thematic analysis helps in summarizing key elements of a massive body of data by offering a 'thick description' of the data, and drawing attention to potential differences and similarities within the data, especially for this study in which a massive amount of data was collected. Also, this method is useful in generating unpredictable ideas, and social interpretations of data. Furthermore, the product of this sort of analysis can be useful in informing policy development related to the use of new technologies for students with dyslexia in the Cypriot context.

6.5 Thematic analysis of data

The analysis of semi-structured interviews, observations and WBLE implementations was not based on pre-existing categories and themes, thus patterns were identified while I was exploring the data. The procedure is described below. Some examples are provided.

i. Familiarization

All the data were stored electronically in audio files and video files. The collected data was transcribed into written form and stored electronically in MS word documents. The original version of transcriptions was in the Greek language, and later translated into the English language for the purposes of the analysis and presentation of the data in my thesis. The first step of the analysis was based on reading and re-reading the transcriptions. It aims to familiarise the researcher with the data, and helps him to extract some general patterns within the data and note down some initial ideas.

For the mechanical process of coding the data and producing organized reports of the coded transcriptions, I used NVivo 9. Nvivo 9 is a software that facilitates the organization and coding of qualitative data. The researcher can import and organize the transcriptions into the program, and manually track the categories and subcategories, themes, labels, etc. Apart from labelling with any given category, NVivo allows category overlaps, that is to say, the researcher might decide to categorize the same text under different coding themes. Also, the researcher can create new themes, modify or even delete existing themes, while he is exploring the data, without effecting the already categorized sections of the text. Nvivo also helps the researcher to engage in a creative process of understanding the text, which is directly associated with the notion of familiarization with data, working with the text and enriching the process of analysis (Richards, 1999).

ii. Generation of initial codes

The second stage of the analytic approach suggested by Braun and Clarke (2006) is the identification of salient themes and categories in the data. For this step I followed the method suggested by Auerbach & Silverstein (2003). They suggest a model for the analysis of data with detailed steps to be followed by inexperienced researchers from the raw text, towards the emergence of themes and the construction of the theoretical constructs, which leads to the theoretical narratives. This model is based on the notion of grounded theory which comprises an important method for theory generation (Cohen et al., 2010).

The steps suggested by Auerbach and Silverstein (2003) from the raw text towards the formation of repeating ideas (for example, categories) are presented in the diagram below.

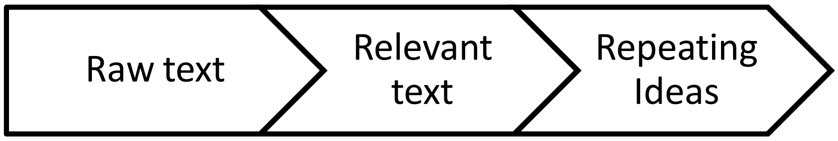


Figure 6.2 Steps towards the indication of repeating ideas

The first step refers to cutting down the text to controllable portions while reading the raw text. By bearing in mind my research concerns, I isolated the text that refers to particular research concerns, which can be described as relevant text.

After the selection of the relevant text, we find repeating ideas within this text. Repeating ideas are similar phrases that express the same idea, and “shed light on our research concerns” (Auerbach & Silverstein, 2003; p.37). Repeating ideas consists of interesting features of the data, that is to say, they comprise interesting patterns in association with researcher’s research concerns, which lead to the generation of initial codes.

Using NVivo, I grouped the relevant text and identified the repeating ideas. In essence, I labelled segments of the transcriptions for the preliminary categorization. Relevant text could be multi-labelled where there were categorization overlaps. After grouping the relevant text into categories, and after I was not able to identify any further new categories, I used NVivo in order to group any repeating ideas within the relevant text.

In the provided example, I chose some relevant text in which the special teacher and the class teacher from the first individual implementation talk about the use of the computer in their instructions. Some repeating ideas are underlined and isolated. The relevant text in the left column is about the same topic. In this case, both teachers express their opinions about the use of ICT in their instructions, and the way and the frequency they use it. Some ideas are repeating, thus they were isolated in the right-hand column of the below table. In this example, the repeating idea is the lack of time as a justification for not using ICT frequently in their instructions. The repeating ideas will give some themes at the next stage of data analysis.

Table 6.1 Repeating ideas are isolated in relevant text

Relevant Text	Repeating Ideas
I use the computer every day. It is very good. First of all, it is a motivation for us. Secondly, students' attention is not distracted. Their interest remains unflagging. They stop looking around. It helps in writing improvements. For example, Alexis is getting tired when I erase what he wrote and when I ask him to re-write what he has written down. […] Lack of time is our biggest problem and the funds we didn't get yet. I check what is available in the market. There is a lot of good quality educational material. But they are very expensive. (Source: Special Teacher 2 Pre Interview)	Lack of time is our biggest problem
You can dedicate a 40-minute session for activities on the computer but you cannot do that every time. Because, you cannot give the knowledge only in that way. You do not give knowledge. You just give to the students the chance to interact with the computer that time. (Source: T2 Pre Interview)	You can dedicate a 40-minute session for activities on the computer but you cannot do that every time
Δ: *If I had the option/facility I would definitely do it. However, the time is very pressing with the compulsory curriculum demands, so you cannot do some things very often. You can do it once but not always.* (Source: T2 Pre Interview)	The time is very pressing with the compulsory curriculum demands, so you cannot do some things very often. You can do it once but not always.

iii. Searching for themes

The next step is to search for themes by pulling together codes into potential themes. According to Auerbach and Silverstein (2003), the researcher groups the repeating ideas which have something in common. What they have in common is known as a 'theme'. A theme is an implicit topic that organizes a group of repeating ideas (Auerbach & Silverstein, 2003; p.38). "A theme captures something important about the data in relation to the research question, and represents some level of patterned response or meaning within the data set” (Braun and Clarke, 2006; p.10). Again, NVivo 9 helped me to pull together the repeating ideas in order to form the potential themes. Also, for grouping the repeating ideas or the codes, I used mind-maps and played with the themes in order to sort the different codes into theme-piles (Braun & Clarke, 2006).

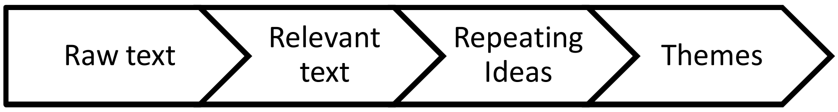


Figure 6.3 Steps towards the indication of themes

The repeating ideas of the above provided example, and some other similar repeating ideas, can be pulled together into a theme.

Table 6.2 Themes deriving from repeating Ideas

Repeating Ideas	Themes
Lack of time is our biggest problem	• Lack of time as a reason for not using ICT very often
You can dedicate a 40-minute session for activities on the computer but you cannot do that every time	
The time is very pressing with the compulsory curriculum demands, so you cannot do some things very often. You can do it once but not always.	

iv. Reviewing themes

The next phase of the thematic analysis suggested by Braun and Clarke (2006) is the review and refinement of themes, by checking if themes work in relation to the coded extract and the entire data set which will lead in the generation of a thematic map of the analysis. During this stage, themes will be reviewed and examined, since some of them might not be coherent enough. Patton (1990) suggests that themes should be characterized by internal homogeneity and external heterogeneity. That is to say, data within a theme should fit together in terms of meaning, and simultaneously there should be clear-cut borders between themes.

An example of the thematic map of the analysis from the data collected before the implementation of the second individual case study is provided below. From the relevant text, some repeating ideas were isolated and gave themes relating to Maria's learning difficulties. Such themes were gathered to create the thematic map of the general category of student's learning difficulties.

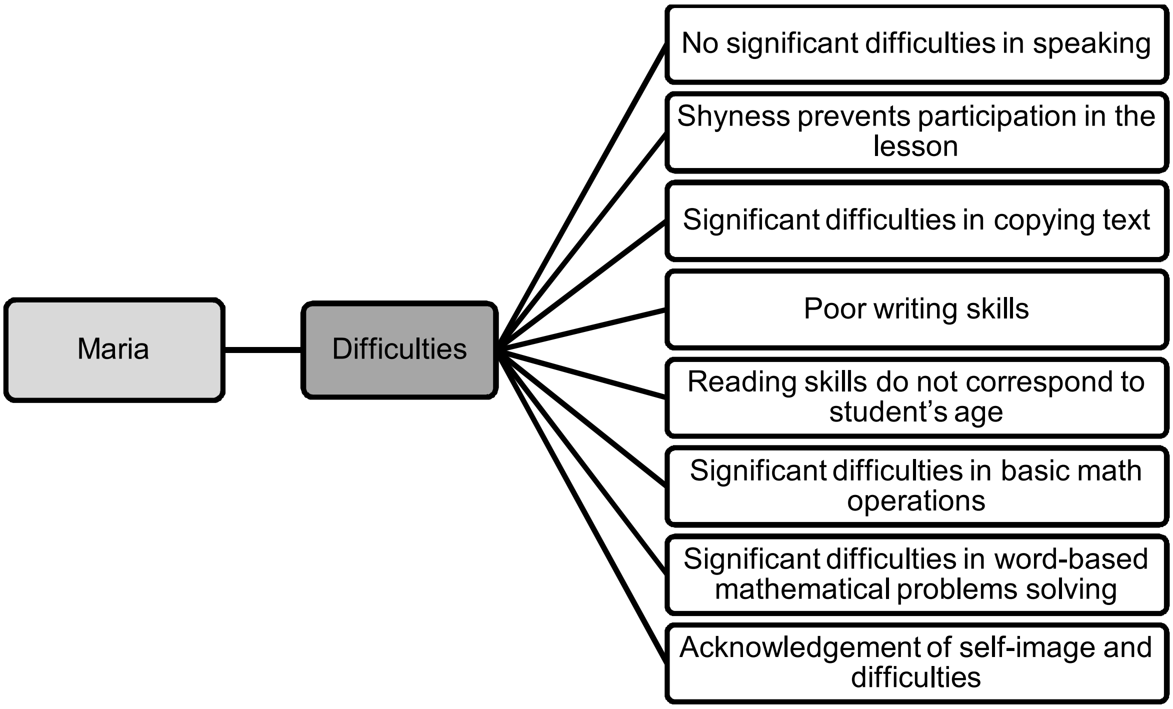


Figure 6.4 Example of thematic map of the analysis

v. Defining and naming themes

After reaching a high-quality thematic map of the data, we define and refine the themes that we are going to analyse and present. For the identification of sub-themes, I adapted the last two steps of the thematic analysis suggested by Braun and Clarke (2006). At this stage I organized the data references of the repeating ideas in tables under their themes, and then attempted to underline and isolate some sentences that constituted the sub-themes. After this, I started analysing the data by not only paraphrasing them, but also pointing out interesting aspects and justifying why these aspects might be important. Also, at this phase, the themes and sub-themes are given their final name. “Names need to be concise, punchy, and immediately give the reader a sense of what the theme is about” (Braun & Clarke, 2006; p.23).

In the table below, I present an example on how sub-themes were derived, refined, and identified.

Table 6.3 Identification of sub-themes

Main Themes	Repeating Ideas	Sub-themes
Lack of time as a reason for not using ICT	Lack of time is our biggest problem	Time-demanding compulsory curriculum Time oppression
	You can dedicate a 40-minute session for activities on the computer but you cannot do that every time	
	The time is very pressing with the compulsory curriculum demands, so you cannot do some things very often. You can do it once but not always.	

vi. Producing the report of the final analysis

During the last phase of the thematic analysis process, the researcher writes up the final report of the analysis. It is important for the report to go beyond the description of the data, and create links to the research questions. Diagrams, tables and maps can provide graphical explanations of the analysis of themes. Also, findings can be explained and discussed with the support of such diagrams. For organization purposes, the findings will be discussed after the presentation of data analysis for the three case studies of this project.

6.5.1 Inter-rater reliability

It is often required to include inter-rater reliability statistics into data analysis, when researchers report their research findings. This procedure is a quality indicator of the reliability of coding. Two or more raters code the same data where a high level of consistency in their coding should be reached in order for the coding system to be reliable. Otherwise, any potential deviations between the raters will put the reliability of the coding system in jeopardy. In order to ensure the inter-rater reliability of the analytical methods, a sample of raw text from both interviews and observation notes were coded by following the thematic analysis by my supervisors and me. The outcomes of the three different coding efforts did not have many deviations, a fact that immunizes the reliability of the chosen analytical method.

6.6 Coding schemes for pre-tests and post-tests

This section presents the coding method followed for the analysis of pre-tests and post-tests, administered before and after the implementations respectively, only for those students participating in the whole-classroom implementations. The coding was developed in order to standardize the coding schemes for the individual items of each WMP, in order to ensure that all responses were scored and coded similarly.

The tests consist of four WMPs, and each problem involves different solving strategies and levels of difficulty. Each problem is marked with 25 points. The maximum mark is 100 per cent, and the minimum mark is 0 (zero) per cent. Each WMP contributes 25 points. The following table shows the distribution of 25 points. The current rating scale was decided in cooperation with the mainstream classroom teacher (T1), after the whole class implementation. In addition, some tests were corrected twice by the researcher and the class teacher in order to confirm the inter-rater reliability of the decided marking system. There was agreement of 95 per cent. Any potential disagreements were discussed and solved with the teacher.

Table 6.4 The marking system for pre-tests and post-tests

	Marks
Trial	5
Investigation of the problem	2
Correct choice of strategy	5
Execution/operations	5
Answer	6
Explanation of how they worked	2
TOTAL	**25**

Each WMP is marked with five points when the student tries to solve it, even if the response is completely wrong. Two points are dedicated for the investigation of the problem, that is to say, when the student underlines or highlights the given details and the question of the problem, or lists them in a table. The correct selection of the solving strategy is awarded with five points, and the correctness of math executions and operations with five points. Any correct and completed answer is marked with six points. Also, students were asked to explain how they thought and worked out in order solve each WMP. Satisfied explanations, regardless of their correctness, are marked with two points.

Abraham et al. (1994) suggest criteria for scoring and coding student responses. According to their scheme, students' responses can be classified as: 'Correct Responses', for responses that include all components of the validated answers; 'Partially correct responses', for responses including at least one of the components of the validated answers; and 'Incorrect Response', for not logical or incorrect, unclear answers, or even no response.

The following are examples on the marking schemes of students' pre-tests and post-tests. At least one example for each WMP is provided.

The first WMP of the test involves combinatorics. The scenario describes a girl who has four bracelets of different colours - green, red, blue, white and pink. Every day she wants to wear two bracelets of different colours. The question is 'how many different combinations there are'.

The provided examples fulfil the criteria to gaining full marks. The students investigate the problem (underlying or highlighting the given details and the question or creating a table to organize this information). They then choose and follow the correct strategy. After solving the problem, the students give the right answer. At the end, they explain exactly what they did and how they solved the WMP.

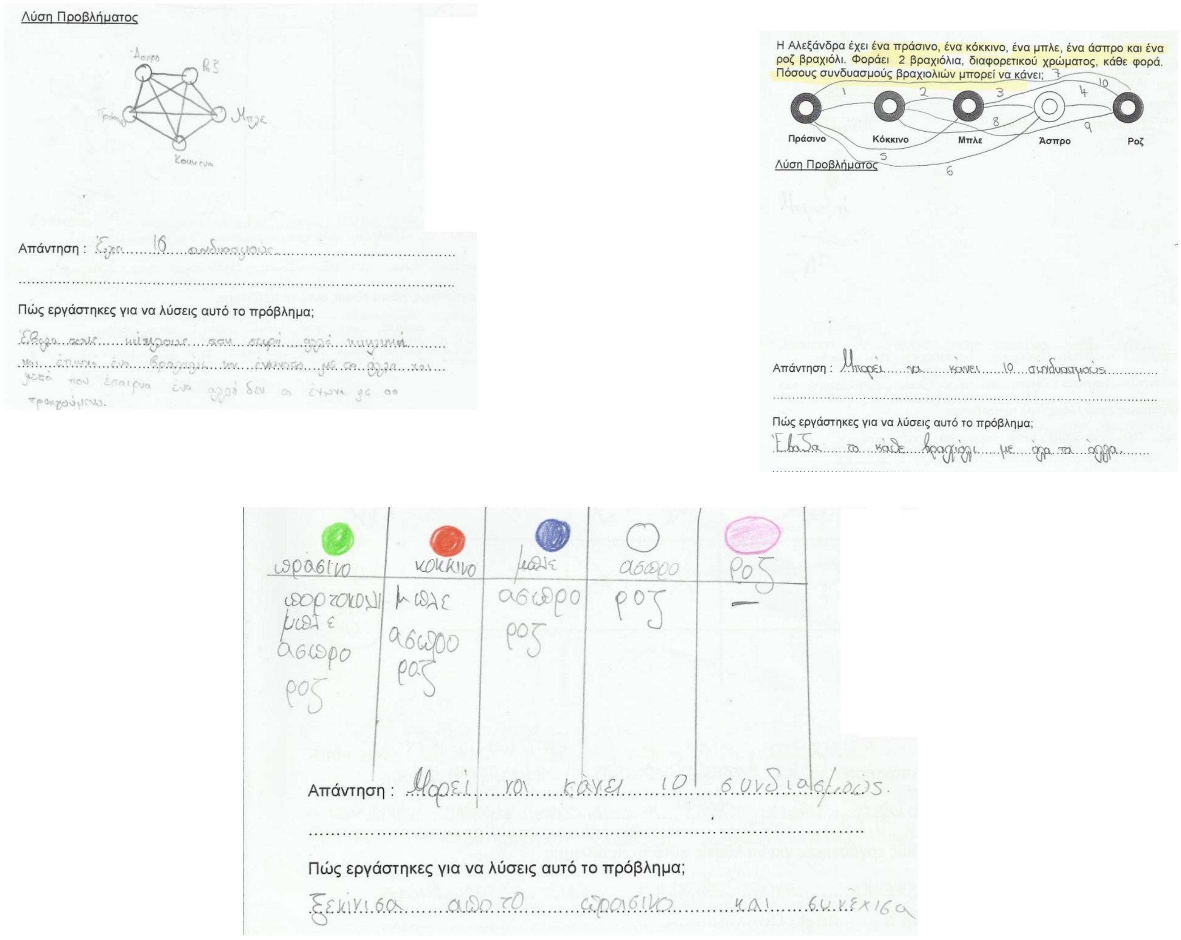
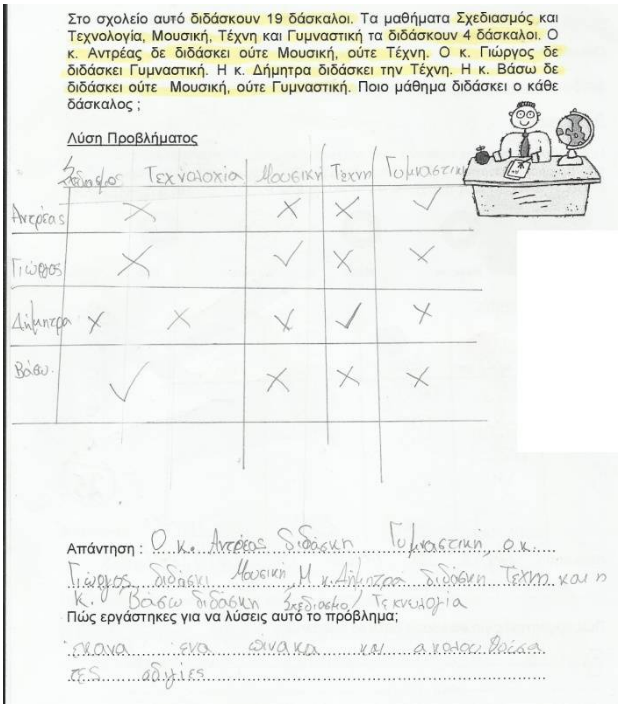


Figure 6.5 Examples of the first WMP of the tests

The second WMP involves the strategy of drawing a table and inductive thinking. The scenario describes a school with 19 teachers and provides information for four teachers who teach design and technology, music, art and physical education. Students should consider all given information and decide who teaches what.

The provided examples fulfil the criteria to gaining full marks. Similarly to the first WMP, the students investigate the problem and then they choose and follow the correct strategy, which is the creation of a table for the organization of the given information. After solving the problem, the students give the right answer. At the end, they explain exactly what they did and how they solved the WMP.



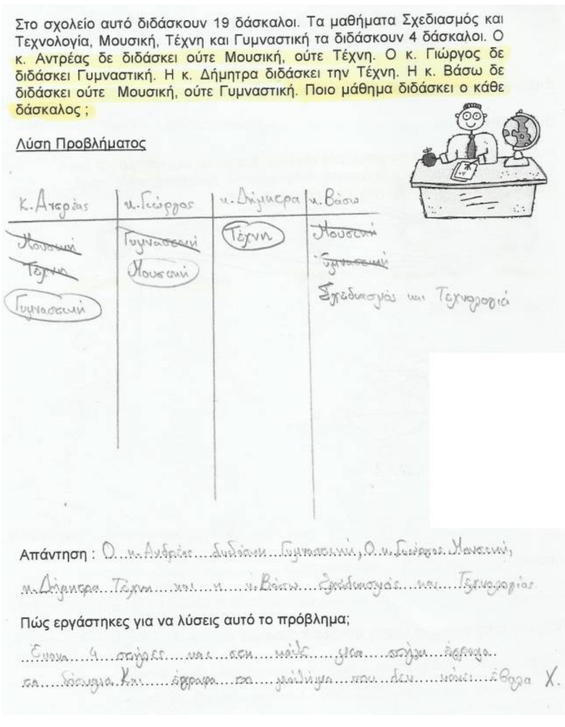
Στο σχολείο αυτό διδάσκουν 19 δάσκαλοι. Τα μαθήματα Σχεδιασμός και Τεχνολογία, Μουσική, Τέχνη και Γυμναστική τα διδάσκουν 4 δάσκαλοι. Ο κ. Αντρέας δε διδάσκει ούτε Μουσική, ούτε Τέχνη. Ο κ. Γιώργος δε διδάσκει Γυμναστική. Η κ. Δήμητρα διδάσκει την Τέχνη. Η κ. Βάσω δε διδάσκει ούτε Μουσική, ούτε Γυμναστική. Ποιο μάθημα διδάσκει ο κάθε δάσκαλος;

Λύση Προβλήματος

	Σχέδιος Τεχνολογία	Μουσική	Τέχνη	Γυμναστική
Αντρέας	X	X	X	✓
Γιώργος	X	✓	X	X
Δήμητρα	X X	X	✓	X
Βάσω	✓	X	X	X

Απάντηση:

Πώς εργάστηκες για να λύσεις αυτό το πρόβλημα;



Στο σχολείο αυτό διδάσκουν 19 δάσκαλοι. Τα μαθήματα Σχεδιασμός και Τεχνολογία, Μουσική, Τέχνη και Γυμναστική τα διδάσκουν 4 δάσκαλοι. Ο κ. Αντρέας δε διδάσκει ούτε Μουσική, ούτε Τέχνη. Ο κ. Γιώργος δε διδάσκει Γυμναστική. Η κ. Δήμητρα διδάσκει την Τέχνη. Η κ. Βάσω δε διδάσκει ούτε Μουσική, ούτε Γυμναστική. Ποιο μάθημα διδάσκει ο κάθε δάσκαλος;

Λύση Προβλήματος

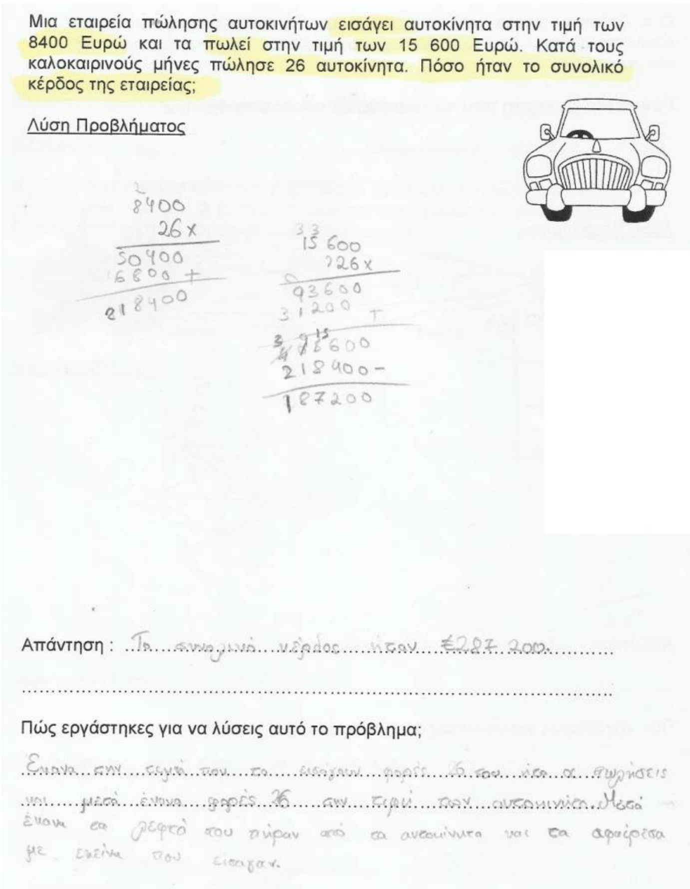
κ. Αντρέας	κ. Γιώργος	κ. Δήμητρα	κ. Βάσω
~~Μουσική~~	~~Γυμναστική~~	Τέχνη	~~Μουσική~~
~~Τέχνη~~	Μουσική		~~Γυμναστική~~
Γυμναστική			Σχεδιασμός και Τεχνολογία

Απάντηση:

Πώς εργάστηκες για να λύσεις αυτό το πρόβλημα;

Figure 6.6 Examples of second WMP of the tests

The third WMP involves maths operations. It describes a car sales person, who buys cars and then resells them, gaining a profit. Students should first calculate the profit for one car and then for 26 cars. However there are alternative ways to solve this problem. I provide an example that fulfils the above mentioned criteria in order to gain full marks. The student highlighted the details and the question of the problem, then chose and executed the right maths operations correctly. She wrote the answer and then gave an explanation of her thought process.


Μια εταιρεία πώλησης αυτοκινήτων εισάγει αυτοκίνητα στην τιμή των 8400 Ευρώ και τα πωλεί στην τιμή των 15 600 Ευρώ. Κατά τους καλοκαιρινούς μήνες πώλησε 26 αυτοκίνητα. Πόσο ήταν το συνολικό κέρδος της εταιρείας;

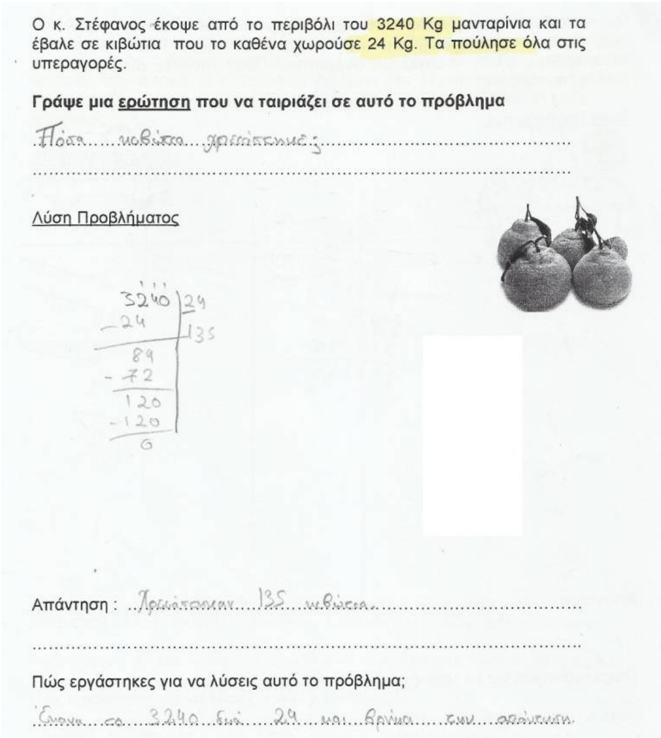
Λύση Προβλήματος

Απάντηση :

Πώς εργάστηκες για να λύσεις αυτό το πρόβλημα;

Figure 6.7 Examples of the 3rd WMP of the tests

Similarly to the third WMP, the fourth WMP involves maths operations. It describes a farmer who produces mandarins, putting the fruits into boxes. The given information lies on the weight of the whole quantity of fruits and the weight of each box. The particularity of this problem is that the question is missing, so the students should write down their own question and then solve the problem. The most common question was “how many boxes does he need?” Of course there were some alternatives, and thus more complicated questions, such as “if he sold each box for 10€, how much euro did he earn?” I provide two examples that fulfil the above mentioned criteria in order to gain full marks.



Ο κ. Στέφανος έκοψε από το περιβόλι του 3240 Kg μανταρίνια και τα έβαλε σε κιβώτια που το καθένα χωρούσε 24 Kg. Τα πούλησε όλα στις υπεραγορές.

Γράψε μια ερώτηση που να ταιριάζει σε αυτό το πρόβλημα

Πόσα κιβώτια χρειάστηκε;

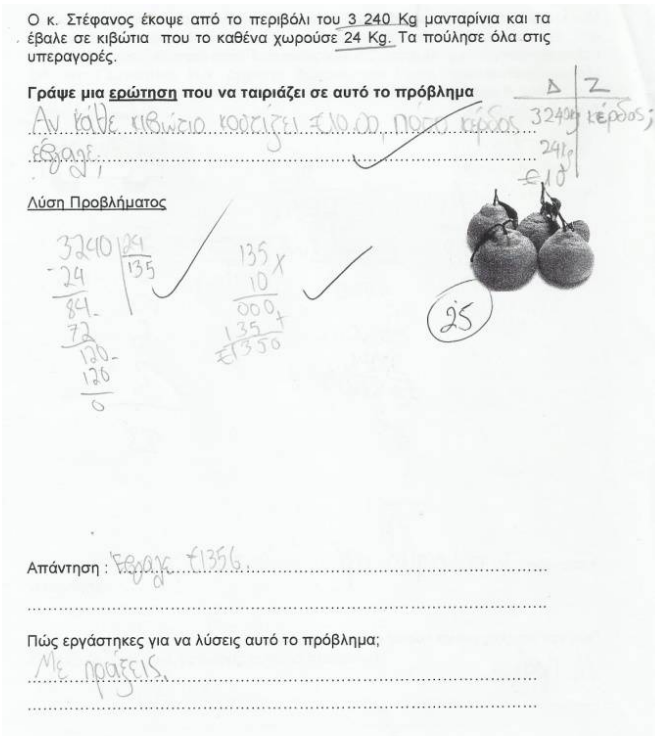
Λύση Προβλήματος

3240 | 24
−24 | 135
84
−72
120
−120
0

Απάντηση : Χρειάστηκαν 135 κιβώτια.

Πώς εργάστηκες για να λύσεις αυτό το πρόβλημα;

Έκανα τα 3240 διά 24 και βρήκα την απάντηση.



Ο κ. Στέφανος έκοψε από το περιβόλι του 3 240 Kg μανταρίνια και τα έβαλε σε κιβώτια που το καθένα χωρούσε 24 Kg. Τα πούλησε όλα στις υπεραγορές.

Γράψε μια ερώτηση που να ταιριάζει σε αυτό το πρόβλημα

Αν κάθε κιβώτιο κοστίζει €10.00, πόσο κέρδος έβγαλε;

Δ | Ζ
3240kg | κέρδος;
24kg |
€10 |

Λύση Προβλήματος

3240 | 24
−24 | 135
84
−72
120
−120
0

135 × 10 = 000 + 135 = €1350

25

Απάντηση : Έβγαλε €1356.

Πώς εργάστηκες για να λύσεις αυτό το πρόβλημα;

Με πράξεις.

Figure 6.8 Examples of the fourth WMP of the tests

6.7 Summary

In this chapter, I provide details on the procedure followed for the analysis of data collected in the three different cases of this study. After the discussion of some theoretical aspects regarding the analysis of data in qualitative research, I justify why I did not choose the grounded theory which constitutes probably the most popular analytic method in the field of qualitative research. I then discuss the main aspects of thematic analysis, and provide justifications as to why this method is more suitable for my study, and how this study will benefit from thematic analysis. Thematic analysis is not based on pre-existing categories and themes, as patterns are identified through the exploration of data. Each of the six steps of the chosen analytic method is described, having been enriched with some additional steps of analysis found in the literature. Each step was associated with examples of real data collected in order to explain the process followed for analysis. At the end of this chapter, I have presented the coding method followed for the analysis of pre-tests and post-tests administered both before and after the implementations of the whole-class case study. Some examples of the followed coding and marking system are provided. The analysis of data is provided in the next three chapters for each case study separately.

Chapter Seven
Case Study One: Peter

7.1 Introduction

In this chapter, I present the analyses of data collected from the first case of this project: the whole-classroom implementation. The chapter is organized in a way to present evidence that supports the extent that the computer-assisted learning environment can support students with dyslexia with difficulties in WMPS; the impact of computer-assisted learning in solving WMPs for students with dyslexia, and the extent that collaborative learning can help a more beneficial use of computer-assisted learning environments for WMPS, in accordance with the main and supplementary questions of this research. The sequence of the presentation of the data starts with the performance of Peter, his participation and behaviour before, during and after the implementations. Following this, data related to the opinions about mathematics and the WMPS, and the opinions about the use of the computer are presented. After this, I overview the difficulties related to WMPs, and how those difficulties were overcome, or not, with the use of the computer. Then some advantages and weaknesses of collaborative computer-assisted learning are overviewed which lead to the extent that computer-assisted learning environment can help. It is important to mention that this chapter will be mainly limited to the presentation and brief explanation of findings. The results are presented in tables with the descriptions of themes written in the right-hand columns. A comprehensive discussion of findings' interpretations and their potential implications will be offered in Chapter Ten.

7.2 Features of Peter

Before the data analysis, it is useful to point out some features of Peter as a personality and student, noted before, during, and after the implementations.

One of the core results concerning the features of Peter as a student and personality is the fact that he was not able to work alone since he was dependent on his classmates. He also had a habit of cheating by copying answers from other students. The same extent of dependency was observed after the implementations. He was a weak student due to his learning difficulties, and most of the time, he seemed reluctant to think for himself, or take initiative.

The class teacher pointed out that Peter's difficulties were not obvious. She referred to the difficulties derived from dyslexia. Peter gave the impression of being a weak student, like any other weak student in the classroom, therefore, his classmates did not see him as different from the others. I observed the same during the sessions in the classroom, and the breaks. Difficulties in reading and writing were common difficulties for the majority.

According to the special education teacher, Peter was very shy when they had started. He had difficulties in expressing his thoughts, and was too shy to read because he recognized his difficulties and was anxious that his classmates would laugh at his mistakes. This supports the fact that he had low self-confidence regarding his abilities because of the potential reactions of his classmates in any failure. Also, he did not consider himself as a good student, and made it clear that he did not like mathematics and was not good at mathematics.

In terms of dyslexic-type difficulties, he had problems in decoding. For example, when he saw a word, he changed some graphemes, so he could not read the word correctly, thus he did not recognize it. He also used to miss and skip the lines. These difficulties lead into difficulties in understanding. Moreover, he had more difficulties in writing - in orthography, syntax and grammar; and also had difficulties such as confusion, bemusement and replacing graphemes/phonemes. Such difficulties caused problems in many fields involving reading and writing and in daily life. In addition, he had difficulties with the English language, such as letter or space omissions, and miswritten words when he copied text from the board.

Although he seemed to be dependent on his classmates during the lesson when he had to write something by himself, the special teacher pointed out that he was able to concentrate and think alone. He had good perception. He could write properly and understandably with possible wrong words because of his habit of changing some graphemes. As the special education teacher said, he used to write what he had in his mind, and would continue from that point and beyond with a different thought. Consequently, the coherence of the sentences was lost.

Similarly, he stated that the most difficult subject for him was mathematical problem solving. WMPs demands good reading abilities and perception. As the special teacher stated, he was able to understand the problem when someone else was reading the problem to him, when he was listening carefully. He was able to handle with WMPs decoding, like every student, when he was taught, trained and practiced how to do it. Peter admitted that he had difficulties in understanding the WMPs, a fact that occurred before, during and after the implementation of the project.

In terms of the type of WMPs, he preferred those involving operations than problems which involve other strategies. The core difficulty here lies in the ability of understanding. Nonetheless, he said that he was able to solve mathematical problems alone, a fact that did not concur with what I observed, and what his teachers and mother pointed out. In addition, Peter's difficulties in simple calculations were obvious since he used his fingers. He also faced problems with his short-term memory, thus he had difficulties with problems involving large amounts of information.

Furthermore, some interesting results occurred during the implementations regarding Peter's features as a student and personality. For instance, there were some cases where Peter brought his group-mates back to on-task discussions, when they were occupied with irrelevant topics. Nonetheless, Peter was easily distracted by one of his group-mates, thus he was often occupied with irrelevant topics while they were waiting for the most able student of the group to solve the WMP. Moreover, Peter was reluctant to undertake the responsibility for the navigation of the WBLE, probably because of his limited IT skills.

Further features of Peter will be presented through the analysis of data in the following sections of this chapter.

7.3 Performance, participation and behaviour of Peter

The impact of computer-assisted learning in solving WMPs includes any potential changes of Peter's performance before, during and after the implementations. By saying 'performance of the student', I mean his overall proficiency during the lessons in terms of abilities, capabilities related to understanding, the level of mastering unknown notions, and latent learning difficulties in many aspects of learning. Apart from observations, some statements of the teachers regarding Peter's performance, participation and behaviour were pointed out at the interview, before and after the implementations. Some examples concerning his performance, participation and behaviour are provided below, showing the potential alterations of Peter's proficiency level through the procedure.

It is important to mention that the participation level of the student is reviewed here through some examples interpreted, by bearing in mind the Cypriot classroom context. In the interview given before the implementations, the class teacher asserted that Peter did not participate during the lesson in the classroom, giving the impression of being lazy. The teacher justified the characterization 'lazy' because Peter did no usually do his homework, or he was reluctant to read and write in the classroom during the lesson. However, I observed that the he did not always give the impression of being lazy. As observed, Peter used to follow the instructions of the teacher, looking at her when she was giving explanations, and used to be interested in correcting any mistakes. However, participation was at a low level.

When Peter answered a question without any help, most of the time his attempt led to failure. It is important to mention that a general habit of Peter was that when they had an exercise to complete, he often waited for his group-mates to find the answer, even if the teacher had asked them to work individually.

As noticed from observations, as well as interviews with the class teacher and the special education teacher of the school, Peter used to work at his own pace, and much slower than his classmates - a fact that was imbedding him to follow the lesson while the rest of the students were continuing to the next exercise. This factor increases stress levels, so Peter would activate those strategies that would help him to reach the pace of the others. Therefore, he was merely copying from the whiteboard or his next peer; he missed instructions given by the teacher while he was trying to finish copying. This perpetuated his weak performance, not only in mathematics, but also in English and Greek language lessons, and Science.

Ref 1

Peter is working very slowly. The rest of the students finish the graph but he continues while the teacher moves to the next activity. (P/WC-PRE-OBS–English)	*Peter was learning slowly*

Peter did not usually raise his hand when he wanted to speak in the classroom, although he did so sometimes, especially when he was feeling confident with the correctness of the answer. The fact that he was not raising his hand to say something in the classroom frequently gave the impression that he was a student with low performance and not interested to participate. In the cases that he did raise his hand, he gave random answers, or answers that were surely correct because either he had the answer written in his textbook from home, or the group agreed that the answer was correct in advance. Also, Peter did not express his own opinion when there was collaboration in the group. He would agree passively and accept the ideas of his classmates.

Ref 2

8:46 He is asking his group members to announce the answer on behalf of his group. (P/WC-PRE-OBS–Science)	*Peter was rarely raising his hand unless he was sure for the correctness of the answer*

When there were instructions, Peter was not able to understand unless the instructions were provided again, in a simpler way.

Ref 3

Peter seems he does not understand the instructions. He is saying "I don't understand" to his next peer. (P/WC-PRE-OBS–English)	*Peter is unable to follow and understand instructions without support*

Peter's insecurities led him to always ask others to explain an exercise orally. This phenomenon was not only observed in the mainstream classroom but also noticed by the special teacher. When the special teacher worked with Peter, there were no time limits or other students around; therefore Peter had the chance to work at his own pace, although he still needed additional oral explanation of the instructions in order to understand them. It is apparent that this difficulty influenced his performance level. This point was mentioned by the class teacher as well as his mother.

Ref 4

Students are asked to work individually. Peter isn't working individually. He is scraping his pencils. It is obvious that he has difficulties. (P/WC-PRE-OBS–English)	*Peter could not work individually while he was depended on collaboration in group*
Peter is waiting for his group mates to solve the problem. (P/WC-PRE-OBS–Maths)	

Peter used to externalize some of the difficulties derived from dyslexia leading to difficulties in understanding, and therefore influencing his performance and participation significantly.

Ref 5

It seems that Peter is not able to recall terms or theories from the last lesson. He doesn't remember when the teacher asks about terms and theories they talked the last time. Also, he is lifting his shoulders to show his unawareness. (P/WC-PRE-OBS–Science)	*Dyslexic-type difficulties were influencing Peter's performance and participation*

In terms of dyslexic-type difficulties, Peter had problems in decoding. For example, when he saw a word, he changed some graphemes, so he could not read the word correctly, thus he was not recognizing it. He also used to miss and skip lines. All these difficulties lead to difficulties in understanding.

Ref 6

K:In terms of the language, does he have dyslexic-type difficulties, e.g. difficulties in decoding the graphemes? *ST:Yes, decoding is the cause of his difficulty in reading. For example, when he sees a word, he changes some graphemes, so he does not read the word correctly, thus he does not recognize it, he does not know it. Also, he misses the lines, he skips the lines. All these difficulties lead into difficulties in understanding. (P/WC-PRE-InterviewST1)*	*Peter had significant language difficulties*
K:How about writing? Does he have similar difficulties? *ST:He has more difficulties in writing; in orthography; in syntax; in grammar; also difficulties such as confusions, bemusing and replacing graphemes/phonemes. (P/WC-PRE-InterviewST1)*	

Although he seemed to be dependent on his classmates during the lesson when he had to write something by himself, the special teacher pointed out that he was able to concentrate and think alone. He had good perception skills. He could write properly and understandably with possible wrong words because of his habit to change some graphemes. Furthermore, Peter was not going back to read what he had just written. He used to stop writing, then write about something completely different. As the special education teacher said, he used to write what he had in his mind, he was continuing from that point and beyond with a different thought. Consequently, the coherence of the sentences was lost.

Ref 7

He can concentrate. He can think alone, he has good perception. He can write properly. If you read what he wrote you can understand but the word may be wrong. He might write a word with "κ" instead of "π". For example, he might write "πoυ" instead of "κoυ".	*Peter was able to write texts but he had difficulties to complete the process.*
He doesn't go back to read what he wrote. He might stop somewhere, he thinks about something different, he won't go to see how to continue. He writes what he has in his mind, he continues from that point and beyond with a different thought. Consequently, the coherence of the sentences is lost. (P/WC-PRE-InterviewST1)	

During the implementations, Peter was an active member of his group. He had the chance to collaborate with his group mates, a fact that helped him develop his performance and increase his participation in the process of WMPS. Some examples of his performance and participation level during the implementations are provided below.

Peter was able to explain the 5-step model for WMPS by using the provided diagram at the bottom of the page. It seemed that he memorized the process.

Ref 8

4':32'' They are discussing about the navigation. Peter is explaining the diagram which exists at the bottom of each webpage regarding the solving process. (5 stages of Krulik & Rudnick) (P/WC-DUR-IMPL3)	*Peter was able to explain the 5-step model for WMPS*

Furthermore, Peter was able to understand the WMPs and was able to narrate the problem's scenario in his own words as an indication of comprehension. Most of the time, he could narrate the problems' scenarios without additional help.

Ref 9

Peter is narrating the problem in his own words with the help of the computer, his book and his group-mates. He understands but it seems he has difficulties with the amount of information. (P/WC-DUR-IMPL2)	*Peter was able to understand and narrate the WMPs in his own words*

Also, the use of the WBLE and the collaboration in group enabled Peter to investigate the problems and indicate the given and asked details.

Ref 10

He is explaining the problem in his own words. He identifies the details and the question of the problem at the stage of investigation	*Peter was able to investigate and indicate the given and asked details of WMPs*
They identify the details of the problem. Peter is good in finding the details of the problem especially when the problems are in simple form. (P/WC-DUR-IMPL2)	

Also, Peter was aware about the solving strategy they chose since he was able to justify their choice and explain how they reached the solution, with some help.

Ref 11

They move on to the last stage of the first WMP. They pass it by but I intervene so we check the answer together. I am asking them to explain how they have thought and reached the answer. The three of them are participating in the discussion. They complete each other.	*Peter was aware and able to justify the way they solved a WMP in his group*
I am asking them to show me their answer. Peter is opening the word document and he is explaining how they found the correct answer. (P/WC-DUR-IMPL5)	

However, Peter's performance and participation reduced and he remained silent in more difficult problems, especially when all the group members faced difficulties in a particular problem - Peter was unable to offer any help to his group. Again, his performance was influenced by his difficulties and his dependency on his group mates. It seems he was expecting his group mates to move him away from the awkward position.

Ref 12

Me: Nice, so how will you find what the problem asks? Peter doesn't reply. He stays silent and smiles. He looks at the other 2 students with quandary. (P/WC-DUR-IMPL2)	*Peter was dependent on his group mates when he was facing difficulties*

Furthermore, some of the features of the WBLE were helpful for Peter to understand difficult notions, such as the meaning of fractions through several examples. The fact that the WBLE was helping Peter to overcome particular difficulties, it potentially helped him in developing his performance in the subsequent stages of the solving process, which would be inaccessible otherwise.

Ref 13

He faces difficulties in understanding the fractions but it seems the WBLE helps in understanding, especially the table and the figure. (P/WC-DUR-IMPL2)	*WBLE helped in developing performance*

Additionally, Peter was performing well during the discussions in whole-classroom level, a fact that confirmed what was observed before the implementations that his performance and involvement was better after the collaboration in group.

Ref 14

In the discussion, Peter raises his hand and has the chance to explain the way they worked successfully. (P/WC-DUR-IMPL2)	*Peter was performing well during the discussions in whole-classroom level*

After the implementations of the project, Peter's performance and participation levels were similar to his performance and participation extent before the implementations. In terms of collaborative activities in groups, Peter participated in the discussions without expressing his opinion. He would agree with his group mates, but he continued to not express his own opinion. He also did not change his habit of waiting for the others to think and answer on his behalf, either because he did not know the answer or because he was unwilling to express his opinion. His dependency on his group mates influenced his performance during the lesson.

Ref 15

Peter participates in the discussion but he doesn't express his opinion. He says: "I have no idea". He agrees with the others. (P/WC-POST-OBS1)	*Peter continued to be dependent on his peers after the implementations*
He is cribbing the answer from the other students. The same happens for the 3rd problem which is even more complex. (P/WC-POST-OBS5)	

However, Peter faced significant difficulties in operations, mathematical formulas, instructions and terminology. As I noticed, the majority of students also faced such difficulties with mathematical formulas and terminology. Such difficulties influenced Peter's performance and that of his classmates, since the lessons I observed after the implementation involved difficult terminology, formulas and operations with large numbers.

Ref 16

Peter sticks on the instructions. It seems he didn't understand what to do. He is asking his opposite group classmate: "What is the 'edge' of cube?" (P/WC-POST-OBS1)	*Difficulties with terminology, mathematical formulas and operations involving large numbers*
The teacher is asking Peter what is that number and what is the metric unit. He cannot recall the cubic meters but he remembers that they counted the volume of a room. (P/WC-POST-OBS4)	

Peter raised his hand when he was confident that he was going to answer correctly. This happened when he crosschecked his answers with his group-mates, or he announced the answer on behalf of his group. Interestingly, when he raised his hand in order to announce his group's answer, the teacher challenged him by asking him to explain how they had reached the solution. He looked embarrassed and almost unable to explain, since he did not think about the solution but rather just took the solution from his group-mates.

Ref 17

They correct the exercise. Peter is raising his hand for the 1st and 2nd shapes. He is announcing the answer of the 1st one. The teacher is asking him to explain how he has reached the solution. He looks to be embraced. The teacher is helping him by reminding the mathematical type for the volume of solids. He looks happier now. He is explaining correctly. (P/WC-POST-OBS3)	*Peter used to participate in the lesson when he was sure for the correctness of the answer*

It is important to mention that Peter and many other students adopted some tactics that were used during the implementation of the WBLE. For instance, many of the students were underlying the given details and the question of the WMPs they had to solve in their textbooks. Interestingly, I had the chance to discuss about the first world mathematical problem with Peter. He underlined the given details of the problem and put in a circle the question of the problem.

Ref 18

Peter is highlighting (underlining) the given details and he puts the question in a circle. (It seems he adopted this habit from the implementation of the program with the use of WBLE). (P/WC-POST-OBS1)	*Peter adopted some of the strategies taught during the implementations*
Some students and Peter are underlining the given details and the question of the problem. (P/WC-POST-OBS4)	

He did well when he was asked to explain the problem in his own words, something that was part of the procedure of world mathematical problem solving, promoted by the implementations of WBLE.

Ref 19

I am asking him to say the problem in his own words and he is doing well. (P/WC-POST-OBS5)	*Peter was able to narrate the problem's scenario in his own words*

When I asked Peter to think of one of the strategies that he knew, in order to simplify it more, his first reaction was ignorance. With additional help he suggested making a drawing which was helpful indeed for the particular problem. This is an indication that Peter adopted some of the strategies taught during the implementations.

Ref 20

The problem is simple. I am asking Peter to think one of the strategies he knows in order to simplify it more. Peter says that he doesn't know but then he suggests making a drawing. (P/WC-POST-OBS5)	*Peter adopted some of the strategies taught during the implementations*

In addition, Peter had the chance to increase his participation levels during the feedback provided by the teacher and myself, and also during the whole-classroom discussions that followed after each WMP, which students solved with the use of the computer.

Ref 21

Peter is raising his hand to read the answer from his notebook but he is not willing to announce the solution, although he showed that he understood it.	*Peter's participation increased through the opportunities to discuss with group mates, teachers and whole-classroom discussions*
In the discussion Peter raises his hand and has the chance to explain the way they worked successfully. (P/WC-DUR-IMPL2)	
They are solving the problem on the whiteboard. Peter is raising his hand but he doesn't have the chance to talk.	
Peter is explaining the problem with the help of one of the students in his group. (P/WC-DUR-IMPL5)	

However, there were cases where Peter lost interest, a fact that influenced his level of participation. The main reason for losing his interest was distraction by one of his group mates, which reveals a potential disadvantage of collaborative learning in groups with friends. This fact played its role in the reduction of Peter's participation levels in many cases.

Ref 22

One of the students of the group starts explaining and Peter continues. The 3rd student of the group is not very interested.	*Peter was easily enticed by one of his group mates*
While they are listening to the provided help, Peter is discussing about irrelevant topics with one of the students in the group (off-task). (P/WC-DUR-IMPL5)	
Peter is not participating in the discussion because he is talking to his group-mates. They are thinking the break. (P/WC-DUR-IMPL6)	

After the implementations, Peter continued to participate to the same extent as before the implementations of WBLE. For example, when the students had some WMPs to solve at home and the teacher asked them to check their answer and discuss the solutions. I observed that participation was relatively increased in comparison to participation in other cases. The same happened with Peter. Nonetheless, he mainly only participated here when he felt that he was able to succeed and especially after the collaboration in the group.

According to the class teacher, Peter's participation level increased during the discussions of how they had solved the problems, in comparison with individual work. He seemed to be surer of what he was saying, and did not seem to have the usual hesitation. The teacher asserted that collaborative learning greatly helps, and therefore she tried to take advantage of the fact that they were sitting in groups to ensure that the less able students benefited from collaboration. What the teacher pointed out here confirms what I observed in the classroom after the implementations of WBLE.

Ref 23

Hence, Peter's participation was increased during the discussions we had of how the children of the classroom solved the problems, in comparison with individual work. He seemed to be surer of what he was saying and I did not see the usual hesitation.	*Participation was increased after the collaboration in groups*
Collaborative learning helps a lot and I try to take advantage of the fact that they sit in groups to ensure that weaker students are benefited from collaboration. (P/WC-POST-InterviewT1)	

7.4 Opinions about mathematics and WMPs

Another possible impact of the computer-assisted learning in solving mathematical problems is potential alterations in terms of Peter's opinions and attitudes towards mathematics and WMPs. At this point, his opinions and attitudes as recorded in the interviews before and after the implementations are explored.

Peter expressed a negative attitude towards mathematics and admitted that he faced many difficulties. His statement agreed with what I observed and what teachers pointed out, and it was likely associated with his low self-esteem as a result of a chain of failures in mathematics. Interestingly, Peter did not choose maths as his favourite school subject in a poll-like activity in an English language lesson that I observed before the implementations. Also, he agreed that WMPS was the most difficult part of mathematics. He also agreed that he could cope more easily with understanding when someone read the problem for him, explaining it in a simpler way.

Interestingly, Peter said that he changed his opinion more positively about mathematics after the implementations, and the use of the computer at the lab.

Ref 24

K:Has your opinion about mathematics changed since the last time I asked you? *P:Yes.* *K:What has changed? Do you like it more now?* *P:Yes.* *K:Why? What has changed since then?* *P:Because I liked what we have done together at the computers' lab…(P/WC-POST-InterviewSD1)*	*Peter saw mathematics more positively after the implementations*

7.5 Opinions about ICT and the use of the computer

Apart from Peter's opinions and attitudes towards mathematics, it is interesting to examine the opinions and attitudes towards the use of ICT in the lessons, and the use of ICT in mathematics and WMPS before, during and after the implementations. In general, the use of the computer was limited to the use of some tools for the facilitation of the lessons, and remained the same before and after the implementations. Despite the inadequate use and limited opportunities for the students to use the computer during the instructions, the students expressed their will to use the computer more often and recognized its value in learning processes. The opinions and the extent of ICT usage before, during and after the implementations are presented below.

Before the implementations, the students mentioned that they had never had the opportunity to work on the computer previously for any topic related to mathematics. Peter never used the computer for any activity in mathematics, even during the supporting lessons. His only use of the computer was for gaming.

Ref 25

K:Did you play games related to mathematics? *P:No, just games. (P/WC-PRE-InterviewSD1)*	*Peter never used the computer for activities in Maths*

He expressed a desire to work on the computer for mathematics, and liked the idea of solving WMPs with the use of the computer. He agreed that a computer-based program for WMPS could be helpful in understanding the problems more clearly.

The majority of the students held the view that it would be better to use the computer instead of studying with books. They also held the view that activities on the computer were like a type of game. Generally, the students were excited by the idea of working on the computer during the lesson, and were positive about the idea of solving WMPs on the computer. Several features provided by the computer, such as an audio version of the problem, video, etc., seemed to make students' attitudes more positive towards the use of the computers for WMPS. The same happened with Peter, as he admitted that he liked working on the computer. Even from the first implementation, Peter and other students were excited with the idea of solving WMPs with the use of the computer, and asked to repeat such exercises.

Ref 26

Students are excited with the WBLE. Three students are asking whether we will work on the computers the next day. (P/WC-DUR-IMPL1)	*Students were excited with the idea of solving WMPs on the computer*

After the implementations, many students expressed their desire to use the computer more often in their lessons. The teacher confirmed this by stating that Peter and other students were enthusiastic and had asked to visit the computer lab more often. It seems they maintained their positive attitude towards the computer after the implementations, and Peter expressed that he had enjoyed the chance to use the computer for mathematics.

Ref 27

The students are enthusiastic and ask to go to the computer lab more often. (P/WC-POST-InterviewT1)	*Positive attitude towards the computer was maintained after the implementations*
It was something that children liked. (P/WC-POST-InterviewT1)	

Peter admitted that the computer was not only for entertainment, but also that it made the learning procedure easier.

Ref 28

K:Why did you like it? Do you think it was entertaining? *P:It is more easy. (P/WC-POST-InterviewSD1)*	*Peter admitted that the use of the computer facilitates the learning procedure*

7.6 Difficulties and approaches related to WMPS

As far as the difficulties and capabilities of the students, including Peter, in WMPS are concerned, it is interesting to overview any latent changes through the process of the implementation of the project. In addition, the approaches of the teachers, through the process, are presented here in order to shed light on any potential changes on teaching approaches in WMPS. Some of the results that occurred before, during, and after the implementations are presented below. It is important to note that such results were helpful at the stage of the design of the WBLEs where particular difficulties and capabilities of Peter and his classmates were taken into account.

Before the implementation, I observed that a few students were employed some strategies in order to understand the WMPs, such as highlighting or underlining the details and questions of the problem. Most of the students, Peter included, could not solve the problem unless the teacher had offered some hints. Yet, even if the teacher did disclose some helpful clues, they were still remained dependent on their group mates, as well as the teacher. The most difficult part of the procedure was the choice of correct strategy. The difficulty was greater in the WMPs that involved more strategies than the basic, simple operations. Even the more able students seemed to face difficulties with this kind of WMPs, a fact that was confirmed not only by the observations and the pre-test, but also by the teacher.

Ref 29

All of the students, even the more able ones have difficulties when they have non-numeral problems to solve. (P/WC-PRE-InterviewT1)	*WMPs not involving one of the four operations were more difficult*

When the students worked in groups, the outcome was much better and the majority of students, Peter included, were able to solve the problem with the help of the teacher. This showed the advantages of collaborative learning in groups. Peter also benefited from the collaboration in his group.

Ref 30

After the explanation, students work in groups to solve the WMP. (P/WC-PRE-OBS–Maths)	*WMPs can be solved easily in cooperation in groups*

It is important to mention that the teacher used to explain the problems by using the question and answer technique (Q&A). They also read the problem a second and third time, and would highlight keywords and details of the problem. One usual method that teacher followed was to ask a student to explain the problem in their own words.

Ref 31

Teacher explains the problem by using comprehension questions	*Some strategies were helping the students to solve WMPs*
Students are reading the problem from the textbook. (P/WC-PRE-OBS–Maths)	
Some students highlight the details and the questions of the word problems in the textbook (P/WC-PRE-OBS1)	
We read the problem for a second and third time, we highlight the keywords and the details of the problem.	
I usually ask a student to explain the problem in his/her own words. (P/WC-PRE-InterviewT1)	

The teacher referred to the ability to understand the problem as one the most significant problems of the students, even the more able ones.

Ref 32

…most of the students face difficulties in solving such problems. Even the students who are good in solving WMPs face difficulties.	*Understanding the problems was one of the most significant difficulties*
They have difficulties in understanding what the word problem says. (P/WC-PRE-InterviewT1)	

In addition, choosing the correct strategy was another considerable difficulty for the majority of the students.

Ref 33

Students cannot find the strategy that helps to reach the solution of the problem. (P/WC-PRE-OBS–Maths)	*Choosing solving strategy was one of the most significant difficulties*

When the word problem contained numbers, many of the students, including Peter, selected one of the four operations randomly, without any indication of thinking about the problem.

Ref 34

Most of the time, students select one of the four operations randomly, just to say that they solved it. (P/WC-PRE-InterviewT1)	*Some students were choosing math operations randomly without thinking about*

Many students, including Peter, could not remember or recall keywords even if they were repeated, during the lesson, in particular WMPs. This reflects the weaknesses of the students in terms of those two particular steps (understanding the problem and choosing the suitable strategy) of WMPs.

Ref 35

They don't remember keywords even if we repeat them many times during the lesson. (P/WC-PRE-InterviewT1)	*Some students could not recall keywords useful for the WMPS*

The teacher also stated that many of the students were not able even to start the procedure to solve the word problems, and therefore waited to copy the solutions from the board. Even if the teacher helped them individually, they could not continue alone from that point in order to reach the solution.

Peter was one of those students.

Ref 36

Many of them don't solve the problems but they wait to copy the solutions from the board. Even if I help them to understand the problem, they won't know how to continue in order to reach the solution. (P/WC-PRE-InterviewT1)	*Some of the students were dependent on teacher's help regarding WMPS*

Similar difficulties occurred during the implementations of the WBLEs. Most of the students faced difficulties with problems containing unknown terms, such as the meaning of 'percentage', which is a term that they did not meet often in the WMPs of their textbooks. The same occurred with Peter and his group mates.

Ref 37

The (b) question of the problem asks the student to find the percentages of the pieces of pizza the children ate in the problem	*The students were facing difficulties with problems containing unknown terms*
The students find the procedure difficult. Only one group continued without any special help. It seems the students in the group of Peter do not know what percentage means. One of the students is not native speaker of Greek language. When the more able student of the group hears the term "per cent" he understands immediately. (P/WC-DUR-IMPL2)	

Furthermore, Peter and the majority of the students had difficulties concerning WMPs involving strategies other than simple math operations, such as 'reversal route', 'try and check', etc. Even if students had the chance to solve similar WMPs previously, they still did not get used to them, a fact that was obvious from their performance. This difficulty was also noticed before the implementations.

Ref 38

26':35" I am asking if they found how to solve the problem. Only the most able student is answering to my question. The problem needs no operations to be solved, although the good student of the group is trying to find which operation is suitable for the problem. (P/WC-DUR-IMPL3)	*Difficulties with WMPs involving strategies other than simple math operations.*
These WMPs (reversal route) are not familiar to the students. (P/WC-DUR-IMPL5)	

After the implementations, it seemed that many students had adopted the habit of investigating the instructions of WMPs before solving them, by highlighting, underlining or circling given details and questions of the problem. Peter also did the same.

Ref 39

Peter is highlighting (underlining) the given details and he puts the question in a circle. (It seems he adopted this habit from the implementation of the program with the use of WBLE). (P/WC-POST-OBS1)	*The students adopted the skills for the investigation of WMPs*
Some students highlight the given details and they put the questions of the word problem in a circle. Peter has done that as well. (P/WC-POST-OBS2)	

In a discussion with Peter, I asked him to say out loud the problem in his own words. He did this well, which showed that he had comprehended the problem, after careful reading and investigation.

Ref 40

I am asking Peter to say the problem in his own words and he is doing well. The problem is simple. I am asking him to think of one of the strategies he knows in order to simplify it more. He says that he doesn't know but then he suggests making a drawing. (P/WC-POST-OBS6)	*Peter became more able to narrate WMPs in his own words*

However, Peter showed difficulties in choosing a suitable strategy. Peter seemed to be embarrassed and unsure in himself in saying what he thinks, thus he claimed that he did not know the answer. After our discussion, he found the right strategy. Peter faced the usual difficulties in operations, thus he would ask for help from his peers.

Ref 41

After the drawing, Peter understands how to solve the first problem. He faces minor problems with the operations but he asks for help from his next peer. (P/WC-POST-OBS6)	*Peter faced difficulties in choosing the solving strategy and in dealing with math operations*

In addition, students faced difficulties with recently introduced terms and notions, which made the comprehension of WMP more difficult. When the problems particularly involved notions of proportionality, ratios and surface areas, students showed significant difficulties. Such difficulties were also observed before and during the implementations.

Ref 42

They continue to the second problem. It is a more complicated problem of proportionality. But in order to find the terms of the rations they need to count the surface areas of two different rooms by using the details from the architectural plan of the house. (P/WC-POST-OBS6)	*The students were facing difficulties related to novel mathematical notions*

7.7 Advantages and weaknesses of collaborative computer-assisted learning

Before the implementations, I asked Peter, some of his classmates and the class teacher about their opinions on collaborative learning. It was important to take into account the opinions' of the students, and the approaches of the class teacher, since the project could not be conducted without collaborative learning for many reasons. Any prejudiced or biased attitudes towards collaborative learning on behalf of Peter, his classmates, and the teacher, could influence the outcome of the implementations. Some of these opinions are provided below and confirmed by the observations. Following this, some findings taken from the data collected during and after the implementations are overviewed in order to delineate the extent that collaborative learning in groups can help Peter in WMPS.

Before the implementations, the students understood the collaboration as a procedure that takes place between friends. A few students understood this collaboration as an opportunity to exploit others, by trying to cheat and copy from the other students. This was stated by one of the members of Peter's group that I interviewed. The student was the most able student in that particular group, so other group members tended to depend on him, and he had the feeling that everyone in the group wanted to copy from him. He continued by saying that there was no collaboration with Peter because the latter only wanted to crib and copy from him.

Ref 43

K:Do you collaborate with him (Peter)? *S5:No, we don't collaborate because he wants to crib and cheat from me. (Sources:P/WC/PRE-InterviewS5)*	*Peter used to exploit collaboration*

Generally, students had no negative reactions with the fact that they were going to collaborate in groups in the lab because of the few computers. At first Peter felt that it would be better if he was using the computer alone, but then later admitted that collaboration could be better because it would give the group's members the opportunity to help each other.

The class teacher supported collaborative learning because students had several benefits when they worked together in groups and helped each other. The students worked in groups of five to six per group. The more able students used to help the weaker ones, so participation in the classroom increased. In addition, the teacher asserted that students did not usually raise their hand when they worked individually, but participation increased when they collaborated in groups. In general, there were many benefits derived from collaborative learning, especially when there were less more able students in the class, which is why the teacher tried to form mixed ability groups, so each group had at least one more able student. From the observations, it was obvious that students had benefitted from collaboration in groups. They had more chances to talk in the group than in the whole classroom. During the first observation, there were low levels of collaboration. They would collaborate only when they had difficulties.

Ref 44

I was always a supporter of collaborative learning because students have several benefits when they work in groups and help each other. As you saw, my students work in groups of 5-6 students and I ask them to collaborate in their groups. The able students help the weak ones so the participation in the classroom increases. Students usually do not raise their hand when they work individually, but the participation increase when they collaborate in groups. In general, there are many benefits derived from collaborative learning, especially when the able students are few in the classroom, that's why I tried to form mixed abilities groups, so each group has at least one good student. (Sources:P/WC-PRE-InterviewT1)	*The teacher recognized the advantages of collaboration*

It is important to mention that some students were dependent on others, and would usually stay silent; they would agree passively, and often expected to find answers and solutions from their group mates. Peter also acted like this. He was very slow when working alone, and often felt the need to ask his group mates for help.

Ref 45

Peter is trying to answer the exercise but very slowly. He is asking for help from his group members. (Sources:P/WC-PRE-OBS-English)	*Peter was depended on the collaboration with his group mates.*
There is collaboration between his group members after the teacher's encouragement. Student with dyslexia doesn't express his opinion during the discussion. He is listening to the others, agreeing and writing in his textbook. (Sources:P/WC-PRE-OBS-Science)	

It is also important to mention that during the first four implementations, Peter's group consisted of three boys. Peter chose to sit with his two closer friends, his peers sitting next and opposite to him in the mainstream classroom. The latter was the most able student of the group while Peter and the third student were the weaker students. The most able student undertook the initiative to use the mouse for the management of the WBLE's navigation, and coordinate the collaboration in the group. However, in some cases Peter and the third student passively accepted the opinions of the most able student, which gave the impression of a 'guided-by-one' collaboration.

Ref 46

The most able student is still leading the group	*Collaboration in target group was guided by the most able student*
They collaborate but the most able student of the group expresses his ideas and the other two students are following. They discuss when they have to decide about the operation, although they follow the opinion of the best student of the group. (P/WC-DUR-IMPL1)	
Ideas for choosing the strategy for solution: Peter doesn't say his opinion. He is waiting for the other two students to say their opinion. (P/WC-DUR-IMPL2)	

During the last two implementations, students were placed in mixed-ability groups. This helped the students to collaborate with their group mates who were not necessarily their closest friends. The different features and capabilities of the group's members were important in terms of a healthy collaboration between the members, since they helped each other to overlap any potential gaps in terms of knowledge, abilities and behavioural issues.

Ref 47

We created mixed-ability groups. Peter is a member of a different group this time. He is the user of the computer's mouse.	*Peter was benefited from the collaboration with his new group mates*
They seem to be very careful.	
One of the students bring them back to the session (P/WC-DUR-IMPL5)	

The students had many opportunities to participate in the lesson during the implementations, either in the discussions within their groups or with the teachers or even in discussions in the whole-classroom level. The collaboration played its role in the increase of the participation for the majority of the students. The participation level significantly increased, especially for students of the target group, when they collaborated, stayed on-task, and were not working completely independently.

Ref 48

17':15" They keep trying as long as I am with them. The three of them are participating. (P/WC-DUR-IMPL4)	*The students of the target group increased their participation level during the implementations*
The three of them are participating in the discussion but the student S1 is participating more than the other two students. It seems the student S1 has understood better than the others. (P/WC-DUR-IMPL5)	

However, there were cases where the students of the target group were collaborative, but occupied with off-task discussions or activities. This happened especially when the students of the target group were working independently with no guidance from the teachers.

Ref 49

off-task:laughs, discussion with a student of the next group. (P/WC-DUR-IMPL1)	*The target group's students were occupied with off-task discussions when they were working totally independently*
Students are showing less willingness, they look tired. It's the last session of the day and it is obvious from their off-task discussions during the lesson. (P/WC-DUR-IMPL2)	
Student in the target group are discussing about off-task things (P/WC-DUR-IMPL3)	

After the implementations, the first student I interviewed pointed out that the collaboration in groups of three to four students in the computer lab created a noisy environment, because students were all talking together. The student declined that the problem was that many students were gathered in the same place, thus the problem might have lied in the particular groups.

Ref 50

K:Didn't you like the place because you were many students all together? *S1:It was not that. It was too noisy. They were talking all together. (P/WC-POST InterviewS1)*	*Collaboration in large groups was not productive and causing noisy environment*

It is important to mention that this particular student was one of the three students in Peter's group. When he was asked about the collaboration they had in their group, the student answered that the two other teammates

(Peter included) waited for him to think of solutions and answers on their behalf. Characteristically, they even asked him to hurry up and let them know when he understood the problem and was ready to explain it to them.

Peter preferred to work on the computer with the help of his teammates instead of working alone, because the collaboration provided additional aid. However, he pointed out that the size of the group played its role on the outcome of the task.

Ref 51

K:Do you think it would be better for you to work on the computer without any help from anyone else? Or do you think it is better to have additional aid from somebody else? *P:It is better to have additional aid from someone else.* *K:Nice. So, you would like to have additional help from any of your classmates or your mum or anyone else...* *P:yes.. It was hard when we were 4. But it was much better when we were 3 or 2 in the group.(P/WC-POST-InterviewSD1)*	*Peter recognized the benefits of collaborative learning*

The class teacher stated that Peter was obviously helped enough from the collaboration with his classmates. Although he was not sitting with classmates who could help him more the first few times of the implementations, when he changed group there was good collaboration, and students helped each other and discussed together while they worked on the computer.

Ref 52

I think it was obvious that Peter had enough help from the collaboration with his classmates.	*Peter received significant help from the collaboration with his group-mates*
He was not sitting with classmates who could help more, the first few times we implemented the program. There was collaboration and students were helping each other and discussing together while they were working on the computer. (P/WC-POST-InterviewT1)	

The teacher gave some examples of the help that Peter gained as a result of the collaboration in groups. She focused on the facilities provided by the computer, for example, listening to the problem, something that could be replaced by the teammates who could explain the WMP in a simpler way to the less able students.

Ref 53

Peter has difficulties in reading; so, beyond the provided help from the computer, he had help from his classmates.	*Peter received significant help from the collaboration with his group-mates and the facilities provided by the WBLE*
Either he could listen to the problem or somebody from his group could explain it orally.	
Hence, Peter's participation was increased during the discussions we had of how the children of the classroom solved the problems, in comparison with individual work. He seemed to be surer of what he was saying and I did not see the usual hesitation. (P/WC-POST-InterviewT1)	

She also stated that greater acceptance was achieved through collaborative learning because students became closer.

Ref 54

I think more acceptance is achieved through collaborative learning, because students come closer, they help and support each other and feel the importance of their contribution to the group. (P/WC-POST-InterviewT1)	*Collaboration brought students closer to each other and improved the level of acceptance*

The students continued sitting in groups of five to six in the mainstream classroom after the implementations. They collaborated in the same way as before the implementation, either in groups or in pairs. The effectiveness of the collaboration depended on the topic. When all members of the group faced difficulties in a particular topic, or understanding the instructions, or were not paying attention to teacher's instructions, then the collaboration was not fruitful. The teacher used to implement different styles of collaboration during the lesson, depending on the topic and the extent of difficulty. For example, when the students were able to work on an exercise alone, she asked them to work individually. When the students faced difficulties, she asked them to collaborate in pairs. When pairs still faced difficulties, the teacher then asked them to collaborate in groups. It seems that the students preferred working in pairs, as when they were given the option to work in pairs, the majority of the students chose to collaborate with their next peer.

7.8 The extent that computer-assisted learning environments can help

The main research question refers to the exploration of the extent that computer-assisted environments can support students with dyslexia in WMPS. After the presentation of findings related to the difficulties faced by Peter and his classmates in solving WMPs, before, during and after the implementations, some findings concerning the ways that computer-assisted environments helped Peter and his group mates to deal with their difficulties during the process are presented below. The provided examples are taken from the analysis of data collected during and after the implementations.

During the implementations, the students were helped in solving the WMPs by using the provided facilities, such as audio versions of the problems, the possibility of repeating listening to the audio version of the problems, text with the problem scenario, pictures, descriptive figures, tables, animations; downloadable material such as documents, etc.; the use of a calculator for checking the answer; helpful tips; navigation buttons and the provision of immediate feedback. Animation and pictures especially made the students more excited and caught their interest while they worked in groups. The students referred to some of those benefits during the interviews after the implementations.

One of the students agreed that WBLE provided additional help and explanations of the word problems in simpler words, which helped in understanding the problems and thus reaching the solution more easily.

Ref 55

It was easier to reach the solution. The program helps me to understand the problem, so it was easier to solve it. (P/WC-POST InterviewS3)	*WBLEs helped students in understanding and solving WMPs*

Additionally, Peter stated that he liked the fact that he could listen to the WMPs, and that he could listen to the audio version of the problems as many times as he wanted.

Ref 56

P:The fact that I could listen to the problem...	*The audio version of WMPs and the facility to repeat the audio were additional benefits for Peter*
K:How about the fact that you could listen to the problem again and again.. I am saying that because I noticed that you were listening to the problems many times. *P:Yes. (P/WC-POST-InterviewSD1)*	

He also stated that it was easier and more pleasant to solve WMPs with his classmates, with the use of the computer. Peter and his classmates benefited from the pleasant climate and the simplification of the WMPS from the use of the computer.

Ref 57

K:Did your peers in your group help you? *P:Yes.*	*WMPS made the lesson more pleasant*
P:Because it is easier and the time passes more pleasantly. (P/WC-POST-InterviewSD1)	

Two of the interviewed students pointed out that the provided help at the stage of “understanding the problem” and the stage of the provided “help tips” was very helpful. This helped them to understand the problem and solve it in a more creative way. Also, Peter agreed that solving WMPs on the computer was easier because it provided helpful tips. He also had the same opinion that the steps he was following for WMPS on the WBLE were more helpful instead of solving the same problem in his textbook or notebook.

Ref 58

P: It is easier. *K:So, where was it more helpful for you when you say it is was easier? Explain to me what you are saying if you can…* *P:Because it provides help tips…* *K:So you think that the steps you were following for each WMP were more helpful instead of solving the same problem in your textbook or notebook.* *P:Yes. (P/WC-POST Peter Interview)*	*WBLE made solving procedure easier*

Interestingly, the class teacher explained that the computer can help the students, since it can fill the gaps of the group and form a pleasant ambiance automatically, because the students held the view that working on the computer was similar to playing computer games.

Ref 59

But I would say that it is a great way to differentiate the instruction, especially in classrooms with students who face diversified difficulties.	*Benefits from using the computer for the differentiation*
The computer can help since it fills the gaps of the group and forms a more pleasurable climate automatically because students believe that working on the computer is something like playing computer games. (P/WC-POST-InterviewT1)	

The teacher also mentioned some of the good quality features of the WBLE design, for instance the audio facilities, and the illustrative pictures and diagrams that helped Peter to understand the problems. She also believed that the WBLE provided navigation buttons for the steps of WMPS, from understanding the problem to the selection of strategy and the solution, which was very helpful for the students.

Ref 60

Especially the fact that he could hear the word problems apart from reading them, the fact that there were pictures and diagrams explaining the problem apart from textbook's images and text.	*Benefits derived from the features of the WBLEs*
WBLE had navigable steps from understanding the problem to the selection of strategy and the solution. I think it was very helpful.	
It was very helpful when he could listen to the word problem in simpler words at the stage of 'understanding the problem'.	
Computers can help students to understand and guide them how to solve a word problem in Maths, what strategy to choose in order to solve a problem, concern them, give them ideas and feedback. (P/WC-POST-InterviewT1)	

Although the teacher was already positive towards the use of ICT in education, her experience after our cooperation somehow changed the way she perceives the integration of new technologies in the instruction, as she pointed out.

Ref 61

It was a very good experience and I changed somewhat the way I think about the integration of new technologies in the instruction.	*The teacher was willing to embed new technologies in a more interactive way in her instructions*
I will try to embed new technologies when it is possible but in a more interactive way in comparison to what I was doing before the implementation. (P/WC-POST-InterviewT1)	

It was obvious that the teacher of the mainstream classroom had very positive views on the use of ICT in order to help students with dyslexia, or any student who faced difficulties in WMPS. The use of the word 'definitely', with its strong meaning, revealed that her positive view towards that use of ICT in education was undoubted. In addition, the teacher gave an example of the facilities of ICT in WMPS. I did not ask her to suggest further benefits, thus she only referred to audio facilities provided by the computer. According to the teacher, this facilitated the first stage of WMPS, that is to say the students were able to understand the problem when they could listen to it in simpler words.

Ref 62

It was very helpful when he could listen to the word problem in simpler words at the stage of 'understanding the problem'.	*ICT could help Peter to overcome his difficulties*
K:Do you think that ICT can help Peter to cope with the difficulties they face in WMPS? *T (POST):Definitely yes, I think it is obvious from the case of Peter. (P/WC-POST-InterviewT1)*	

Nonetheless, some factors constricted the extent that the computer assisted environment provided differentiation and support. The extent to which the computer assisted environment could provide support and differentiation was limited where the teachers had to intervene in order to give solutions to technical issues, behavioral problems, or other students' inquiries. In addition, the teacher referred to some other factors that played a role in the limited use of ICT for WMPS in her instructions. For instance, the lack of ready-to-use educational software, the limited available time for the design of WBLEs and their implementation, and the demanding national curriculum were some of those deterrent factors.

The teacher had never tried to implement new technologies in her instruction in a more interactive way for the students, because she was always afraid of a lack of time and the high demands of the national curriculum, and how these may deter such implementation.

Ref 63

I have never tried to implement new technologies in my instruction because I always was afraid of the lack of time and the large compulsory curriculum.	*Lack of time and high demands of the curriculum*
I do not know if I would design similar software because it takes much time and great pleasure and love. But I do not rule it. (P/WC-POST-InterviewT1)	

She said that she was willing to embed the new technologies if she was provided with ready-to-use software, and if long term investment was not necessary for the preparation of the programs. She described this case as perfect, but on the other hand she admitted that the majority of the teachers would not be eager to do it. As she explained, time and a positive attitude were needed by the teacher in order to design and create WBLEs.

Ref 64

If I was given ready-to-use software and if I should have not devote time to prepare them, then yes it would be perfect. But time and good mood are needed when the teacher has to design and create the WBLE. I think many teachers would not be willing to do it.	*Readymade software is preferable*
If the ICT team of the ministry of education provides with ready-to-use software then I would use them. (P/WC-POST-InterviewT1)	

The implementations were a great opportunity for Peter and his classmates to use the computer for learning purposes, for the first time in their student lives. Apart from the differentiation of the instruction of WMPS through several computer-based tools and facilities, continuous support through feedback and guidance was provided by the teachers during this process. Hence, the class teacher believed that her presence was important during the implementations, even if the WBLE was well-designed. She probably meant that even if the WBLE was well-designed, it could not replace, in any way, the role of the class teacher.

Ref 65

I think that the teacher should be present and help the students because many times students have unexpected questions...so even if you created/designed a good and organized web-based learning environment, it will never cover all the arisen questions or difficulties of the students.	*The presence and the role of the teacher is vital*
I think the way we designed such WBLE offered great help. (P/WC-POST-InterviewT1)	

She also mentioned that expensive educational software and specialized knowledge were not necessary. Well-designed programs could be created with the use of simple and cheap software, if the teacher is willing and has the time to do so.

Ref 66

It was proved that expensive educational software and specialized knowledge are not necessary. Good-designed programs can be created with the use of simple software and good willing and free time on behalf of the teacher, without massive costs. (P/WC-POST-InterviewT1)	*A well designed WBLE does not require expensive software for its creation*

7.9 Pre-test and post-test data analysis

Two tests were administered, one before the implementations and one after. The initial test (pre-test) assessed understanding in solving WMPs, as well as potential problems or weaknesses of Peter and his classmates. After the implementation of the program, a post-test was administered which re-evaluated understanding, and skills in using cognitive and meta-cognitive strategies in WMPS.

The pre-tests and post-tests were administered to the whole class, whether they were considered as having dyslexia or not. I was, therefore, able to assess the level of the classroom as regards WMPS and make comparisons between their performances from before and after the implementations. The pre-test and post-test were the same.

The tests consisted of four WMPs with additional comprehension questions. The first two WMPs involved strategies other than math operations, such as ‘creating a table’ and ‘creating a drawing’. The last two WMPs involved multiple maths operations. All of the WMPs were chosen from the textbook of the Fifth Grade, and students were already experienced in implementing such strategies.

Each problem was rated with 25 points. The 25 points were distributed as follows: five points for effort; two points for the investigation of the WMP (indication of given data and the question); ten points for the implementation of strategy and maths operations; six points for the answer; and two points for explaining the followed process.

7.9.1 Pre-test

Peter scored 12/100 which is the minimum mark from the N1=20 out of 23 students who completed the test. The highest score was 99/100. The standard deviation of the scores is σ= 27.26 and the mean equals to $\bar{x}$ = 60.1. That means that Peter scored almost 2 standard deviations under the mean.

The graph below shows the results of the pre-test.

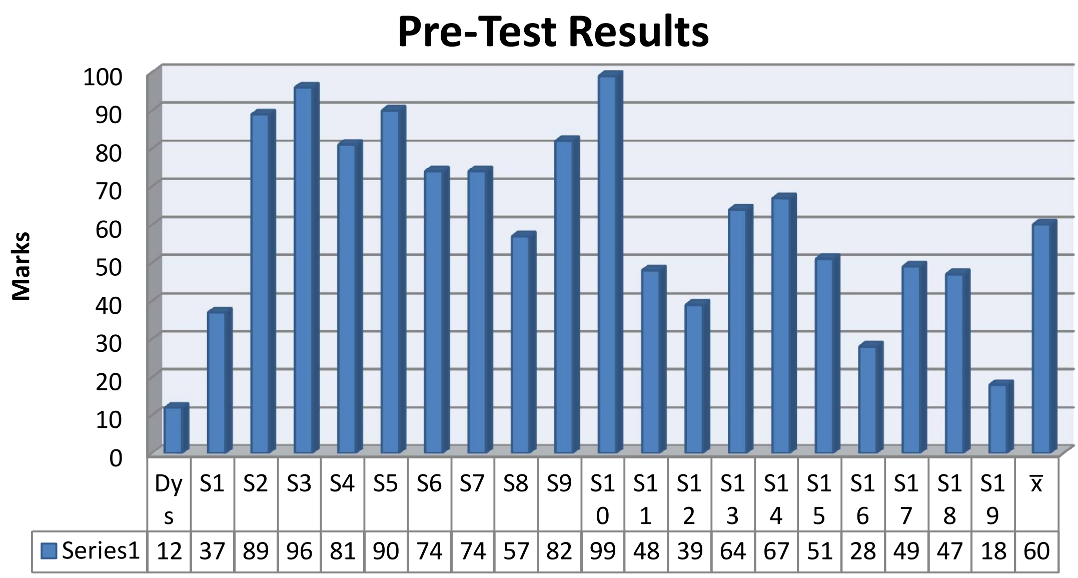


Figure 7.1 Pre-test results

7.9.2 Post-test

Peter scored 54/100 in the post-test. The minimum mark was 29/100. All students completed the post-test, N2 = 23. The highest score was 100/100. The standard deviation of the scores is σ= 21.23, and the mean equals $\bar{x}$ = 68.35. These results show that Peter scored close but below the mean.

The graph below shows the results.

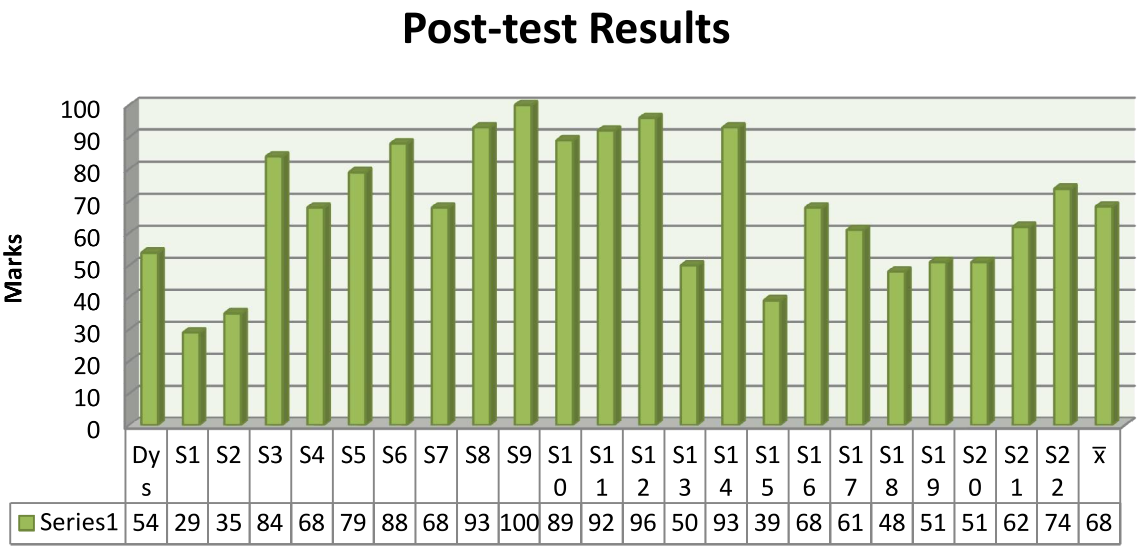


Figure 7.2 Post-test results

The mean increased between the pre-test and post-tests, showing that students performed better in the post-test than the pre-test. However, it is important to mention that Peter did not solve two out of the four WMPs in the pre-test, a fact preventing us from making safe conclusions. Peter did not save those problems either because he faced difficulties, or because of the lack of time and his slow pace. Nonetheless, the majority of students managed to solve, or at least managed to initiate, all of the provided WMPs.

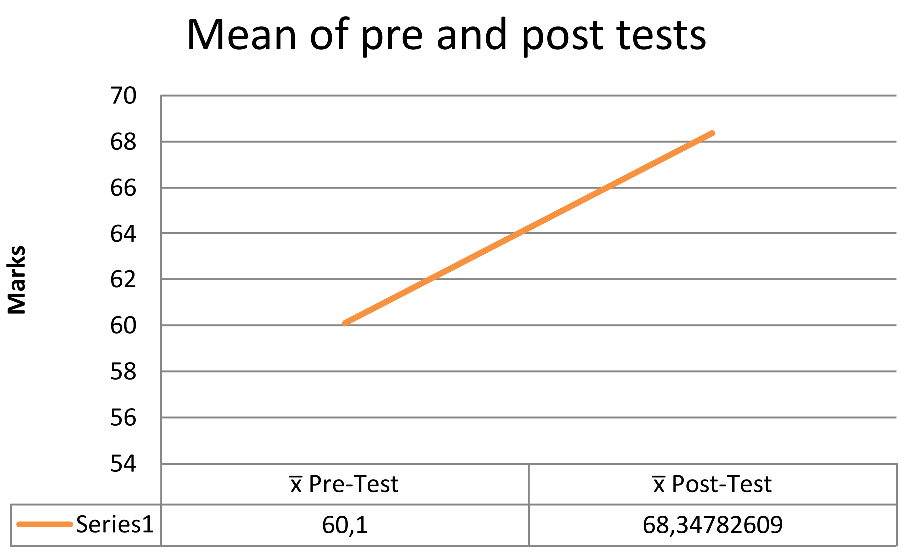


Figure 7.3 Comparison of the means

The same occurred with Peter's performance. The graph below shows that Peter's score increased by 4.5 times between the pre-test and the post-test.

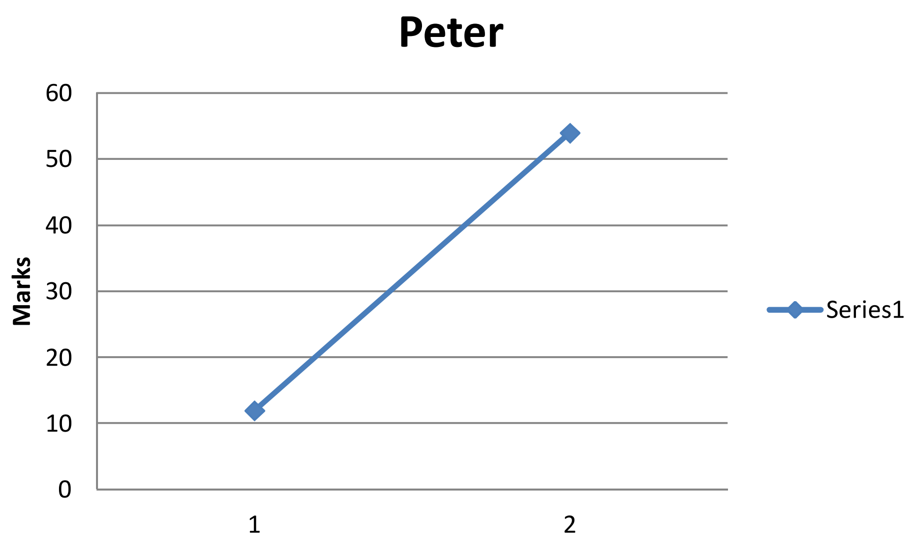


Figure 7.4 Peter's scores

The graph below shows the changes in Peter's scores between the two tests in each WMP separately. In the first WMP he scored 8 out of 25, while in the post-test he scored 20 out of 25 for the same word-based mathematical problem. He did not solve the second problem in the pre-test (for unknown reasons), while he scored 17/25 in the post-test. For the third problem, Peter scored 4/25 in the pre-test, which increased to 11/25 in the post-test. Finally, Peter did not solve the forth problem in the pre-test, but scored 6/25 for this problem in the post-test.

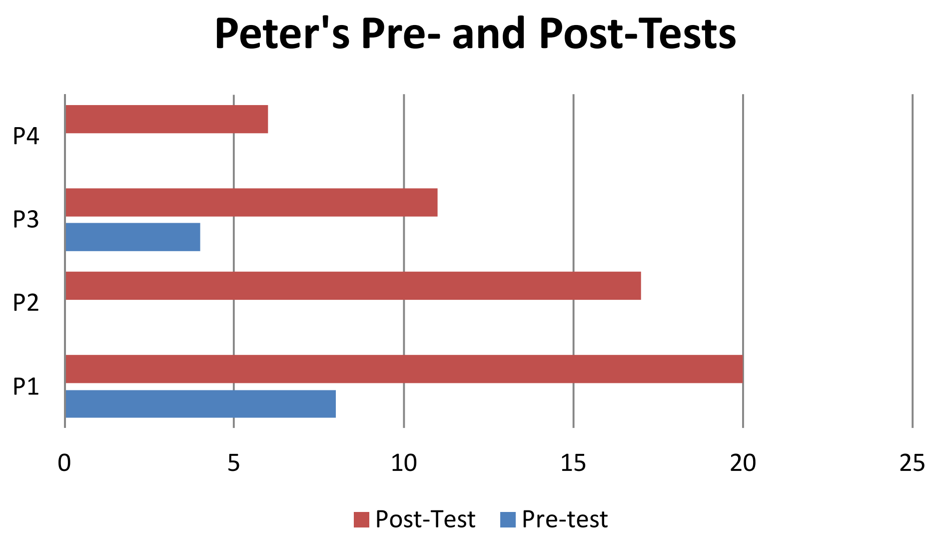


Figure 7.5 Peter's pre- and post-test comparison for each word-based mathematical problem

The tables below present the results of Peter's pre-test and post-test for each problem separately, and the allocation of marks in the five pre-decided marking criteria. It is important to note that Peter did not solve the second and the fourth word-mathematical problems in the pre-test for reasons that remain unknown. His performance considerably increased in solving the problems involving strategies other than the basic math operations, for example, the two first WMPs of the test. For instance, Peter received double marks for the implementation of a suitable strategy when solving the first WMP again in the post-test.

Table 7.1 Peter's pre-test results

	Pre-Test					
	Effort (5)	**Investigation (2)**	**Implementation of strategy and operations (10)**	**Answer (6)**	**Explanation (2)**	**TOTAL**
Problem 1	4	0	4	0	0	**8**
Problem 2	0	0	0	0	0	**0**
Problem 3	4	0	0	0	0	**4**
Problem 4	0	0	0	0	0	**0**
TOTAL	**8**	**0**	**4**	**0**	**0**	**12**

Table 7.2 Peter's post-test results

Post-Test						
	Effort (5)	**Investigation (2)**	**Implementation of strategy and operations (10)**	**Answer (6)**	**Explanation (2)**	**TOTAL**
Problem 1	4	2	8	6	0	**20**
Problem 2	4	2	5	6	0	**17**
Problem 3	4	2	4	1	0	**11**
Problem 4	4	1	0	1	0	**6**
TOTAL	**16**	**7**	**17**	**14**	**0**	**54**

7.12. Summary

In this chapter, I have presented the analyses of data collected from the first case study of this project: the whole-class case study. The chapter is organized by bearing in mind the research questions. The data presentation started with Peter's features, performance level, his participation and behaviour before, during and after the implementations. Following this, the data related to opinions about mathematics and the WMPs, and the opinions about the use of the computer were presented. After this, I presented an overview of the difficulties related to the WMPs, and how those difficulties were overcome, or not, with the use of the computer. Some advantages and weaknesses of collaborative computer-assisted learning were then overviewed, which led to the extent that computer-assisted learning environments can help. In addition, the scores of pre-tests and post-tests were analysed in this chapter. A comprehensive discussion of the findings' interpretations and their potential implications will be offered in Chapter Ten. The next chapter contains the presentation of data collected in the second case study of this project: the first individual case study.

Chapter Eight
Case Study Two: Alexis

8.1 Introduction

In this chapter, I present the analyses of data collected from the second case of this project: the first individual case study. Similarly to Chapter Seven, this chapter is organized in a way that presents evidence that supports the extent that computer-assisted learning environments can support a particular student with dyslexia, Alexis, with difficulties in WMPs, and the impact of computer-assisted learning in solving WMPs for students with dyslexia, but this time on an individual level, in accordance with the main and supplementary questions of this research.

The presentation of the data starts with a description of Alexis, and continues with his performance level, his participation and interest before, during and after the implementations. After this, I present an overview of the difficulties that relate to WMPs, and how these difficulties were overcome, or not, with the use of the computer. Following this, data related to the opinions about mathematics and WMPs, and the opinions about the use of the computer are presented. Then some strengths and limitations of computer-assisted learning are overviewed which seek to provide an answer to the extent that the computer-assisted learning environment helped the student. Again, it is important to mention that this chapter is limited mainly to the presentation of findings, and brief explanation of them. The results are presented in tables with the themes written in the right-hand columns. A comprehensive discussion of the findings' interpretations, and their potential implications, will be offered in Chapter Ten.

8.2 Features of Alexis

Before the data analysis, it is useful to point out some features of Alexis as a personality and student, which were noted before, during and after the implementations.

Alexis was giving the impression of being a ‘lazy’ student. He was disorganized and his was unable to keep his school bag tidy. Another characteristic related to the features of dyslexia was his problem with orientation. Nonetheless, he was sociable and open with his friends, and was often trying to make new friends.

According to the special teacher, Alexis’s attention was disrupted easily, which was why she preferred for him to sit at the right-back corner of the classroom when he had to work alone during the supporting lessons. Another example is that he was unable to ignore environmental sounds and discussions when working alone.

Alexis had low self-image, thus the class teacher often worked toward helping him to increase his self-confidence, and make him feel better in general. According to the teacher, even though the demands were few, the expected outcome was positive because her aim was to make him feel confident to be able to write, and manage to do something significant, which would provide a positive reinforcement and enhancement of his self-confidence. For the teacher, the most significant, core problem was Alexis’s low self-confidence due to continuous learning failures, thus in her point of view, this was the first thing that needed improvement, and hopefully the consequence would be an improved self-image.

According to the special teacher, Alexis was very immature for his chronological age and was not able to understand where additional support was needed, or not. Mathematics helped him to externalize his strong abilities, and helped him to outweigh his weaknesses in other subjects, such as the Greek language lesson.

In terms of speaking, Alexis had no significant problems. However, when he was stressed or very excited, he would start to stutter. This occurred during the interviews and implementations with the student. An additional feature was his impulsivity and dependency on his peers and teachers.

After the implementations, Alexis was much more careful, and seemed to care much more about several things relating to the lesson, with no need for motivation. According to the special teacher, Alexis was now aware of his timetable, which had not happened before. He was also able to start his work alone, without any need to urge him to do so. In addition, his self-confidence improved, and therefore he was no longer reluctant to give an answer, even if it was wrong. Of course this might be due to the fact he was maturing during the year, and was therefore able to understand that he should attempt more by himself, without being dependent on the others.

Further features of Alexis will be presented through the analysis of data in the following sections of this chapter.

8.3 Performance, participation and interests of Alexis

The impact of computer-assisted learning in solving WMPs includes any potential changes of Alexis's performance and participation before, during, and after the implementations. Apart from the teachers' statements regarding Alexis's performance, which were pointed out in the interviews before and after the implementations, some patterns of his performance during the implementations are overviewed. Some examples concerning his performance are provided below, showing the potential alterations of Alexis's proficiency level through the procedure.

According to special teacher, Alexis did not need any significant support in mathematics because he was doing well. However, some support was provided in this subject because he was a slower learner than other students, so they aimed to follow classroom's level and flow. The main support was provided in Alexis's Greek language lessons.

Ref 67

I think Alexis doesn't need a lot of support in mathematics. But we do support him because we prefer to follow classroom's level/flow. Mainly we focus on Greek language support. (A/IND-PRE-InterviewST2)	*Alexis was good in mathematics but slower than his classmates*

In terms of writing, Alexis faced many difficulties. Interestingly, the special teacher stated that a year ago, he was not able to write even a single word correctly, not only in terms of orthography, but he faced more significant problems. He used to omit letters, replace letters, and whole syllables. The special teacher started working on phonemic awareness, by working on simple activities with Alexis, which helped him to improve. The class teacher stated that she was shocked after her first reaction with Alexis. At the beginning of that school year (2012-2013), he was not able to correctly write even a single sentence, and his handwriting was not comprehensive.

Ref 68

K: How would you characterize the student with dyslexia in your classroom? A weak student, for example? *T: Look. I was shocked after my first reaction with that student. He couldn't write correctly even a sentence. I couldn't recognize his handwriting. (A/IND-PRE-InterviewT2)*	*Alexis had significant learning difficulties at the beginning of the school year*
Last year we finished phonology... he learned it. I hope he doesn't omit letters any more. He says them aloud and listens to them. (A/IND-PRE-InterviewST2)	*Alexis got improved after the intervention in phonology*

According to the special teacher, Alexis did not face any significant difficulties in mathematics. However, she delineated that they mainly focused on basics such as numbers, the four operations, and WMPs during the supporting lessons. In terms of WMPs, the teacher said that Alexis had difficulties in understanding the problems. She explained that most of the time he had difficulties with concentration, which prevented him from understanding what he was reading. This caused significant difficulty in solving WMPs.

Ref 69

He has difficulties in understanding the problem. Many times, he has difficulty in concentration in order to understand what he reads.	*Difficulties in understanding WMPs*
K: So the difficulty lies on the first part: in reading the problem and understanding it? *T: Yes, I think it lies in understanding. (A/IND-PRE-InterviewT2)*	

The teacher pointed out that he was not able to solve the problems in the tests. The teacher interestingly explained that at the beginning of the school year, Alexis was able to solve only one exercise out of seven to eight exercises of the test. He then started performing better and was able to solve two to three exercises more. It is a common phenomenon for students with dyslexia to be slower learners and thus not be able to keep up with the learning pace of other students.

Ref 70

T: So, we have a problem with WMPs because he cannot solve it in the tests. *K: So does he need additional time in tests?* *T: Yes. At the beginning of the school year, he solved one exercise out of 7-8 exercises I provided in the test. The next time, he solved 2-3. (A/IND-PRE-InterviewT2)*	*Alexis was not able to solve all the WMPs in Maths tests because of his slow pace*

During the individual implementations, Alexis worked on the WBLEs for WMPS with my guidance. Some examples of his performance during the implementations are provided below.

Alexis was interested, and was able to describe the 5-step model through a diagram, even from the first implementation with minor guidance. This shows his capability to describe figures, and his positive attitude towards the use of the WBLE for WMPs from the first time. Especially in the last step, ‘checking the answer’, Alexis highlighted the importance of checking the answer. However, when he was asked to describe the 5-step process at the beginning of the third implementation, he expressed some hesitation and difficulties.

Ref 71

Interestingly, at the last stage of "checking the answer", Alexis is able to explain the role of this step. He explains that it is important to check if there is any mistake that needs to be corrected. (A/IND-DUR-IMPL1)	*Alexis was able to describe the 5-steps model through a diagram with minor guidance.*
I ask him to describe the 5-steps model for WMP. He starts explaining the process but with some hesitation and mistakes. I revise the process after his description and immediately we move on to the first problem. (A/IND-DUR-IMPL3)	

Furthermore, Alexis was able to narrate the WMPs in his own words with the use of the provided pictures and information at the first step 'understanding the problem', as an indication of his capability to understand the problem's scenarios with the WBLE's assistance. However, he faced difficulties in initiating the narration.

Ref 72

The stage of "understanding the problem" provides two pictures of two ships and underneath information for each ship. Alexis is able to narrate what the problem says with the help of the pictures. (A/IND-DUR-IMPL1)	*Alexis was able to narrate the WMPs in his own words with some minor difficulties to start the narration*
At the stage of "understanding the problem", Alexis is able to say what the problem says in his own words. Again, he needs some help in how to initiate his narration, but then he does not face significant difficulties. (A/IND-DUR-IMPL2)	

Alexis was able to find the details of the problems by answering my questions, and was able to choose suitable maths operations with no significant difficulties, and with minor guidance.

Ref 73

After minor off-task discussion, Alexis underlines the given details and the question of the problem in his textbook, with my helpful questions. (A/IND-DUR-IMPL1)	*Alexis could find the details of the problems and choose suitable math operations with guidance*
At the second step "investigating the problem", Alexis is asked to describe what we have to do and what given details and the question of the problem mean. The student detects the given information and the question of the problem with my guidance. (A/IND-DUR-IMPL4)	

Alexis also worked well with simple maths operations, and operations involving fractions. Nevertheless, Alexis had difficulties with handling maths operations involving divisions and multiplications.

Ref 74

Alexis finds out the answer by doing the operation with no significant problem. It seems he is good in doing maths operations. (A/IND-DUR-IMPL1)	*Alexis is doing well in handling simple math operations and fractions*
Alexis solves the problem with my guidance by filling in the solving sheet, with no significant difficulties (A/IND-DUR-IMPL3)	

In addition, Alexis was able to explain and fill in diagrams for solving WMPs, when he was asked to do so.

Ref 75

We download and open the word document provided. Alexis finds it easy, as he says. He fills in the diagram without significant help. (A/IND-DUR-IMPL1)	*Alexis was able to explain and fill in diagrams for solving WMPs*
He completes the diagram provided in word document with my guidance but with no significant support. (A/IND-DUR-IMPL2)	

Alexis performed well when he concentrated on the task, thus he was able to answer comprehensive questions correctly.

Ref 76

Alexis listens to the first problem carefully and answers correctly to my questions with the help of the pictures provided. (A/IND-DUR-IMPL3)	*Alexis had the capabilities to perform well when he was on-task*

The class teacher indicated some improvements in terms of Alexis's particular difficulties, after the implementation of the WBLEs. She stated that Alexis had suffered with a lack of concentration, and that the approach that followed the steps of WMPs, helped him even more. According to the teacher, Alexis benefited from the implementations of the WBLEs. He was helped with his concentration and became better in mathematics. Again, we cannot claim that the main reason was the implementation of the WBLEs, as he was becoming more mature over time.

Ref 77

Sure, because this student has lack of concentration, the approach you followed with the steps of WMPS, helped him even more. The fact that he worked on the computer, visually helped him to concentrate better and focus on the problem. This is very important, and I see that he approaches the problem in a different way. Of course he continues to have deficient attention, but I find out that he is much better in mathematics and has improved immensely the last month. (A/IND-POST-Teacher Interview)	*Alexis improved concentration and got better in mathematics*

The special teacher stated that she never left Alexis alone to solve WMPs, and therefore, she did not notice any improvement. She explained that if she did leave him alone to solve problems, he would start reading and immediately solving them without following the correct procedures, which is why he was not able to reach the solution most of the time. He was not very experienced from the previous years in solving WMPs by following the 5-step procedure. She always had to remind him to highlight the numbers, find and write down the given information, and so on. She highlighted that when they were following and completing this procedure, he was able to continue and solve the problem without any difficulty. However, when she would leave him alone, he would try to solve it incorrectly. Again, it is obvious that Alexis was dependent on the teacher, and would fail most of the time when solving

WMPs alone.

Ref 78

T: actually, I didn't notice that because I don't leave the student alone to solve the WMPs. Second, when I let him to solve a problem alone, he starts reading and immediately solving it. I have to tell him, "Alexis, we must highlight the numbers, find and write down the given information. It might be my fault because I don't give clear instructions. I should try it once and let him solve a problem alone just to see how he solves it. When we complete this procedure, he might continue and solve the problem without any difficulty. But if I leave him alone, he will solve it wrongly. (A/IND-POST-InterviewST2)	*Alexis continued to be dependent on the teacher when he was solving WMPs alone*

Similarly, the class teacher admitted that she never let the students work alone or solve the problems. Alexis would take into account the more able students when he was collaborating with his group mates. Again, this is an additional example of his dependency on his classmates.

Ref 79

When we solve WMPs, we do it together; I don't let the students alone to work. I didn't let him alone to solve a problem. When he works in his group, he takes into account the more able students, so he cannot work alone. (A/IND-POST-InterviewT2)	*Alexis continued to be depended on his teacher and classmates*

Finally, the teacher noticed such changes in terms of participation, performance, and interest with Alexis in the WMPs that we solved in advance with the use of the WBLEs, when they resolved them in the mainstream classroom.

Ref 80

In general, his performance in Maths has been improved. It is much better than his performance in Greek language. After you worked with him, I noticed that he was raising his hand much more, in the particular problems you solved together. (A/IND-POST-Teacher Interview)	*Alexis's participation, performance and interest were improved*

8.4 Difficulties and issues related to WMPS

Furthermore, it is interesting to overview any latent changes concerning the difficulties and capabilities of Alexis in WMPs, through the process of the implementation of the project. It is important to note that such results were helpful at the stage of the design of WBLEs, where Alexis's particular difficulties and capabilities were taken into account.

Before the implementation, Alexis recognized his difficulties in solving WMPs that involved operations with divisions, and sometimes multiplications, and difficulties in handling problems with big numbers. However, he did not admit any difficulty in understanding WMPs. When I asked him to confirm that he didn't have any problems with understanding, he admitted that sometimes he did have difficulties, so he used to ask for help from his teacher, his peers, or his mother at home. When he had WMPs to solve at home, he said that he was able to solve them without any additional help. The references for these points are mentioned above.

The special teacher pointed out that if she read the problem out loud to Alexis, he would understand the problem. If she left him alone to decode the problem, he would not understand it. His whole attention was focused on struggles to read it, at first. He had difficulties in reading the problem, so he was not able to understand it. When the problem only involved one operation, such as addition or subtraction, Alexis was able to solve it easily. When the problems were complex and contained two or three operations, he then faced more difficulties. He also faced significant difficulties with WMPs involving strategies other than the four basic operations. Difficulties in understanding the problems could be seen in other students as well.

Ref 81

If I read the problem orally for him, he understands. If you let him alone to decode the problem, he won't understand. His whole attention is focused on struggles to read it, at first. He has difficulties in reading the problem, so he does not understand it. When the problem involves only one operation: addition, subtraction... he solves it easily. When the problems are complex and contain 2 or 3 operations, then he faces more difficulties.	*Difficulties in reading and understanding the WMPs*
K: Also, there are WMPs that do not involve the 4 basic operations but some other strategies, such as combinations etc... *T: He faces difficulties with those ones. (A/IND-PRE-InterviewST2)*	*Difficulties in handling with complex WMPs involving more than one operations or other strategies*

She explained that Alexis and the other students could not concentrate and focus on the problem in order to understand it, because nowadays children are interested in many other things which do not help then to focus on the text in order to understand it. The same happens with literary texts.

Ref 82

They cannot concentrate and focus on the problem in order to understand it. It is because nowadays our children are interested in many other things which do not help then to focus on a text in order to understand it. The same happens with literary texts. (A/IND-PRE-InterviewT2)	*Difficulties in understanding WMPs because of lack of concentration and attention*

The teacher suggested visualization of the text as a helpful approach, for example, a drawing, or using educational material. She would repeat and explain the same problem orally many times, but would also write the numbers on the whiteboard in order to help the students remember them. The teacher also found it helpful to start solving short (easy) WMPs, and steadily move on to longer (more difficult) ones, because Alexis and the other students were not that able to handle difficult operations or mathematical problems, and therefore they solved similar but simpler problems, and steadily moved on to more difficult ones.

Supportive and guiding approaches, such as reading the problem for Alexis, putting the numbers in a circle, underlining the question of the problem, making drawings and so on, were useful and helpful for the student in order to solve WMPs. However, he was not able to follow this procedure alone, therefore the special teacher would do it for him, or guide him most of the time.

Ref 83

T:I read the problem because there is no reason for him to read it. Then we will put the numbers in a circle and underline the question of the problem. If a drawing is necessary, we will make it. He is good enough. I cannot say that he has severe difficulties, but he needs that procedure in order to solve WMPs. *K:How about other strategies such as "I make a drawing" etc?* *T:Yes, but I will do it for him. He cannot do it alone. I didn't try that, to be honest. He might be able to do it. If you like try it with him. (A/IND-PRE-InterviewST2)*	*Alexis was unable to solve WMPs without assistance*

During the implementations, Alexis had difficulty with understanding some significant details of the WMPs. The main difficulties were with phrases, such as 'more than' or 'less than', which were included in problems involving comparisons of two quantities, and caused confusion.

Ref 84

He faces some difficulties so I help him to explain what the problem says. The problem describes two ships. We know the passengers that the first one carries. For the second one, we know how many more passengers it carries than the first one. Alexis confuses the quantity of "more passengers" with the quantity of the passengers. After a discussion, he overcomes the confusion. (A/IND-DUR-IMPL1)	*Some phrases included in WMPs caused confusion to Alexis*

During the first implementations, Alexis faced difficulties in indicating and understanding the required details of the WMPs.

Ref 85

Alexis is able to find the details of the problems by answering my questions, with no significant difficulties. However, he faces difficulties in understanding the question of the problem (A/IND-DUR-IMPL1)	*Difficulties in indicating and understanding some problems' details*
He comments on the provided pictures by saying that it is clear from the pictures that brown wheat is less than white wheat. So he concludes that the operation needed is subtraction. (A/IND-DUR-IMPL2)	

In addition, he had some difficulties in giving examples of his own WMPs with the use of diagrams. In this case, Alexis might have not understood the particular diagram, or he had general difficulties in generating his own WMPs based on given details.

Ref 86

Then we move on to the next stage "how to solve the problem". Alexis says with enthusiasm that he understood how to solve it, while we listen to the recording. At this stage, the use of diagram is suggested for the solution of the problem, according to the textbook. Alexis is willing to explain the diagram by giving as an example, a WMP of his own. However, the example he gives is unrelated to the asked by the diagram problem. (A/IND-DUR-IMPL1)	*Difficulties in giving own examples of WMPs based on solving diagrams*

In some cases, Alexis seemed to be unsure in terms of the selection of the suitable maths operation for the solution of WMPs. This might reveal potential difficulties in indicating keywords and the selection of the suitable operation, although it was limited to only a few examples.

Although Alexis was able to complete simple math operations, some minor difficulties with subtraction were observed during the implementations. For instance, he had difficulty with subtraction where the subtracter was larger than the subtrahend number. Difficulties in additions and subtractions were observed, especially after he dealt with numerous math operations. Nonetheless, no difficulties in dealing with simple divisions and multiplications occurred during the last implementation.

Ref 87

He is a bit slow in thinking the answer of subtractions where the subtracter is bigger than the subtrahend. We correct the answer together. (A/IND-DUR-IMPL1)	*Difficulties in dealing with simple subtractions, divisions and multiplications*
Alexis faced some minor difficulties in operations, thus some time is wasted. Surprisingly, he has difficulties in operations involving additions and subtractions, and no significant difficulty in multiplications and divisions. (A/IND-DUR-IMPL4)	

During the implementations of the WBLEs with Alexis, we used some simple but helpful strategies for understanding the problem, such as finding the given details and the questions, underlining them or putting them in a circle, drawing a simple picture, making a simple table, etc. However, the special teacher did not notice that he adopted or at least used those strategies by himself. She explained that he would follow her instructions, a fact that allows us to conclude that Alexis was depended on the special education teacher.

Interestingly, Alexis pinpointed that he was doing better in mathematics and WMPs in general, after the implementations. He knew divisions by heart, although before the implementations he expressed difficulties in problems involving divisions and multiplications. It is important to mention the fact that Alexis felt confident in doing operations with divisions, and was not reflecting his abilities in solving WMPs.

Interestingly, the class teacher pointed out that Alexis was not able to solve WMPs in the quizzes that they had in mathematics. He would complete the Maths operations, but he would not solve the WMPs, a fact that mirrored his significant difficulties in handling WMPs in stressful and time-limited conditions. It also indicates the significant consequences of his dependency on others in the case that he was left to be an independent WMPs solver. This difficulty also occurred before the implementations.

Ref 88

In the case of a quiz, he cannot think (how to solve the problems). He will do the operations…but the problem... I didn't give him the chance to solve a problem in order to check that to be honest. (A/IND-POST-InterviewT2)	*Alexis was unable to solve WMPs in stressful and time-limited conditions*

8.5 Opinions about mathematics and WMPs

Apart from performance, another possible impact of the computer-assisted learning in solving mathematical problems is the potential alterations in terms of Alexis's opinions and attitude towards mathematics and WMPs. At this point, his opinions and attitudes as recorded in the interviews before and after the implementations are explored.

Alexis liked mathematics because he liked executions, as he said. The special teacher confirmed that he was doing well in mathematics, which gave him confidence and increased his self-esteem, regarding his capabilities in mathematics. Alexis said that he was doing well with multiplications, although he was not very good at divisions. It seems that he was aware of his abilities in Mathematics, which influenced positively his opinion about the subject.

Ref 89

K: Are you good in doing Maths executions? *A: Yes. But I am not very good in division… a bit.* *K: In multiplication and the multiplication tables?* *A: I am doing very well. (A/IND-PRE- InterviewSD2)*	*Alexis was aware about his capabilities in mathematics*

Therefore, he believed that Mathematics is useful in our daily lives, and gave examples.

Ref 90

K: Do you think that Mathematics is useful for us *A: Yes.* *K: In what?* *A: For example, at the super market, if they ask us to pay wrong amount. For example, if they give us 20 euro instead of 11 euro, we will need to give change back.* *K: Well done. So, when we go for shopping…* *A: Yes.* *K: Anywhere else? When someone is building a house?* *A: He must know Maths as well...* *K: Why? Does he have to know how to…..* *A: to count/estimate. (A/IND-PRE- InterviewSD2)*	*Alexis admitted that mathematics is useful for our daily lives*

Regarding WMPS, Alexis did not give a clear answer. He did not consider himself as either a good or bad solver of WMPs since he used to find some problems easy and some difficult. It is quite normal for a student to face difficulties in some WMPs and in some others not, however, it is interesting that he did not express the expected feeling of failure. When he was asked to explain what kind of WMPs were more difficult for him, he referred to problems involving divisions and multiplications. It is obvious that Alexis would make associations in his mind between the mathematical operations and the WMPs per se. He delineated that executions with small numbers were easy for him, while executions with larger numbers were more difficult. Of course, this means that for Alexis, the only thing to worry about was the operations, but not any other feature of the WMPs. However, he admitted that many times he had difficulties in understanding WMPs, although he said that he did not know what to do in such cases. Alexis probably meant that in such cases he was asking for help, as he could not solve the problem when he was not able to understand what it was saying.

Ref 91

K: Which problems are more difficult for you? *A: Problems with divisions. Also I have few difficulties with problems with multiplications*	*WMP is difficult depending on the kind of math operations it involves*
A: (Executions with) small numbers are easy. (Executions with) larger numbers-that we are learning currently-are more difficult. *K: I see. The larger numbers in executions, the more difficulties you have. When you are reading a WMP, do you understand it easily? Can you solve it without any problem or you need help to understand it?* *A: No, I can…a bit. I can manage to solve it. (A/IND-PRE-InterviewSD2)*	

After the implementations, Alexis pointed out that he was doing better in Mathematics and with WMPs in general. The fact that Alexis did not change his mind and attitude towards Mathematics is a positive sign that the intervened implementations did not negatively change his attitude towards Mathematics and WMPs.

Ref 92

K: What is your opinion about mathematics? Did it change? *A: I like mathematics very much because it is good.* *K: You mean useful..?* *A: Yes, also when you are working it gives… if you are a costumer who is going to buy (something), you will know how much you will pay (for it).* *K: Very good example… so mathematics are useful in our life.* *A: Yes.* *K: So do you like it? You do not get bored when you have Maths... are you happy?* *A: Yes, my worst is Art Education, Geography or English language. (A/IND-POST- InterviewSD2)*	*Positive attitude towards mathematics after the implementations*

8.6 Opinions about ICT and the use of the computer

Apart from Alexis's opinions and attitude towards Mathematics, it was interesting to examine the opinions and attitudes towards the use of ICT in the lessons either in the classroom or the supporting lessons in the special education classroom, and the use of ICT in Mathematics and WMPs before, during and after the implementations.

The special teacher stated that she used the computer in her lessons every day. She referred to motivation for the teachers as one of the reasons for doing so. She most likely meant that the use of ICT in the instructions provided many beneficial facilities for the teacher, a fact that was operating as motivation for the educators to implement new technologies in order to enrich their lessons. The second reason for using the computer in lessons was that it reduced attention disruptions

Ref 93

...students' attention is not distracted. Their interest remains unflagging. They stop looking around. (A/IND-PRE-InterviewST2)	*The computer reduces attention disruptions*

She also nominated some other benefits that derived from ICT, especially for Alexis and other students with learning difficulties, such as handwriting improvements, and so on. She gave an example of Alexis was getting frustrated when she was erasing what he had written, and then asking him to re-write it in a better way. On the contrary, he became excited when working on the computer. He was able to change font color, size, etc, which seemed to help him.

Ref 94

It helps in writing improvement. For example, Alexis is getting tired when I erase what he wrote and when I asked him to re-write what he had written down. His notebooks are getting smudged. In contrast, he is excited when he works on the computer; it is better. He can change font's color, size; it helps him a lot. (A/IND-PRE-InterviewST2)	*Benefits from the use of the computer for students with learning difficulties*

In addition, the use of the computer helped students to increase their self-image through the opportunities they were given to succeed. The special teacher recognized the many benefits that ICT could provide for her students, and therefore she had a positive attitude towards the use of the computer. This is one of the reasons that she was positive from the beginning to collaborate with me for the implementation of my project.

Ref 95

...he reaches the success a fact that improves his self-esteem. (A/IND-PRE-InterviewST2)	*ICT can help self-image improvement*

Nonetheless, she pointed out that using the computer was time consuming. She had 11 students with learning difficulties, a fact that prevented the extended use of the computer during the supporting lessons. In addition she teaches in another school twice a week. She felt it would be better for herself as well as her students if she was present at the school every day.

Ref 96

In general, I use the computer a lot, but you need more time for doing that. I think I should not have 11 students (for supporting lessons). In addition I work in another school twice a week. I should be at this school every day. Lack of time is our biggest problem (A/IND-PRE-InterviewST2)	*Use of the computer in supporting lessons was time consuming*

Apart from a lack of time, there was also the problem of a lack of funding. Even though she checked what was available on the market, which was a great deal of good quality educational material, the fact that it is very expensive made it inaccessible, due to a lack of funds for purchasing further educational material.

Ref 97

…and the funds we didn't get yet. I check what is available in the market. There is a lot of good quality educational material. But they are very expensive. Given that we didn't get any fund for educational material yet, how can you exploit what is available in the market? (A/IND-PRE-InterviewST2)	*Inexistence of funds prevented the renewal of software collection*

Alexis liked to use the computer, but often looked worried as he was not very good at using it. He expressed concerns of visiting the computer lab, because he felt that he might have been unable to handle the computer. These concerns quite possibly derived from his inexperience of working with computers, as well as the fact that he had no opportunities to interact with computers previous, either at school or at home.

Ref 98

K:Do you like using the computer? *A:I like it a bit. I am not very good in using it. I don't know the letters on the keyboard very well.* *A: No, I don't want that much because I might not be able to… (handle the computer)* *K: So, you don't like a lot the idea to go to computer lab..* *A: I like it… but we don't go…* *K: If you had the chance to go.. would you like it?* *A: Yes. It is easier to have subject of ICT. (A/IND-PRE- InterviewSD2)*	*Alexis was positive towards the use of computer but worried due to his limited ICT skills*

Although the special teacher pointed out that she used the computer with Alexis in many cases, it seemed that the way they used it during their supporting lessons was not sufficient. Also he expressed the desire to use the computer lab more often for their school lessons. He also expressed a desire to use the computer at home, although he repeated that he had no computer at home, apart from his father's computer which was only used for his father's work. He mentioned that his father had promised to buy a computer for him when he was older and more able to handle the keyboard. It seems that Alexis was aware about his restricted ICT skills as a result of limited ICT training and restricted exposure of the use of the computer, both at school and at home, a fact that caused him insecurities in using the computer. Interestingly, he delineated that the computer should not only be used for gaming but also for school lessons.

The class teacher supported the idea of using ICT in the instruction, but she looked skeptical. She highlighted her enthusiasm regarding the facilities provided by using interactive whiteboards, although she pointed out that there are many useful teaching methods apart from the use of ICT. She believed that teacher-student contact was very important. According to her, the teacher can use ICT for differentiation and visualization, but not in a way that will harm the learning process.

Ref 99

There is no (interactive board) in my classroom but there is in few classrooms in the school. Of course, the use of ICT should be judicious, so you can use other useful teaching methods as well apart from the use of ICT. I believe that the contact of the teacher with the students is very important. Of course, we must differentiate the instruction, which means that we will use the computer, we will visualize using suitable means, we will use interactive board. All these means supports the learning procedure. But the use of those means should not be against learning procedure. (A/IND-PRE-InterviewT2)	*ICT can be used for the instruction but not in a way that will harm the learning process*

The teacher also referred to the lack of time. She believed that the teacher could dedicate a 40-minute session for activities on the computer, but it was impossible to do so in every lesson. She explained that knowledge could be provided in other ways also. Apart from the knowledge that students may gain from the use of computers during the instruction, she also believed that the teacher just provides the students the chance to interact with the computer. The teacher was not well trained in how to embed the new technologies in her instruction, and invoked the lack of time and the mandatory curriculum in order to justify why she did not integrate new technologies in her lessons to a greater extent. Although, she recognized some of the benefits, she insisted on the importance of more teacher-centered approaches and the use of alternative methods other than using ICT which, of course, is not a solution.

Ref 100

You can dedicate a 40-minute session for activities on the computer but you cannot do that every time. Because, you cannot give the knowledge only in that way. You do not give knowledge.	*Lack of time prevents the use of the computer*
K: It is not a panacea. *T: Yes. (A/IND-PRE-InterviewT2)*	*There are many ways to transfer knowledge instead of using the computer*

After the implementations, and after cooperation with the special teacher and the outcomes of the implementations on the student, the special teacher stated that she would embed ICT in her instruction, not only for WMPs and

Mathematics, but for all subjects. She pointed out some of the benefits of using ICT in supporting lessons. Apart from being excited, Alexis's self-image and confidence improved. The special teacher nominated some of the benefits, but did not mention any negative comments on the use of ICT in the instruction. This reflected her positive attitude towards the use of ICT in supportive lessons.

Ref 101

It is something exciting for him, he likes it.	*The use of ICT made Alexis excited and improved his self-image*
It helps him very much and improves his self-image. (A/IND-POST-InterviewST2)	

She pointed out that the implementations of the WBLE were helpful in understanding the WMPs. She explained that the main reasons she did not use ICT for WMPs was the lack of ready-to-use educational programs, as well as the lack of time needed for the creation of her own WBLEs.

Ref 102

It would be better if we have ready-to-use educational programs, instead of creating mine ones. Because of the lack of time...we have so many things to do (A/IND-POST-InterviewST2)	*ICT for WMPS if there were available readymade computer educational programmes*

Alexis's teacher continued to be the main user of the single computer of the mainstream classroom. Alexis explained that she used to project the notebook page onto the board, and they used to write on the picture, which she was doing before the implementations. During the midterm, Alexis's classroom had Geography and English Language lessons in the computer lab of the school, as he mentioned previously. However, it is important to say that different teachers taught these subjects. Also, the special education teacher continued to use the computer in the same extent for Greek language lessons mainly. Alexis delineated that they were not using the computer for Maths, and that after they finished their work, they were allowed to play freely on the computer.

The class teacher pinpointed that after our cooperation, she would embed

ICT in her instructions. However, she mentioned that due to time pressures and the compulsory curriculum demands, it was hard for her to do so frequently. The teacher justified again why she did not embed ICT in a more interactive manner for the students, by mentioning a lack of time and the demanding curriculum.

Ref 103

If I had the option/facility I would definitely do it. However, the time is very pressing with the compulsory curriculum demands, so you cannot do some things very often. You can do it once but not always. (A/IND-POST- InterviewST2)	*Time pressure and curriculum demands prevented from using ICT in instructions*

8.7 Strengths and limitations of the computer-assisted learning environment

The main research question refers to the exploration of the extent that computer-assisted environments can provide differentiation and support for students with dyslexia in WMPs. After the presentation of findings related to the difficulties of Alexis in solving WMPs before, during and after the implementations, some findings concerning the ways that computer-assisted environments helped Alexis to deal with his difficulties during the process are presented below. The provided examples are taken from the analysis of data collected during and after the implementations, and refer to some of the strengths that expand the extent of latent help, as well as its limitations.

The pictures and information provided by the WBLE in the first step, ‘Understanding the Problem’, of the 5-step model for WMPs facilitated Alexis’s attempts to narrate the problem’s scenario in his own words. Also, the WBLEs provided downloadable Word documents in the ‘Solving the Problem’ stage. Alexis was asked to download, open and fill in the diagrams and tables which were associated with helpful tips. The documents in association with the provided helpful tips enabled Alexis to organize, devise and reach the problem’s solution. In addition, animations and pictures were attractive for Alexis who was excited by them, which helped him to maintain an active interest.

Ref 104

The stage of "understanding the problem" provides two pictures of two ships and underneath information for each ship. Alexis is able to narrate what the problem says with the help of the pictures. (A/IND-DUR-IMPL1)	*WBLEs' features were facilitating WMPS*
We download the word document which is provided and he fills in the solving sheet with my help. (A/IND-DUR-IMPL3)	
He is enthusiastic with the animation provided in that particular page. (A/IND-DUR-IMPL1)	
The second problem is about olive producers. Alexis is excited when he sees pictures with olives since he likes olives as he says. (A/IND-DUR-IMPL2)	

The WBLE provided the ability to listen to WMPs and instructions, as well as read them. Also, some examples explaining mathematical notions and terms were provided in audio and text versions.

Ref 105

We listen to the second problem. Alexis reads also the text. (A/IND-DUR-IMPL1)	*WMPs and explanations were available in audio version and text*
We listen to the audio version of the first WMP of the session. (A/IND-DUR-IMPL2)	
The audio instructions provide some examples about the notion of the fractions. Two examples are provided by the WBLE. (A/IND-DUR-IMPL3)	

The WBLE provided continuous and interactive feedback, and also awarded a certificate for the student's achievement in solving the WMPs correctly at the end of the session.

Ref 106

The last page provides a certificate award giving positive feedback for the achievement of the student to solve two WMPs on the computer. (A/IND-DUR-IMPL1)	*Feedback and motivation were provided*

In the second step of the process, 'Investigating the Problem', helpful questions (audio and text available) provided by the WBLE guided Alexis to indicate the problem's given and asked details.

Ref 107

After we underline the details and the question of the problem, with the help of the provided questions, we move on to the stage "how to solve the problem". (A/IND-DUR-IMPL2)	*Helpful questions were helping to investigate the WMPs*

WBLEs provided opportunities for gaming in order to help the student to master mathematical notions, such as fractions. Some game-like tools taken from educational websites were used. Furthermore, illustrative videos were available in the third stage 'How to Solve the Problem', in order to elucidate the solving strategy. Additionally, Alexis had the opportunity to use the 'Paint' function in order to draw potential combinations in the last WMP of the fourth implementation. These sorts of activities were helpful, and the same time attractive for the student.

Ref 108

Alexis has the chance to play a game to practice on the notion of fractions, before we continue with the problem solving. He is very excited with the idea. (A/IND-DUR-IMPL3)	*WBLEs' features were facilitating the process*
Alexis is enthusiastic when we move on to the fifth stage of the process "solving the problem". A Paint file is provided. Alexis chooses his favourite colour for the pencil and with my help he draws the lines in order to estimate the potential combinations. (A/IND-DUR-IMPL4)	

After the implementations, Alexis agreed that the computer could help him to overcome some of the difficulties. Interestingly, he agreed that some elements of the WBLE were helpful in understanding the WMP easily. He explained that it was useful to be able to listen to the word problem, and that there was the option to listen it as many times as he wanted. This statement possibly mirrored his potential difficulties in reading and understanding the WMPs, something that could be overcome with the facility of the audio version of the text that could be repeated as many times as needed. In addition, he found provided pictures, outlines, and tables helpful. He commented on the calculator provided by the computer at the last stage of the problem solving procedure, which made it easier. He also remembered the animations and funny pictures that made the design more childish, game-like and attractive.

Ref 109

K:Were there anything that helped you to understand the problem easily? *A:Yes.* *K:such as?* *A:The fact that (the WBLE) was telling us what problem is...* *K:do you mean the fact that we could listen to the problem?* *A:Yes…also if we did not understand (the problem) from the first time, we should have read it again…2-3 times until we understand it.* *K:Were the provided pictures helpful? The tables? Some outlines? Were they helpful as well?* *A:Yes. (A/IND-POST-InterviewSD2)*	*Some features could help him to overcome some difficulties in WMPS*

Despite the strengths of the WBLE, some limitations occurred during the individual implementations. For instance, some technical problems relating to audio files arose unexpectedly. Also, the WBLEs were not fully functioning without an internet connection.

Ref 110

At this stage there was a technical problem with the recording of the instructions. Therefore, I read the instructions to the student, since they are also provided in writing. (A/IND-DUR-IMPL1)	*Some unexpected technical problems arose during the implementations*
Alexis does not have internet access at home, so we use the WBLE offline. However, a problem with the audio recordings popped out, thus I take the decision to read the texts in order to counterbalance the arisen technical issue.	
My laptop was used for the last implementation, since no computer was available at student's home. Also, there was no internet access, therefore, a backed-up version of the WBLE was used. However, some of the features of WBLE were not accessible. (A/IND-DUR-IMPL4)	

Some steps' designs were repeated. The design of the repeated stages might have caused boredom to Alexis since he was more excited with the new, and got bored with the repeated previous designs. Also, sometimes, the provided pictures were misleading and caused miscomprehensions. In addition to this, the animations sometimes caused disruptions to Alexis's attention, thus he was discussing the animations, but not paying attention to the audio instructions.

Additionally, some WMPs were relatively easy for Alexis, however, he was forced to follow the 5-step process, even though he was able to understand and solve the problem without using the WBLE. Alexis became particularly tired during the last implementation, which took place at his home, and thus he asked to pass on some steps, or be allowed to solve the problem in his own way.

8.8 Summary

In this chapter, I have presented the analyses of data collected from the second case study of this project: the first individual implementation. The presentation of the data was organized by bearing in mind the research questions of this study. It started with a description of Alexis, and continued with his performance level, as well as his participation and interest before, during and after the implementations. Following this, the difficulties related to WMPs and how those difficulties were overcome, or not, with the use of the computer were overviewed. After that, data relating to the opinions about Mathematics and the WMPs, and the opinions about the use of the computer were presented. Some strengths and limitations of the computer-assisted learning were overviewed. A comprehensive discussion of the findings' interpretations and their potential implications will be offered in Chapter Ten. The next chapter contains the presentation of data collected in the third case study of this project: the second individual case study.

Chapter Nine
Case Study Three: Maria

9.1 Introduction

In this chapter, I present the analyses of data collected from the third case of this project: the second individual case study. Similarly to Chapters Seven and Eight, this chapter is organized in a way to present evidence that supports the extent that computer-assisted learning environments can support a particular student with dyslexia, Maria with significant difficulties in WMPs and the impact of computer-assisted learning in solving WMPs for students with dyslexia on an individual level, in accordance with the main and supplementary questions of this project.

The presentation of the data starts with a description of Maria, and continues with her performance level, and participation and interest before, during and after the implementations. Afterwards, I overview the difficulties and capabilities related to Mathematics and the WMPs and how those difficulties were overcome, or not, with the use of the computer. Following this, the data related to opinions about Mathematics and the WMPs, and opinions about the use of the computer for this reason are presented. An overview of various strengths and limitations of computer-assisted learning follows, which seeks to provide an answer to the extent that computer-assisted learning environments helped the student. Again, it is important to mention that this chapter will be limited mainly to the presentation of findings and brief explanations. The results are presented in tables with the themes written in the right-hand columns. A comprehensive discussion of the findings' interpretations and their potential implications will be offered in the next chapter.

9.2 Features of Maria

Before the data analysis, it is useful to point out some features of Maria's personality, noted before, during and after the implementations.

Maria was a low-profile child–her behavior was carrying out with modesty in many functions of her daily school life-and lacked self-confidence. According to the special teacher of the school, Maria had insecurities and fears because she knew and understood that she was behind her classmates and the expected level. The comparison with her classmates was extended especially during her special education support, because there was direct contrast with a less able fellow student who was still more able than Maria.

Moreover, she was not able to work independently or without guidance, however, she rejected that she was depended on the other's help and support when we had a discussion about her difficulties in Mathematics and WMPS. Interestingly, Maria was not willing to express her difficulties or potential weaknesses, and did not admit that she faced significant difficulties in fractions, even though her teachers mentioned the significant problem with the notion of fractions, and any operation or word problems involving fractions. The partial premise of the difficulties could reduce her self-image, something that she used to avoid doing in the case of the WMPS with fractions. Additionally, she could not recall the notions, terms and methods that she had been recently taught, and was not even aware of simple Maths terms, such as 'addition'. This might reflect her weaknesses in terms of long term memory.

Maria maintained her interest and cooperation during the four individual implementations. She was not reluctant to work on the WBLE in any case, which reflects the features of her personality. She was cooperative, patient, calm and obedient. If we compare Maria's behavior with Alexis and Peter's behaviour during the implementations, we can conclude that Maria was more mature than her other two coevals.

After the implementations, Maria continued to have low levels of self-confidence, although according to the special teacher of the school, after the implementations she was more willing to work alone and struggle when she knew how to handle with operations in Mathematics. She also became more independent, and abandoned the insecurities of the need for guidance.

In general, Maria used limited expressive language associated with a limited amount of speech (one-word answers), laconic responses and phrases such as, ‘I don’t know’, in order to avoid answering some of my questions. She also gave answers such as, ‘I like both’ or ‘I like everything’, in order to avoid giving further detail. This might be a result of her shyness, low self-image and lack of self-confidence. It also seems that she lacked courage in her opinion, which prevented her from expressing her opinion.

Further features of Maria will be presented throughout the analysis of data in the following sections of this chapter.

9.3 Performance, participation and interests of Maria

The impact of computer-assisted learning in solving WMPs includes any potential changes of Maria’s performance and participation before, during, and after the implementations. Apart from the teachers’ statements regarding Maria’s performance that were given at the interviews before and after the implementations, some patterns of her performance during the implementations are overviewed. Examples concerning her performance are provided below, showing the potential alterations of Maria’s proficiency levels throughout the procedure.

Maria faced some typical dyslexic-type difficulties, mainly in reading and writing. In terms of speaking and verbal communication, according to the special education teacher, Maria did not have significant difficulties, although in the interviews she was not talkative at all, and would only answer with ‘yes’ or ‘no’. Of course, this may have been a result of her shyness, which seemed to be one of her personal profile features.

On the other hand, the class teacher stated that her participation during the lesson was limited, which might have been a result of potential restricted verbal communication skills, although the teacher clarified that she was a low-profile, child, which seemed to automatically prevent her from raising her hand and participating in the lesson. The teacher always took her shyness and difficulties in general into account, and therefore he would give her opportunities to participate in the lesson when he felt that she would be able to answer, and not become embarrassed.

Ref 111

Her oral speaking-participation is limited. She will answer to something I will ask her when I know that she is able to answer. She will not raise her hand; she is not willing to raise her hand. She is low profile girl. Her oral participation is restricted. She must be sure in order to answer to a question. I must ask her intentionally to answer when I judge that she is able and capable to answer. (M/IND-PRE-InterviewT3)	*Shyness prevents participation in the lesson*

Maria faced significant problems in writing. According to the special education teacher, the main problem occurred when she was asked to write out a text of her own. Difficulties arose relating to punctuation, syntax, annotating events in chronological order, orthography, reversions or omissions of letters in combinations of two-three consonants, use of non-capital letters after full stops, and so on. These problems are significant if one takes into account that they were identified when Maria was in the 4th Grade of primary school. The class teacher confirmed that her writing skills were poor. Orthographical mistakes took a core place in the spectrum of the difficulties in writing. However, he stressed that her texts were understandable, thus what she was writing was meaningful, although it did not match with her actual age level of what one would expect to read.

Ref 112

She has many difficulties in writing, especially when she writes something alone. She can copy a text, but she has problem in constructing a correct sentence, in limiting the length of the sentence, in putting in time order some events related to the given topic and many problems in orthography. That is to say, there are many difficulties in writing.	*Maria had poor writing skills*
I have not noticed this problem, but we have difficulty in combinations of 2-3 consonants. She might reverse or omit some letters.	
She has difficulties in using capital letter after the full stop, but those are minor difficulties. (M/IND-PRE-InterviewST3)	
There are orthographical mistakes, you can understand what she writes. It is not representative of her real age. But when someone reads her text, he will understand what she says. However, her writing skills are poor. (M/IND-PRE-InterviewT3)	

Here I provide an example of Maria's written work. She was given 20 minutes to write one long sentence. Punctuation was missing, apart from the last full stop, which would have been omitted without the intervention of the special education teacher. At least seven out of twenty words had orthographical mistakes (35 per cent). The text reflects Maria's poor expressive skills, difficulties in syntax, difficulties in using punctuation, and influences of the Cypriot accent. It is also important to note that she avoided most of the stresses which are important for Greek language. A translation in English is provided.

Title: What do I do before I leave for school?

In the morning, before I leave for school I make my bed I go and have a shower I get dressed and I put water foods and I come to school.

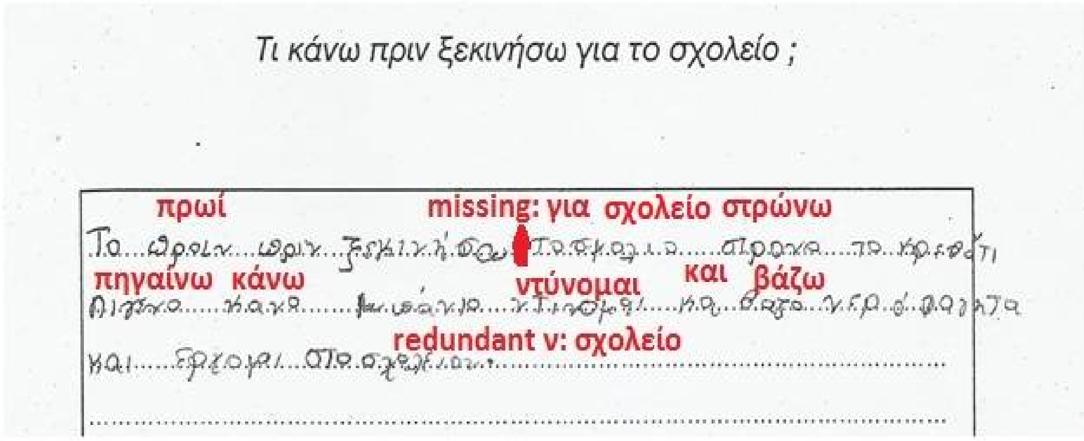


Figure 9.1 Sample of Maria's written work

In the provided example, it is apparent that Maria does not have a good command of punctuation rules. For instance, she does not use a capital letter after a full stop, and omits using stresses in many words. In addition, there are some cases where she does not leave a space between words, which are underlined in the figure below. The letters in circles indicate the letters that should have been capitalized.

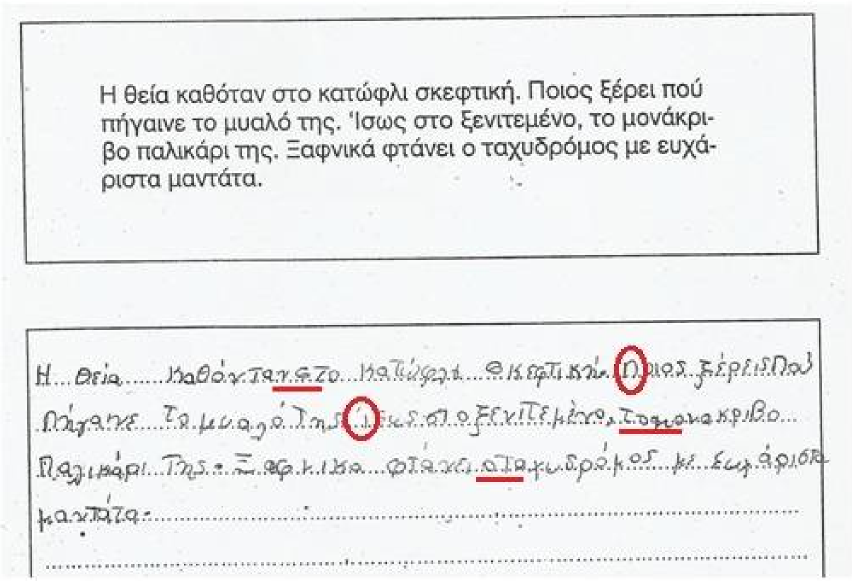


Figure 9.2 Sample of copied text

The problems with punctuation rules, orthography mistakes, and the absence of stresses can be seen in the following example, where Maria was asked to write dictation. It is important to mention that 14 out of 34 words are orthographically miswritten (41 per cent). An additional comment is made here is about illegible handwriting. She also avoids leaving spaces between some words, which are underlined in the figure below. The miswritten words are written orthographically correctly above each wrong word.

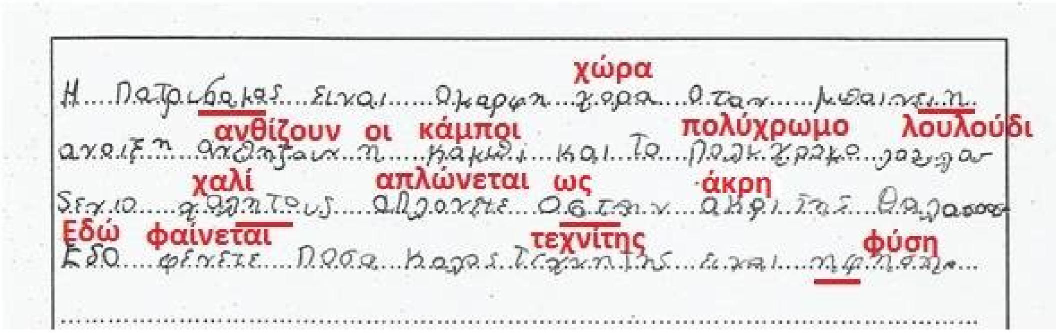


Figure 9.3 Sample of dictation

In terms of reading, Maria had mastered its principles, as the special teacher said. This could mean that she was able to read, although the special teacher delineated that her reading skills were mechanical and accompanied with many difficulties. For example, when she was reading, she was omitting letters in combinations of consonants in a row, and changing whole words. Also, the special teacher mentioned some problems in reading with the suitable stress and problems in expressing punctuation. In general, she was able to read but her reading style did not correspond with that expected for her age. These difficulties had an impact on her ability to comprehend the text painlessly. It is obvious that the main difficulties of the student were associated with dyslexia.

9.4 Difficulties, capabilities and issues related to mathematics and WMPS

Furthermore, it is interesting to overview any latent changes concerning Maria's difficulties and capabilities WMPS through the process of the implementation of the project. It is important to note that such results were helpful at the stage of WBLE's design, where Maria's particular difficulties and capabilities were taken into account.

Similarly in the case of Mathematics, Maria faced significant difficulties. Interestingly, the special education teacher stressed that her actual level of Maths was three grades behind her current class grade and age. In essence, the special teacher stated that Maria was still at the concrete operational stage, meaning that she was still using objects, or her fingers, for simple additions and subtractions, although both operations were not fully mastered and automated yet. The problem became even more major with more complex operations, such as multiplications and divisions. The class teacher confirmed such difficulties in operations, and added that she faced more difficulties in thinking of oral executions, which he usually helped the students with when practicing their solving skills. On the other hand, Maria's performance was better in written executions, probably because she had more time to think on her own pace without the additional pressure of oral practice. The teacher also confirmed her particular difficulties, even in addition and subtractions when they involve ten exceeds and borrowings respectively, when they become more abstracted, as he stated characteristically.

For instance, Maria was given the following test with eight mathematical operations. In 40 minutes she was able to solve five out eight operations (62.5 per cent). Only two out of five operations she solved were correct (40 per cent). She is able to solve additions involving numbers that exceed ten. She could not handle subtractions and multiplications. In the case of operations with divisions, she faced significant difficulties that prevented her from even to trying to solve them.

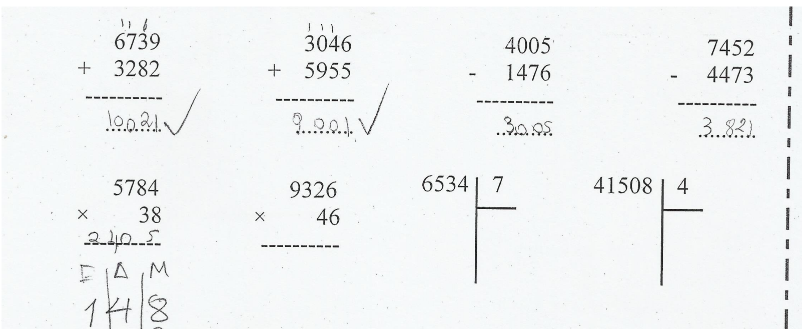


Figure 9.4 Sample of Maria's Maths test

In terms of WMPS, Maria faced significant difficulties deriving from difficulties in reading first, and then in undertaking the Maths operations. The special teacher referred to understanding as the main problem caused by difficulties in reading instructions. The class teacher referred to the same difficulty of understanding. The word problem was usually four to five lines of text long, and Maria was likely to forget it before she had finished reading it, and therefore there was a need to simplify it in order to help her to understand it. Some helpful strategies were the division of the problem into smaller pieces, reading the problem many times, finding sub-questions, and working step by step until finding the solution.

Ref 113

ST3: In fact she faces many difficulties and has many lacks in mathematics. The fact that she must read an instruction which is hard for her to be read and understood, it is obvious that it will be hard for her to solve the execution.(M/IND-PRE-InterviewST3)	*Significant difficulties in WMPS*
T3: We must read word problems 2-3 times. We must explain it in simpler words because a word problem's text might be 4-5 lines long, so she might forget it before we read it all. We simplify it in order to make it as simple we can. We divide it into pieces in order to find the sub-questions. We work step by step until we reach the solution. (M/IND-PRE-InterviewT3)	

The special teacher pointed out that Maria was aware of her problems and deficiencies in Maths, and that she was behind the level of her classmates. That is to say, she was able to figure out her actual self-image, skills and abilities. Nonetheless, this contradicts with what Maria pointed out. The student did not seem to be aware, or she was not willing to admit, that she had difficulties in WMPS. Although she said that there was problem in reading and understanding, Maria admitted that her main difficulty was to cope with math executions and operations. We could not be sure whether the student figured out the real case or if she preferred to hide some of her difficulties, and used to admit some others that could be easily discovered.

Ref 114

K:When you read a problem, do you understand it from the first time or do you need someone else to explain it for you? *M:No, I understand..* *K:So you are fine, you can understand the problem immediately…* *M:Yes (she nods)* *K:And how about the solving process? Are you able to understand if you must choose addition or subtraction or you need some help?* *M:I need some help..(M/IND-PRE-InterviewSD3)*	*Acknowledgement of self-image and difficulties*

Maria was good with doing simple additions. She needed some guidance in putting units under units, tens under tens, and so on, but she knew that the process started from the right towards left. It is important to note that the addition was simple and did not involve any exceeding of tens.

She expressed significant difficulties in understanding basic maths operations such as addition and subtraction. Especially at the 1st individual implementation, she was not able to distinguish the difference between the two Maths operations, therefore she mixed them up. This example reflected her significant difficulties in understanding even the basic mathematical operations. After discussion, we excluded subtraction thus Maria suggested addition as the suitable Maths operation for a particular WMPS. However we cannot be sure whether she gave the correct answer by chance or by concluding to the right answer by excluding the wrong ones.

Furthermore, Maria was provided with two pictures of two different kinds of flour and she was asked to narrate the WMPS. She was able to explain the problem in her own words but with the significant need of help, especially in the ability to initiate the narration and read the numbers correctly.

An example of her significant difficulty in reading the numbers correctly is provided below. From the example, it is obvious that Maria did not have a good command of the numbers' place value. Her weaknesses in understanding the significance of place value occurred when she was solving a subtraction on the whiteboard.

Ref 115

K:How much white flour did he use? Do we know? M:Yes. 2 hundreds.. K:2 thousands… M:2 thousands 7 hundred.	*Weaknesses in place value and reading numbers correctly*
She writes the execution on the whiteboard of the special classroom, however, she does not write the numbers in the right manner. The units, tens, hundreds and thousands are not grouped in the same column.	
Then, when the question is about the quantity of olives from the first olive grove, she reads the number 6000 as 600. (M/IND-DUR-IMPL2)	

Regarding the difficulties related to WMPS, Maria read the text trivially. As a result she was not able to identify the given details correctly, but she was blindly giving raw numbers without further thinking. In the provided example, Maria said that the quantity of brown flour was 1347kg. However, the quantity was 1347kg less than the quantity of the white flour. Such omissions prevented her from understanding the problem and solving it correctly. The same happened during the step where Maria had to investigate and highlight the given details of the WMPS.

Ref 116

K:Right. Do we know how much brown flour? M:Yes. K:how much? M:1347?	*Perfunctory indication of problem's details*
Maria highlights the given information in her textbook. However, she highlights the number 1347kg as the quantity of brown flour. After a short reminding discussion, she understands that she must include the phrase "less than" apart from the quantity 1347kg. (M/IND-DUR-IMPL2)	

Although the indication of the asked details of a WMPS was deemed to be easy, Maria was not able to keep in mind that the asked detail was the question at the end of each problem, even with the reminders. Another example of Maria's perfunctory in indicating the details of the problem is provided below. Maria was asked a simple question about how many olive groves were mentioned in the scenario of the WMPS. Although the answer was ‘two groves’, she recklessly gave the first number she could see in the text, which referred to the quantity of olives collected from the first olive grove in kilos. In another example, Maria perfunctorily replied to the comprehensive question asking the total number of the ships mentioned in the WMPS. The correct answer was two, but Maria just gave the first number appearing in the text, without thinking about its logicality.

Ref 117

It is important to say that when she was asked ‘how many olives groves are mentioned in the word problem?’, she says ‘600000’ probably because she was ‘absent’ or she expected the first question to be about the quantity of olives from the first grove or just the first number occurs in the text. (M/IND-DUR-IMPL2)	*Perfunctory indication of problem’s details*
WBLE:How many ships are there? *M:…* *K:How many ships are there?* *M:hmm.. 850?* *K:ships! How many ships?!* *M:two (M/IND-DUR-IMPL3)*	

An additional example, this time, related to the question of the problem during the narration is provided. Maria narrated the problem mechanically. It seems that she did not think about the problem logically since she gave a question asking about the already known information of the problem.

Ref 118

Maria starts narrating the problem with no significant difficulty. However, she says the question of the problem wrongly. The problem refers to 2 schools. One school has fewer students than the other one. The question of the problem is about how many fewer students go to the second school. In this case Maria says: “Melpo’s school has 270 students. Angelos’s school has 180 students. How many students go to each school?” (M/IND-DUR-IMPL3)	*Perfunctory indication of problem’s details*

Significant difficulties occurred relating to Maths operations, during the implementations. For instance, Maria faced major problems with subtractions when the units of the largest number were less than the units of the smallest one. The same goes for tens, hundreds and thousands.

Additionally, she needed some time to handle the Maths operations, relatively simple if we bear in mind the actual age of Maria, but still she was not able to work without any support. However, we cannot be sure whether my presence may have caused her anxiety, although she did not appear to have any concerns due to my presence. Apart from difficulties with subtractions, Maria also had difficulties with additions, especially when the total of units exceeded the ten.

Similarly, many times Maria was not able to recall the 5-step model for WMPS, and terms such as given and asked details of the problem, even though it was repeated every time we had the session with the use of the WBLE. Another example that revealed Maria's short and long term memory deficiencies is provided below. Although Maria seemed to understand the given details of the problem at the first step of the 5-step model, she immediately forgot it at the second step.

Ref 119

It is important to mention that Maria <u>highlights the number 230 as the number of the passengers travelling with the second ship</u>, but after a discussion she realizes that the correct detail to be highlighted is '230 passengers less than the first ship'. <u>Even if she seemed to understand the importance of the word 'less' during the first step, she forgets it during the second step</u>. (M/IND-DUR-IMPL3)	*Short and long term memory deficiencies*

In addition, Maria faced difficulties in choosing the most suitable Maths operation. Sometimes she gave the impression that she had chosen it randomly.

Ref 120

Nonetheless, when she is asked, after she has filled in the diagram what operation we need to do, <u>Maria wonders if it is 'subtraction'. There is possibility here that she said 'subtraction' randomly without much thinking</u>. (M/IND-DUR-IMPL2)	*Difficulties in choosing the suitable math operation*

In the first stage of the 5-step model for WMPS 'Understanding the Problem', Maria needed help to initiate the narration of the problem's scenario in her own words. This might reflect her weaknesses in expressing her ideas, and her potential shyness and low self-confidence that prevented her from beginning the narration independently.

Ref 121

The student is provided with two of pictures of the two different kinds of flour and she is asked to narrate the problem. She is able to say the problem with her own words but with significant need of help, especially to start the narration and in reading the numbers correctly. (M/IND-DUR-IMPL2)	*Difficulties in initiating the narration*
Maria uses the provided pictures and details in order to narrate the problem's story in her own words. However she faces difficulties at the beginning. She is able to say the problem with my help. (M/IND-DUR-IMPL3)	

After the implementations, the special teacher noticed some improvements, mainly in understanding the given details of the word-based mathematical problem. Maria was able to indicate the problem's keywords (for example, fewer, more, total), which helped her in choosing the suitable strategy or operation. Even though Maria could solve only the problems involving additions and subtractions, she was able to understand and solve the problem alone, something that was not happening before the implementations.

Ref 122

I observed some improvements regarding the understanding of the given details of the problem and in indicating key words that tell her which operation to choose. We talk about addition and subtraction. She understands…she indicates the words fewer, more, total, so she can easily work out some problems alone. She is able to understand and do the operation alone.(M/IND-POST-InterviewST3)	*Improvements in understanding the WMPS*

The special teacher indicated some improvements since Maria was willing to work alone and attempted to solve operations without help.

Ref 123

She continues to have lacks of self-confidence, but when you ask her to do something alone, she struggles and when she knows how to handle with an operation, she goes on and finishes it. There is a minor improvement, but she needs much more training.(M/IND-POST-InterviewST3)	*Independency in solving WMPS was boosted*

9.5 Opinions about maths and word-based mathematical problems

Apart from the performance, another possible impact of the computer-assisted learning in solving mathematical problems is the potential alterations in terms of the opinions and the attitude of Maria towards mathematics and word-based mathematical problems. At his point, her opinions and attitudes as recorded in the interviews before and after the implementations are explored.

Before the implementations, Maria stated that she liked Mathematics. She held the view that it is a useful subject because it helps in learning many new things. Although she was not very talkative during the discussion, she provided some examples from daily life, where Mathematics is deemed to be helpful and useful.

Ref 124

K:What do you think about mathematics? Do you like it or not and why? *M:I like it…* *K: Why? Do you think it is useful for our life?* *M: Yes* *K:Why? Where is it useful?* *M:You learn more things.* *K:So it helps us in doing something. Where is it helpful? For example when I want to buy something, how can Maths help me?* *M:At canteen, if we don't know how much something costs (M/IND-PRE-InterviewSD3)*	*Mathematics is useful in daily life*

Maria gave diplomatic answers and was not very expressive when she was asked about her opinion concerning WMPs. From her first answer a confusion or daze occurred as she did not make it clear whether she was finding them easy or difficult. After my interference she agreed that some problems were easy while some others were difficult for her.

The implementations of the WBLE not only helped in shifting Maria's attitude towards the WMPS process, but also made her attitude towards Mathematics in general more positive. For instance, Maria was willing to do exercises involving Maths operations training apart from solving WMPS, during the implementations.

Ref 125

M:Sir, is it possible to do operations when we meet here? Half session for math operations and the second half WMPS. *K:Do you prefer doing math operations than solving WMPS?* *M:A little bit..* *K:Yes but WMPS involves math operations. (M/IND-DUR-IMPL3)*	*The WBLE changed Maria's attitude towards mathematics*

After the implementations, Maria did not give clear answers whether she liked Maths or not. She did not have a negative attitude towards Mathematics. It could be said that her attitude was more neutral than negative or positive. She agreed that her difficulties might have been a reason for not liking Maths.

In addition, she agreed that WMPS was not a big deal, a fact that mirrors her improved self-confidence in solving Maths problems after the implementations of the WBLEs.

Ref 126

K: OK, how about word-based mathematical problems? Did your opinion change after we worked together on the computer? What do you think about mathematical problems? *M:they are nice (happiness in her face and expression)* *K:Eventually they are not bad and difficult…* *M:(She agrees) (M/IND-POST-InterviewSD3)*	*Maria had positive attitude towards WMPS*

9.6 Opinions about ICT and the use of the computer

Apart from Maria's opinions and attitudes towards Mathematics, it is interesting to examine her opinions and attitudes towards the use of ICT in lessons, either in the classroom or supporting lessons in the special education classroom, and the use of ICT in Mathematics and WMPS before, during and after the implementations.

Before the implementations, both participating teachers agreed that embedding ICT in the instruction can be useful. The special teacher of the school provided an example in the case of students who are not collaborative enough with traditional methods, so the use of the computer, and the occupation of the student with an activity on the computer, might well help. Upon examining the statements of the special teacher, one can extract some findings about her views about ICT in education; that is to say, the new technologies can be used as an alternative way to reach the desired collaboration of the students with the teacher in the case that the former are not cooperative enough. However, this means that ICT can be used without additional value, but only when we want to reach the desired collaboration. She referred to students with ADHD as an example where the use of the computer could be suitable.

On the other hand, the class teacher referred to the use of ICT in the case he wanted to present something to the students, which alternatively would not be possible or not good quality. For example, shapes or problems need long processes, so the virtual representation is deemed to be more useful.

Ref 127

In some lessons, with students with ADHD I will use it, because such children like working on the computer, so we can do the lesson through the computer. In general, I personally use it a little. (M/IND-PRE-InterviewST3)	*Benefits deriving from the use of ICT*
Many times. The computer is useful when we have shapes or problems that need long processes because they are virtually represented for the children. (M/IND-PRE-InterviewT3)	

The main reasons that the special teacher did not use ICT in her instruction were limited time and high demanding support in reading and writing skills.

Ref 128

The problem is the limited time, so we rarely use the computer. What can we do in just two 40-minute sessions per week? We must work on writing, handwriting skills with exercises. So, in fact, I will not use the computer.	*Use of ICT was time demanding*
K:Do you rarely use it because you are not trained on how to use it or because of the lack of time?	
ST3:We are trained but the time is limited. (M/IND-PRE-InterviewST3)	

In terms of using ICT in WMPS, the class teacher held the view that there might have been computer educational programs on the market but he was not aware of these. Interestingly, when he was asked whether he would create a simple programme for his students for WMPS, he expressed his surprise that I had asked such a question, which probably reflected that he had never thought before that the teacher himself could create something simple. When I clarified the question, he rejected the possibility by mentioning the lack of time. The teacher did not show any willingness to create even a simple program on the computer for his students, because as he said, there was no time to do so. However, he did not reject the idea to use readymade software in the case of WMPS.

Ref 129

K:How about using ICT for WMPS? Have you ever heard any application that the teacher can use? *T:You mean if there are educational computer programs?* *K:Yes* *T:From the market?* *K:Yes* *T:There should be some, but I am not aware.* *K:or something that the teacher can create…* *T:Shall we (the teachers) create software?* *K:Something simple* *T:You must have time in order to do this* *K:If there is something ready to be used?* *T:If there is something readymade and suitable for the lesson of the day, why not? But it is not easy to create our own computer programs every day apart from planning the lessons… (M/IND-PRE-InterviewT3)*	*Teachers do not create computer programs; they buy them from the market*

Interestingly, the class teacher used the single computer in his classroom mainly when he was not able to show something alternatively. Therefore, he was the only user of the computer, and the only reason to use it was just to reach features that might be difficult to reach without the use of the computer, for example, complex shapes, graphs, etc. Maria confirmed that the students did not have an opportunity to use the computer in the classroom.

Ref 130

K:You are the main user, not the students… *T3:We have just one computer in the classroom, so I am the main user. Students use it rarely because of the limited time.* *K:Do you use it?* *T3:Many times. The computer is useful when we have shapes or problems that need long processes because they are virtually represented for the children.(M/IND-PRE-InterviewT3)*	*Using the Computer without additional learning value*

Also, the class teacher never used the school's computer lab because, as he said, all applications were available on the classroom's computer, so the teacher could use it for the whole-classroom in the case that they needed it. Again, there was no willingness on behalf of the teacher to provide opportunities for the children to work and interact on the computer, in Maths or other subjects. Maria confirmed that they did not have the chance even to use the computers at the school's computer lab.

Maria did not have her own computer at home. The only computer she had access to was her sisters, which was out of order. That is to say, Maria did not have any opportunity to use a computer, either at home or school. Hence, she had limited ICT skills because she simply had not had a chance to use a computer. The few times that she had used a computer previously, it had been for playing games, and searching for information about school subjects, when the students were asked to do so for homework.

After the implementations, the special teacher of the school pointed out that after the cooperation we had, she would use the computer in WMPS during her instructions. She held the view that visual means could help in understanding by improving the conception and concentration of the students. However, she stated that she would use the computer for WMPS if there was available readymade software suitable for her students' level and attributes.

Ref 131

K:After the cooperation we had and after you saw the outcomes, would you implement/use the computer in WMPS? *ST3:Yes sure. Not always, but I think it can help. I think that visual means are helpful for students with learning difficulties; either the computer or pictures can help much more in understanding and make them faster in understanding something. They improve conception and concentration. So when there is a software about WMPS, I would use it after I check if it is suitable for particular grade/level. (M/IND-POST-InterviewST3)*	*Special teacher would use ICT in her instructions if there are ready-made programmes available*

Nevertheless, the special education teacher pointed out that she did not have time to create a simple computer program suitable for her students, in the case there was no available readymade software. In addition, she explained that her ICT skills were restricted which was automatically prohibitive, even if she was willing to prepare something. She explained that it was easier for the class teachers to create such educational programs, while the special teacher had to prepare differentiated educational material for each student receiving supporting lessons.

Ref 132

K:Would you dedicate time to create anything simple, even on PowerPoint? ST3:It is very difficult. Maybe it is easier for a teacher of a mainstream classroom. But it is very time demanding for special teachers who must prepare educational material for every student separately. Necessarily I prepare stuff for every student, so if I see that it is necessary, I would do it. But because my relationship with the computer is as much as I need for my job, I am not a person who uses the computer a lot, it would take long time for me to prepare something. So I would prefer to have something ready-to-use. (M/IND-POST-InterviewST3)	*Difficult for a special teacher to create suitable WBLE for every student*

Similarly, the class teacher stated that he would use any ready-made computer program for WMPS. However, he pointed out that most of the time computer programs were not suitable for the students.

Ref 133

K: After the cooperation we had and after you saw the outcomes, would you implement/use the computer in WMPS?	*Readymade software was welcomed with scepticism*
T3:If there are readymade programs or digitalized WMPS, why not. In the cases that students face difficulties in understanding the problems. Because many times, the computer provides everything so you do not give them the opportunity to think how to solve the problems because everything will be done and given by the computer step by step. At this age level we try to help them to understand the situation through mental representations than watching it. What this level age demands is to reach the abstracted thinking and not to watch everything by using objects. We solve the complex problems on the whiteboard. If we solve them on the computer, it will be even better. (M/IND-POST-InterviewT3)	

He continued by criticizing the use of the computer, and felt that it did not urge the students to think on their own, while many times ready knowledge was provided. He explained that he would use the computer only when it was secured that students would benefit from it by providing examples. Additionally, he delineated that he would not use the technology for the sake of using technology.

Ref 134

T3:For example, the word problem might say that we put potatoes in sacks. The computer shows the potatoes being placed in sacks. If you show this to the children, they understand that the problem will be solved with division, so they do not have the chance to think about it, because you showed it to them. There are many problems that the students do not think because the computer explains and shows the solving way. They must read themselves and understand it. *K:I got it. So you might use the computer in WMPS but only if there were readymade programs..* *T3:Given that the programs will really help the student and not just to help him not to think how to solve it. I might help the student until some stage and then stop…and tell him to think about the next steps…(M/IND-POST-InterviewT3)*	*Technology should not be used for the sake of using technology*

Maria stated that the teacher continued to be the main user of the single computer of the mainstream classroom, after the implementations. Students were using the computer only when they wanted to open a file relating to an activity they had for homework from their USB memory sticks. Also, Maria expressed the desire to use the classroom computer, and the computer lab of the school more often.

9.7 Strengths and limitations of the computer-assisted learning environment

The main research question refers to the exploration of the extent that computer-assisted environments can support students with dyslexia in WMPS. After the presentation of findings related to the difficulties of Maria in solving WMPs and the impact on her performance, participation and attitudes before, during and after the implementations, some findings concerning the ways that the computer-assisted environment helped Maria to deal with her difficulties during the process are presented below. The provided examples are taken from the analysis of data collected during and after the implementations, and refer to some strengths and limitations of the computer-assisted learning environment.

Some features of the WBLE are provided as well as their impact in facilitating WMPS' understandings for Maria. Amongst the facilities provided by the WBLEs were videos, pictures, audio instructions, use of the Paint function, diagrams, use of the calculator for checking the answer, Word documents and downloadable files. All these facilities constituted the internal features of WBLEs, and the design was based on the available sources. No non-free computer programs were used for the design of the WBLE. Despite the simplicity of the programs used, the latter played a significant role in helping Maria to overcome potential difficulties, especially in understanding and choosing the suitable strategy for each step separately.

Moreover, several skills and strategies taught during the implementations could be adopted and generalized in other subjects and activities. Such strategies were the organization of given and asked information of the WMPS in tables. For instance, these skills could be helpful in improving decoding skills of any text. In addition, Maria concurred that the 5-step model for WMPS was helpful, and could be adopted for the facilitation of any WMPS procedure. The model could be generalized for all WMPS and could be implemented when Maria had to solve WMPs alone.

Furthermore, the implementations helped to improve Maria's self-confidence. Maria found the very first problem easy. The WBLE might have been the main reason that simplified a problem which otherwise might have been difficult for her. As a result, she felt better after her achievement of solving the first problem without significant difficulties, a fact that potentially improved her self-image and boosted her self-confidence to move on to the second WMPS. At the 4th implementation, Maria had overcome her shyness and her low self-confidence, thus she was willing to read the WMPS instead of listening to the audio version, which is something that she was not doing during the lessons in the mainstream classroom.

Ref 135

Before we move on to the next problem, I ask the student: *K:How did you find the first WMPS?* *M:It was good* *K:It was easy, isn't it?* *M:yes, it was (M/IND-DUR-IMPL1)*	*Implementations increased self-confidence in relation to WMPS*
Interestingly, she is eager to read the word problem instead of listening to it. She reads the text without significant problem. She is also ready to answer to my comprehensive questions correctly. (M/IND-DUR-IMPL4)	

Apart from improving her self-confidence, the WBLE potentially helped in improving Maria's performance in comparison to her performance and weaknesses mentioned by the special education teacher. For instance, the steps helped her to understand the word problems and answer correctly the comprehensive questions, and she was able to narrate the scenario of the problem in her own words. Such a task, even with the need of help, improved her abilities to narrate, which improved her expressive language skills, as well as helping us to indicate whether she understood the problem or not, and thus if she was able to move on to the next step or not.

Ref 136

After she listens to the first WMPS carefully, she answers to my comprehensive questions correctly. (M/IND-DUR-IMPL2)	*WBLE developed Maria's WMPS skills*
At the first step 'understanding the problem', we listen to the audio instructions. Maria starts the narration of the word problem in her own words, with no any difficulty. (M/IND-DUR-IMPL4)	

In the same vein, WBLEs helped Maria to understand the importance of the problem's investigation, and she became involved in the procedure of indicating the given and asked details of the problem, and then the definition of keywords that were helping in choosing the most suitable solving strategy.

Ref 137

At the second step 'investigation of the problem', Maria <u>easily finds the given and asked details</u>. (M/IND-DUR-IMPL2)	*The WBLE developed WMPS skills*
<u>Also she understands the idea of putting two quantities together (grouping), and suggests that in the cases of grouping two or more quantities we do addition</u>. (M/IND-DUR- IMPL4)	

In this example taken from the 3rd individual implementation, it is obvious that Maria avoided the mistakes of the first two implementations. She was more careful in reading and listening to the problem's scenario, giving emphasis on the problem's details, an important fact for the comprehension of the problem. The similarity of this WMPS with one of the two problems of the last time might have made her more careful and able to remember the mistake she had made previously, therefore she did not repeat it. Carefulness in coding and analyzing the scenarios of WMPS was an additional essential problem solving skill.

Ref 138

K:Do we know how many passengers travel with the first ship? M:Yes, 850 K:Right… M:…and with the second one 230 more than the first one. K:Well done. If you would say 230 passengers, it would be wrong. Passengers travelling with the second ship are 230 more than the first one. M:Yes, they are more… (M/IND-DUR-IMPL3)	*The WBLE developed Maria's WMPS skills*

Another important benefit derived from the implementations and the use of the WBLE was the creation of WMPS schemas. That is to say, Maria was able to understand the similarity of some WMPS in terms of their content, keywords, syntax and structure, which enabled her to place such problems under the same category. Therefore, when she was meeting problems that were fulfilling the criteria of a particular scheme, she would recall and understand immediately the procedure for the solution of such WMPS.

Not only the WBLE per se, but the implementations in general, provided opportunities for thinking logically. For instance, Maria was asked several times to think about the logicality of several issues related to particular WMPS. Thinking logically was an additional essential skill which could be obtained from this procedure. This logic might refer either to the given details and the question of the problem, or the answer itself. In this example, Maria asks an alternative question for the particular WMPS. The question was logical but not correct.

Ref 139

She suggests a logical, but not the right, question of that particular problem: *M:How many students do both schools have in total?* *K:This could be a question of the problem. But it asks something else..* *After a discussion we conclude to the right question:* *M:How many fewer students does Angelo's school have in comparison to Melpo's school? (M/IND-DUR-IMPL3)*	*WBLE developed WMPS skills*

Furthermore, one of the features of the WBLE was the use of free tools from the internet for teaching and mastering particular notions that were difficult for Maria, such as fractions. The exercises focused on the concept of a fraction as a part of the whole by providing several colorful shapes in a game-like environment, which helped Maria to understand the fraction represented in each shape. Also, the tool provided immediate feedback.

However, the iterative process suggested by the WBLE for each WMPS might have been tedious for Maria. She did not always listen carefully to the audio instructions, especially when they were repeated, or she sometimes tended to skip some steps, and move on to the following steps of the process. The iterative process can be deemed as one of the disadvantages of the WBLE in terms of its design.

Ref 140

While we are listening to the audio instructions Maria interrupts in order to ask if she will write the execution and the operations on the whiteboard. It seems like she is 'absent' from the procedure or sometimes wants to skip to the next stage without following the instructions. (M/IND-DUR-IMPL3)	*The iterative process of the design of the WBLE was tedious for Maria*
We check the answer with the use of calculator at the last step 'checking the answer'. While we are listening to the audio instructions, Maria interrupts in order to ask something irrelevant to the problem question. (M/IND-DUR-IMPL4)	

After the implementations, Maria did not adopt the 5-step model for WMPS. She used to read the problem and then solve it. She did not underline or highlight the given details and the question of the problem. However, the special teacher did not allow her to work alone, a fact that played its role since the special teacher did not follow the 5-step model in the provided support. The special teacher said that Maria might have adopted the step "Choosing the Strategy", as she indicated particular words and keywords to justify why she had chosen the particular operation for the mathematical execution, which she had not done before.

Ref 141

What happened in the case of this student, when I was giving her the word problems, she was reading the problem and then telling, the operation. When I was asking her how she knows it, she was using the stage of "choosing the right strategy" by indicating the key word that helped her to choose the operation. However, she was not underlining or highlighting the details. (M/IND-POST-InterviewST3)	*Only few steps for WMPS were adopted after the implementations*

In addition, Maria did not check the answer she found, as the last step of the 5-step model suggests. According to the special teacher, she did not even suggest to use the calculator for checking the correctness of the operations, or the answer. Again, this might have been a result of the special teacher's approach, since Maria resolved the word-based problems of the implementations with the help of the special teacher, in the traditional way of using paper and pencil. Maria followed the method of problem solving that she used to follow during the supporting lessons with the special teacher, before the implementations.

Ref 142

Nothing like that was happened. She did not even suggest it. She did not indicate the given details. That is to say, she was reading the word problem; she was choosing the operation by focusing on key words and was continuing by doing the operations. (M/IND-POST-InterviewST3)	*Only few steps for WMPS were adopted after the implementations*

Maria herself admitted that she did not remember the 5-step model. She only remembered the second step which referred to the investigation of the problem and the indication of given details and questions, but she could not even recall the terms 'given details' and 'question' of the problem. The fact she remembered the second step goes along with what the class teacher stated, concerning the adoption of the habit of underlying or highlighting important elements of a text. Nevertheless, Maria agreed that the 5-step model was in her mind when solving word-based mathematical problems. However, she did not follow the 5-step model when she solved the WMPS with the special teacher, probably because of the differentiated guidance on behalf of the special teacher.

Ref 143

K:Also, were the 5 steps we followed each time helpful? *M:Yes* *K:Do you remember those 5 steps?* *M:No…I just remember the question and the…* *K:Given details..* *M:yes* *K:Do you think that those steps will come in your mind, when you solve WMPS in your notebook?* *M:I think yes (M/IND-POST-InterviewSD3)*	*Only few steps for WMPS were adopted after the implementations*

Interestingly, the special teacher noticed that Maria could work and solve WMPS more independently, and that she could more easily perform an operation by herself without insecurity, or the need for guidance, after the implementations. According to the special teacher, Maria was more restrained and support-depended before the implementations. Also, the special teacher indicated some improvements after the implementations, but still expressed the view that training was not enough, and that additional training was needed in order for her to master the new skills and improve her self-confidence. The short time and the few implementations prevented long-lasting outcomes and potential improvements in several aspects.

Ref 144

In general, she has been a low-profile child since the beginning of the school year. She is afraid in doing something alone. She continues to have lacks of self-confidence, but when you ask her to do something alone, she struggles and when she knows how to handle with an operation, she goes on and finishes it. There is a minor improvement, but she needs much more training. (M/IND-POST-InterviewST3)	*Implementations were few for long-lasting outcomes*

In addition, the class teacher believed that some notions and strategies taught during the implementations could be adopted, generalized and transferred to other subjects, for instance, the indication of important points and keywords of a text by underlining or highlighting them.

Ref 145

I noticed that she uses her pencil in Greek lesson and underlines what she considers as important or she may need. She might have adopted this habit from Maths sessions and generalized or transferred it in other subjects. She holds her pencil and underlines some lines. (M/IND-POST-InterviewT3)	*Implementations caused notable improvements in some aspects*

In addition, Maria admitted that the implementations helped her. For instance, she referred to the use of the computer's calculator for answer checking, as per the last step of the 5-step model for WMPS. She also referred to the help tips provided by the computer as helpful for the solving process. She also liked the idea of using the computer at home for WMPS. She found it entertaining and felt that it might be a game, but at the same time suitable for the lesson.

9.8 Summary

In this chapter, I presented the analyses of data collected from the third case of this project: the second individual case study. Similarly to Chapters Seven and Eight, the data were presented and organized by bearing in mind the research questions of this study. The presentation of the data started with the features of Maria and continued with the presentation of data relating to her performance level, participation, and interest before, during and after the implementations. Following this, I presented an overview of the difficulties and capabilities relating to Mathematics and WMPS, and how those difficulties were overcome, or not, with the use of the computer. After that, data relating to opinions about Mathematics and the WMPS, and opinions about the use of the computer for this reason were presented. Then some strengths and limitations of the computer-assisted learning were overviewed, which seek to give an answer to the extent that the computer-assisted learning environment helped the student. In the next chapter, a comprehensive discussion of the findings' interpretations and their potential implications will be provided.

Chapter Ten
Discussions

10.1 Introduction

This chapter discusses findings regarding the main research investigation presented in Chapters Seven, Eight and Nine. The first section deals with the first supplementary question (SQ1) focusing on the impact of computer-assisted learning in solving WMPs on students with dyslexia, in the mainstream classroom and on an individual level. This impact will be discussed in terms of latent alterations in the performance, participation, interest, behaviour, and attitudes towards ICT and mathematics for the three cases simultaneously. The second section deals with the second supplementary question (SQ2) which focuses on the extent that collaborative learning in groups can help for a more beneficial use of the computer-assisted learning environment for WMPS. The third section deals with the main research question of this project (MQ) focusing on the extent to which computer-assisted learning environments can provide differentiated support for students with dyslexia, with difficulties in WMPS. The implications of this study, with respect to the classroom practice of the teachers as well as some unanticipated but related issues to the project findings, will also be discussed.

10.2 SQ1: The impact

10.2.1 Performance

Before and during the implementations, many learning difficulties were recorded for the three students, either in the observations of the instructions or the interviews. Especially in Maria’s case, these difficulties occurred through particular tests which were administered in collaboration with the special education teacher of the school. It is important to mention that most of the recorded or observed learning difficulties refer to dyslexic-type difficulties, as cited in the literature (Chinn, 1992, Miles, 2013, Miles and Miles, 1992).

All of the three students were slow learners, and many of their attempts in the classroom led to failure. They were also reluctant to initiate an activity if they felt that they would not succeed, which falls in line with what Chinn (1995) suggests, that students with dyslexia will not begin an exercise when they know in advance that they will not produce the right answer. Another common difficulty was the inability to follow and understand instructions without any support from their teachers, a fact that influenced their performance level significantly, and which shows that the students were not able to work individually while they were dependent on their teachers' guidance, and collaboration in groups. This confirms what Erickson et al. (1985) discovered, that children that are high-risk samples, such as students with dyslexia, are characterised as anxious and avoidant children, who were more dependent on their teachers in comparison with more securely attached children. In addition, participating teachers in Erickson et al.'s research stated that anxious and avoidant children would withdraw and give up more easily than their peers.

Some difficulties that were not related to Maths which occurred were the omission of letters, difficulties in copying from the whiteboard, the inability to recall terms or terminology, and significant difficulties with words of other languages. Another common problem was the omission of a space between the words. Another common problem was the changing of some graphemes when reading, thus they were not reading the words correctly. In addition, they would skip lines while reading texts. Similarly in writing they faced difficulties with orthography, syntax, and grammar, and often confused the use of graphemes and phonemes. Maria's reading skills did not correspond with that of other students of her age, while the other two students had slightly better reading skills. These reflect the core difficulties of students with dyslexia, which are related to the phonological deficit hypothesis. Students face difficulties with grapheme-phoneme schema, and thus often, they cannot easily decode printed words (Ecalle et al., 2009). All these problems relating to language difficulties lead onto difficulties in understanding, and therefore influenced their performance significantly, but to a different extent for each of them. Such difficulties are mentioned in the literature as the main reasons leading to difficulties related to understanding any text (Miles, 1992b, Symeonidou, 2008), and are common for many students with dyslexia (Reid, 2005, Ott, 1997). The triangle model of reading (see Chapter One) fits here to explain that the semantic pathway is weak as a result of the weak phonological pathway (Snowling, 2000). Furthermore, Crain and Shankweiler (1990) asserted that a combination of poor decoding and listening comprehensional skills cause difficulties in reading comprehension.

There are many examples where the WBLEs helped the three students to develop their performance and overcome particular difficulties through the discussions in the group, or individually with me, for the other two cases. During the implementations, the students had the chance to talk and express their opinion either in the group (Peter) or on an individual level (Alexis and Maria) (Malmer, 2000). For instance, the WBLE enabled students to explain the 5-step model for WMPS, as suggested by Krulik and Rudnik (1987), and it also enabled students to understand and narrate the WMPs in their own words, although all of them expressed difficulty in initiating the narrations, probably due to their difficulties with expressive language (Shallice and Warrington, 1975). One of the common features of the students was the insufficient expressive abilities which were enhanced through the collaboration and the stimuli of the WBLEs. This agrees with the Vygotsikian theory on socio-cultural development, where the capabilities of a less able student improve when he collaborates with a more able peer (Vygotsky, 1978). In addition to this, students were encouraged to investigate and indicate the given and asked details of the WMPs, and justify the way they solved a WMP, which they had not done before. This not only enhanced their abilities to solve WMPs, but also increased their performance during the implementations. Mercer and Sams (2006) highlight the importance of using language as a tool for reasoning. Teachers should guide their students to use language more effectively when they participate in collaborative tasks involving mathematical problem solving. Such strategies, which are related to the taught strategies for WMPS in this research, can be beneficial for all students in terms of the development of their mathematical reasoning, understanding and problem-solving - a fact that consequently improves academic performance with respect to WMPS.

Interestingly, Alexis's concentration abilities improved - he had deficient attention before the implementations. As his teacher pointed out, the fact that he had been given the opportunity to solve the problems visually with the use of the computer increased his interest and thus his concentration level. This point did not occur in Maria who did not have any previous problems with attention. Also, Peter's concentration levels depended on several issues, such as the topic, the teacher, the teaching method, and the behaviour of his peers. All these facts deemed to influence the performance of the students. The comorbidity of dyslexia and attention deficit is high as referred by Eden and Vaidya (2008), which influences performance significantly. According to Ota and DuPaul (2002) and Solomonidou (2004), game-like activities on the computer can improve performance in Mathematics in students with a lack of concentration.

Despite the developments in performance during the implementations of the WBLEs, the students did not stop to be dependent either on their classmates or the teacher when they had to deal with difficult Maths operations and WMPs after the implementations. Although some improvements in terms of performance were observed and referred by the teachers of the students, it seems that the WBLEs had ephemeral power which lasted only during the implementations, with no notable long-lasting influence on the students' performance concerning the WMPS. Therefore, the students continued to face difficulties relating to terminology, mathematical formulas and math operations. Of course, each student had difficulties in different sectors and to a different extent. For example, Peter did better with experimental activities and activities relating to daily life. The implementations were few and the training period was short, thus the outcomes were not long-lasting, therefore it was not easy to define the effectiveness of the training program for the upcoming period. Wise and Olson (1995) pointed out that longer training periods provided more time for children to automatize and integrate the taught skills (p.175). According to Gomby et al. (1995), apart from the quality and effective design of an interventional programme, the onset and duration of the programme are crucial factors for the achievement of long-term outcomes. Apparently, long-term effects can be achieved when the interventional educational programmes are implemented during the very early stages after the discovery of particular learning difficulties, and can last for a long time during the first years of schooling. For practical reasons, this project could not be continued for a very long time, but this automatically makes a suggestion for further and more longitudinal research for the investigation of its potential long-term outcomes.

There were minor improvements in terms of the students' performance, referred by their teachers, after the implementations. For instance, Alexis's performance improved, with more frequent participation and more interest in the WMPs solved with the use of the WBLEs when solving the same problems in the whole-class level a few days later. However, it is important to bear in mind that the teachers were aware of the goals of my research project, thus their answers could have been prejudiced in their try to satisfy my ambitions to prove that the WBLEs were successful. This relates to the notion of response bias which refers to the deviation of responses of interviewees away from an accurate or truthful response (Furnham, 1986). Such biases of participants can have a large impact on the validity of their responses and the interview per se (Nederhof, 1985), and are caused by a number of factors. In this case a possible factor is that they were aware of what I was seeking to discover.

Importantly, the students adopted some tactics for understanding and investigating the WMPs, and solving strategies that were used during the implementation of the WBLE. For instance, Peter understood the given details and the question of the WMPs that he had to solve in his textbook and exercise sheets. Maria did the same and expanded this tactic to any text she was reading. They also expanded their expressive language skills, since the three of them developed the ability to narrate the problems' scenarios, and probably other texts in their own words. Narrating and paraphrasing the scenarios of word mathematical problems using own words are included in the cognitive strategies necessary for the acquisition of word mathematical problem solving skills (Montague, 1992). Way and Beardon (2008) also asserted that ICT can be useful in teaching cognitive and meta-cognitive strategies. The adoption of these strategies through the use of ICT can prompt the process that can help the students to successfully perform the required steps of WMPS.

10.2.2 Participation

One of the common characteristics of the three students was low participation during the instructions. Each student had a different reason to not participate, although one common reason could be the fear of failure. This fear prevented them from using their knowledge and demonstrating their abilities in their respective work (Lerner, 1993). The fear of failure of people diagnosed with dyslexia is cited by many researchers affecting the life course of such people. For instance, McNulty (2003) interviewed adults with dyslexia who referred to low self-esteem and self-confidence by school age, due to experienced struggles or failures in school, which could feel traumatic and reduce participation levels during instruction. Also, Maria's shyness prevented her participation in lessons as she avoided raising her hand for participation, unless she was totally sure about the correctness of her response. Similarly, Peter was willing to announce an answer on behalf of his group only if he was certain that the answer was correct, either because it was an outcome of good collaboration in his group, or he had the exercise already solved in his notebook from home. In the case that he worked alone for the solution of a particular exercise, Peter was not willing to raise his hand and was reluctant to respond to the teacher's inquires. This behavior might not reflect shyness on behalf of Peter, as was not noticed during the process and not mentioned by his teachers or classmates, but was likely a reflection of his insecurities of a fear of failure. Therefore, group collaboration increased the students' participation levels, since the outcome of collaborative learning encouraged them to raise their hand more, and answer questions correctly (Malmer, 2000). Continuous learning failures were avoided, and were replaced by positive feedback, which was important and necessary for the students in order for them to improve and develop (Xin, 1999). According to Bryant and Bryant (1998), students with learning difficulties can function effectively in collaborative learning settings, since their group mates can explain in formation and encourage them to work through their potential difficulties in collaborating activities (Marron, 2005, Xin, 1999). Nonetheless, the same researchers argue that some students with SEN may hinder the benefit derived from collaboration, which was observed in Peter's case.

Another common feature of the three students was their slow pace. For instance, Alexis was not even able to solve half of the exercises included in mathematical tests. It is obvious that their slow pace influenced their performance and prevented participation levels to a great extent, especially in the mainstream classroom. This confirms what Markou (1993) says that students with dyslexia learn slower than their peers of the same age, with consequences on their academic performance and participation.

Peter gave the impression of being lazy during the instructions. This characterization was justified as Peter did not do his homework most of the time, and was reluctant to read and write in the classroom during the lesson. The teacher suggested laziness as the main reason for his limited participation, which is also referred to by Apostolides, (2004). However, this case might not be so simplistic. As mentioned above, the student was willing to participate when he was completely confident about the correctness of the answer, which could mean that either he was too lazy to think for himself, or that he had low confidence in himself as well as his actual abilities and skills. According to Apostolides (2004), it is a common phenomenon for students with dyslexia to be considered lazy, especially in Cypriot schools where all students with dyslexia can be found in mainstream schools. Some of them have previously been diagnosed as students with dyslexia, however, some are still characterized as being lazy.

In addition, the students' participation levels depended on their interests, the topic, the teacher and the teaching approach, as well as their awareness regarding their abilities. The topic was a stimulus for participating whether willingly or not, or not participating at all. The teacher's personality and approaches also influenced the level of participation (Mason, 2003). In addition, the teaching methods and approaches, and attitudes towards teaching played their role (Gifford, 2006). For instance, the students were losing their interest, thus their participation level decreased, after long-lasting teacher-centred instruction. Also, the students did not participate when they were aware of their difficulties relating to a particular topic, probably in their attempt to avoid a latent failure (Evans and Goodman, 1995). Pierson (1999) found that students with dyslexia were usually willing to engage in activities when given a voice, and were involved in activities within contexts of learning that allowed them to show their interests. Although Pierson's research focused on an individual instruction, we can conclude that the students with dyslexia easily lose interest in activities that are not student-centred, and when their interests are not taken into account.

The WBLEs were designed by taking into account those factors that potentially play their role in the fluctuations of students' interests and participation levels during instructions. During the implementations, most of the time the students' interest and participation levels were maintained at high levels. For instance, Peter's participation was increased through opportunities to discuss with his group mates and teachers, and participate in the whole-classroom discussions, which corresponds with what Malmer (2000), Putman et al. (1996) and Demetriadis (2001) discovered regarding the benefits deriving from collaboration in groups for students with learning difficulties. Similarly, Alexis and Maria interest and participation levels increased significantly since the implementations were individual. Again, Pierson' (1999) argument is confirmed here. That is to say, the students' interests were taken into account in the design of the WBLEs, and were given a voice, either through collaboration or individual implementation, within the contexts of learning with the use of the computer. This agrees with the notion of differentiation of teaching. Teachers can differentiate their teaching according to the content of the lesson, the interests, tempo and levels of learning of their students, and by their responses to questions and activities as well as the structures and methods of teaching (Lewis, 1992).

Nonetheless, there were many cases where Peter was easily distracted by one of his group mates, a fact that played its role in the reduction of Peter's participation levels. Therefore, apart from the benefits of collaboration regarding the increase of participation, interactions with group mates were distracting, especially due to Peter's vulnerability to be side tracked by his peers. These issues were not observed in the two individual cases, although benefits of collaboration with peers were not exploited. According to O'Connor and Jenkins (1994), collaborative learning can be successful only when the teacher makes instructional adaptations in order to meet the particular needs of the students. In Peter's case, the teacher was not willing to form mixed-ability groups in the first implementations, and therefore Peter was made vulnerable by his peer's behavior, and was involved in off-task activities several times, a fact that affected his participation.

After the implementations, two out of the three students continued to participate at the same level as before. The two boys continued to be selective on the subject and the activity they were participating in. They also continued to participate in the lesson when they were totally sure that they could do so successfully, which agrees with what Gagatsis (1999) pointed out, that the abandonment of effort is common in the case of students with dyslexia, who tend to avoid tasks or leave tasks uncompleted when they are not sure that they can complete them successfully. Also, the extent of participation was influenced by peers and their slow pace. In Maria's case especially, there were some indications her self-confidence increased, and she became more confident to raise her hand and participate in the lesson, which did not occur before the implementations. It seems that Maria's self-confidence increased during the implementations because of the opportunities she had to succeed, be rewarded for her achievements, and overcome some of her difficulties. This agrees with Eaden & BDA's (2005) conclusion, that students with dyslexia, after the experience of success, will empower their resilience and determination to cope with their potential difficulties, and seek to succeed in front of their peers. This empowerment was offered through opportunities to succeed during the implementations.

It is important to note that the level of participation of the two boys remained the same both before and after the implementations. It is normal not to expect long-lasting changes in terms of participation levels, since the project did not focus on this end. However, some of the tactics and strategies adopted by the students during the implementations not only improved their performance and skills in solving WMPs, but also increased the possibility of participation during the instructions. Maria’s case is an example of how the opportunities to succeed, especially for students with continuous learning failures and an underestimated self-image, can change their self-image positively, and enhance the will to participate in the lesson to a greater extent, than before the implementations. Gifford and Rockliffe (2012) assert that “one of the most important features is the child’s positive self-image as a successful learner of mathematics” (p.12), which agrees with what Evans and Goodman (1995) pointed out.

10.2.3 Behaviour

Before the implementations, the students’ behaviour fluctuated depending on several factors. For instance, long lasting teacher-centred instruction caused behaviour deviations for Peter and Alexis. In addition, particular learning difficulties in certain subjects and topics influenced Peter and Alexis’s behaviour, who lost interest easily, and became reluctant to participate in lessons. This reluctance gave the impression of deviated behaviour. Studies comparing teacher-centred and student-centred approaches highlight the importance of the more dynamic students' active involvement in the learning process, which inevitably reduces the possibilities of passive behaviour through their engagement in learning activities than the passive observation of the teacher's lectures in more traditional teaching approaches (Webb et al. 2006).

In general the behaviour of the three students was not challenging especially, when they were interested in the topic, and the teaching method was attractive and not tiring for them. No negative or aggressive behaviour was noticed. This is associated with what Leonard and Harris (1979) concluded, that knowledge of learning style (Kolb, 1985) can be effectively used to recognize distinct patterns of behaviours of students, as well as the attitudes and reactions that they exhibit in a given learning environment, and thus allow the teacher to bend his teaching approach to fit the learner’s learning needs. Students used to behave well when their interests and learning styles were satisfied.

It is interesting to point out that collaboration in groups influenced the students' behaviour. There were cases where the students were not collaborative, especially when the groups worked totally independently, and control by the teacher was limited. This happened in Peter's group, not only before and after, but also during the implementations. That is to say, the limited control and independent collaborative learning lead to off-task and non-collaborative behavior. This example shows Peter's vulnerability to be distracted by his group mates when there was no considerable control of the group by the teachers. According to Kaufman et al. (1999), some problematic personalities of group members affect the effectiveness of the collaboration in small groups. For example, some students might need more motivation or they are too shy, passive or unconfident about becoming involved with the group. Additionally, there might be group members with dominant personalities who have high standards to such a degree that excludes other teammates, as which occurred in this case. Kaufman et al. (1999) suggest an increase of interdependence between the group members which is crucial for effective collaborative learning. The interdependency can be enhanced through the intervention of the teacher, which decreases when the teacher's control becomes limited. In this case the teachers were responsible for many groups of students either before, during or after the implementations, which made the quality of collaboration problematic, especially in groups where the above mentioned problematic personalities were present.

A similar behavior pattern noticed during the implementations was that the students cheated when they were working independently without teacher's control, either because they were used to this behavior before the implementations, or they wanted to save time, or because they were reluctant to think by themselves and therefore waited for their peers to think for the whole group. The fact that Peter and his group mates tried to cheat by omitting some steps of the process when they were left to work totally independently was an example of this behavior. According to Maheady

(1998), in order to maintain good quality collaboration between peers and peers-assisted learning, the teachers should move around the classroom and monitor the students' interactions, performances, participation and behavior. If the teacher fails to do so, then the students might cheat and not collaborate properly. In cases where the teacher was not involved in the collaboration of particular groups, due to many students' groups and limited time, then there was a high risk for this cheating behavior to occur.

It is important to note that Alexis and Maria's behaviour was more controllable during the implementations. Alexis had attention problems, thus he was not able to concentrate for long periods of time and lost interest easily. In such cases, his behaviour was controllable and was easily recovered. He was more excited with new questions and topics but grew bored with the repeated old ones. This charges the design of the WBLEs with the potential disadvantage that their steps and design were repetitious, a fact causing boredom to the students.

Another characteristic of Alexis influencing his behaviour during the instructions was his impulsivity. Thus, in many cases, he insisted on expressing his thoughts and ideas prematurely, which caused behavioural, but manageable, problems in many cases. Although impulsivity is one of the main characteristics of ADHD, there is strong literature evidence to suggest that there is comorbidity of attention deficit disorders with reading disorders, such as dyslexia (Miranda et al., 2011). Yet, this does not mean that Alexis had ADHD in association with dyslexia.

In addition, the environment played its role in the behaviour of the student. For example, the last implementation took place in Alexis's study room at home with the presence of his mother. Alexis' behaviour was not that controllable since he felt much more comfortable in his own home, which was full of many distracting stimuli such as games, and so on. In addition, the presence of his younger sister caused attention disruptions. The fact that the implementation took place during the afternoon also made Alexis less cooperative, since he was wasting time from playing games with his friends. This is another indication of potential comorbidity of developmental dyslexia and attention deficit disorders.

In contrast to the two boys, Maria was very collaborative during the implementations. No trace of deviated behaviour was noticed. She gave the impression of being shy and was not expressive when asked to speak her opinions. According to Heiervang et al (2001), early studies reported an increased disruptive behaviour with dyslexia, while earlier studies yielded high correlation between attention deficits and hyperactivity and dyslexia as a cause of externalised challenging behaviour. Pisecco et al. (1996) stressed that some children with dyslexia show challenging behavioural problems in general, while other students show this behaviour only in school settings. Although the behaviour of the three participating students was not pervasive, some differences in the behavioural differences between Maria and the two boys were reported. Heiervang et al. (2001) found that boys with dyslexia had significantly more teacher-reported externalizing and attention problems than girls. "These results may indicate that dyslexia is associated with more externalizing behaviour in boys and more internalizing problems in girls" (p.255).

After the implementations, some changes in terms of behavioural issues such as concentration, and enhanced collaborative skills were noticed. Of course, these changes are likely to occur due to the maturation of children with the passage of time during the implementations and not a result of the implementations per se. Yet, we could say that the plethora of opportunities that students had to experience successes, with no failures, were crucial to improve their interest in the lesson as well as their self-image as students, and therefore their behaviour during the lesson, whether working individually or in groups. In a research example involving a remediation programme in mathematics for students with dyslexia, Exley (2003) not only found improvements in students' performance and attainment, but also improvements in terms of their emotional difficulties and behavioural issues. The remediation programme took into account the preferred learning styles of the students, a factor which was taken into account for the design of the WBLEs used for this project.

10.2.4 Opinions about mathematics

The students recognized the importance of Mathematics. All three of them referred to the usefulness of Mathematics in everyday life; however, none of them chose Mathematics as one of their favourite school subjects. It is obvious that the particular learning difficulties that the students had in Mathematics influenced their attitudes towards that particular subject. In general, the implementations helped the students to see Mathematics more positively through the opportunities they had to succeed. Students' beliefs about Mathematics, and beliefs about themselves as learners, are important to be taken into account. For example, the students' beliefs about their ability to solve mathematical problems, the importance of increasing their maths ability, and their belief about the usefulness of Mathematics in daily life, relate to their motivation to learn Mathematics (Mason, 2003). The students continued to have a positive attitude towards Mathematics, both during and after the implementations.

10.2.5 Opinions about ICT and the use of the computer

The students had limited opportunities to use the computer at school or at home for educational purposes. According to European Union statistics, students in Europe use the computer more regularly at home than at school (Eurydice, 2011). Nonetheless, none of the three students had a personal computer at home, and therefore used their parents or other members of their family's computer. The main use of the computer at home was for gaming. The single computer in the mainstream classroom was used only by the teachers, and not by the students. Also, the main use of the computer in the mainstream classroom was for screening textbook pages, as well as some other tools, which did not have any additional educational value. Although the three participant schools in this project were equipped with computer labs, the students did not have any opportunities to visit them during that school year. This agrees with Vrasidas's (2014) discovery, that the use of technology by students in Cypriot mainstream classrooms was not frequent, and was limited to solving problems, word processing assignments, use of the internet, playing games, and so on.

Alexis had the most opportunity to use the computer at school, during his supporting lessons. The reason is simple. Alexis's special education teacher was more aware and interested in using new technologies in her instructions than the Peter and Maria's special education teachers. Although, the three special education teachers expressed their positive attitude towards ICT, and recognized the benefits deriving from the use of the computer in their instruction, they did not put this into practice for many reasons. The main reasons were limited ICT skills and training, limited time, demanding curriculum, and restricted available ICT resources. This goes with what Mavrou (2005) pointed out regarding the limited available ICT resources, a situation that has not changed in a decade. The majority of schools are equipped with a single computer in each mainstream classroom, and a computer lab for the whole school. However, the systematic reform efforts of the Cypriot educational system include Cyprus in the list of the countries with the most developed ICT infrastructure in primary schools (Vrasidas, 2014). Yet, research shows that despite the developed ICT infrastructure in many countries, teachers avoid embedding new technologies in their instructions (Aldunate and Nussbaum, 2013).

The three class teachers recognized the benefits deriving from using the computer. They referred to the differentiation and visualization that can be achieved with the use of ICT, however they pointed out that the use of new technologies should not be in such a way that would harm the learning process. The lack of time and the high curriculum demands as well as the restricted available and suitable ICT resources, were additional reasons mentioned by the teachers which prevented the use of computers in instructions very often. They also concluded that the use of new technologies is not a panacea and that there are many alternative ways to transfer knowledge instead of only using the computer. Obviously, the three teachers tried to justify why they did not use the computers very often in their instructions, and why they did not give opportunities to their students to use the computer in the mainstream classroom or at their school's labs. Despite their positive views and awareness about the benefits deriving from the use of the new technologies in the learning process, they referred to lack of time, high demands of the curriculum, and limited ICT resources as the major reasons for not using them in a way that contained additional learning value for the students. Apparently, there is a gap between teachers' believes and acts. This gap was referred also by Vrasidas (2014), who discovered that 95 per cent of the participants in research exploring the extent of ICT usage in Cypriots primary schools, agreed that it is important to integrate new technologies in the instruction, but the main use had no additional educational value for the students.

Alexis's special education teacher deemed the computer in the instruction as an additional motivation for teachers, due to the plethora of additional benefits deriving from its use. The benefits, included assisting the teacher with the preparation of educational material, and helping in the lesson, are mentioned by Franklin and Litchfield (1999). One of those benefits is the fact that the computer reduces attention disruptions, something that could not be overcome alternatively in such a successful manner. This agrees with what Garagouni-Areou and Solomonidou (2004) found in their research, aiming at the identification of the software features designed for the needs of students with attention deficit disorders. The special teacher also referred to benefits in writing, especially for Alexis who had significant difficulties in writing. The computer can replace the paper and pencil, especially in the cases of students who have difficulties with writing, a fact that equalizes the learning opportunities through the compensation of chances to succeed in fields with previous failures. Therefore, the use of the computer can help to improve the self-image of those students facing failures at school. Blamires (1999) and Rahamin (2004) stress that the use of ICT can compensate difficulties of students with SEN by providing physical access to learning, cognitive access with a multimedia approach, on-going assessments and development of self-esteem. Nonetheless, Alexis's special education teacher referred to some disadvantages of using the computer, beyond the benefits. The use of the computer in supporting lessons was time consuming, and a lack of funds prevented the renewal of the software collection. This falls in line with what Vrasidas (2014) and Hadjithoma and Karagiorgi (2009) found, that the main reasons for the limited incorporation of ICT during instruction in Cypriot mainstream classrooms is limited time and lack of software.

Furthermore, the students had limited IT skills because of their limited opportunities to interact with the computer, either at school or at home, and they were not trained on how to use the computer at school. This confirms what Mavrou (2005) pointed out, that Cypriot students are not provided with opportunities to use the computer in school during lessons, nor is ICT as a subject part of the national curriculum, while the main use of computers takes place at home. Furthermore, the EU's Digital Agenda (2012) indicates that the majority of Cypriot students have more access to ICT at home, and less access at school. Despite the positive attitude towards the use of computers at school, the students were worried about their limited IT skills, and this caused insecurities in using the computer which might have made the process more complex for them. This corresponds with the EU's Digital Agenda (2012) which includes Cyprus in the list of countries with the lowest rates of levels of confidence to perform various activities using the computer. Although the students had no previous experience of using the computer for any activity in Mathematics, and possessed limited IT skills, they expressed the view that ICT could help them in WMPS. Also, the students expressed a positive attitude towards the use of the computer in instruction, and the desire to use the computer at school more often. It is important to mention that not only the three students with dyslexia, but also Peter’s classmates were excited with the idea that they were going to use the computer for Maths lessons. This excitement and positive attitude towards ICT maintained inalterable, both during and after the implementations.

After the implementations, the students recognized the benefits of using the computer for WMPS, and admitted that the use of the computer facilitated the learning procedure. They were also willing to repeat it more often, which revealed their satisfaction in working on the computer for WMPS during the implementations. Of course, we can assert that the students expressed positive comments about the use of the computer and the WBLEs because this was something completely novel for them. According to the novelty effect, humans may perform better and be more positive when new technology is introduced for the very first time. This improvement might not be a result of any actual improvement in learning or achievement, but in response to an increased interest in the novel technology (Clark and Sugrue, 1988).

Also, the six teachers that participated in the project asserted that they had never used ICT for WMPS previously, either because they were not aware of its existence or because they were not willing to use such computer educational programs in their instructions. Interestingly, Maria's teacher was surprised when asked whether he would dedicate some time to create a simple WBLE for WMPs for his students. He stated that the teachers do not create computer programs, but buy them instead. However, they all admitted that they would use ICT for WMPS if there were readymade computer educational programs available. This answer was given after the implementations, and it was apparent that the teachers realized that the creation of WBLEs for WMPS is a time-consuming process but beneficial for the students. Therefore, they would use such WBLEs in their instructions only in the case they were readymade. Yet, Maria's teacher pointed out that ready-to-use educational software was welcomed with scepticism because technology should not be used for the sake of using technology. The teachers that participated in Vrasidas's (2014) research also referred to the preferable use of readymade resources, even though finding such resources can be time-demanding. Despite the recognition of the plethora of benefits deriving from the use of new technologies in the instructions, the teachers continued to embed ICT in their instructions to the same extent as before the implementations.

10.2.6 Difficulties and issues related to Mathematics and WMPS

Apart from Alexis who was more able in mathematics, all students had significant difficulties in Mathematics. Even though Alexis had improved in Maths in comparison to Peter and Maria, he had a significantly lower performance in comparison with his classmates. All three of them had difficulties in basic mathematical operations, with Maria the most severe, and Alexis with the fewest difficulties. The students all had basic skills of handling simple maths operations, especially those involving small numbers, additions and even subtractions. The difficulties in handling multiplications and divisions were more severe. Nevertheless, Alexis had difficulties with many maths operations, especially with higher numbers which confirms what Garofalo (1989) discovered, regarding the difficulties of students with dyslexia in mathematics. The improvements in handling maths operations noticed after the implementations were probably a result of maturation and further experience during that time, not only in the implementations but also the instructions in the mainstream classroom. In general, the maturation of the participants during the implementation of interventional programmes can be a threat to the internal validity of the research (Papanastasiou and Papanastasiou, 2005). The observed difficulties confirmed what the literature mentions regarding the difficulties of the students with dyslexia in handling maths operations (Gagatsis, 1997, Symeonidou, 2008, Miles, 2013, Miles and Miles, 1992, Miles and Miles, 2013, Pritchard et al., 1989).

In addition, Maria had difficulties with the place value and weaknesses in reading numbers correctly (Douklias et al., 2010). We do not have any indication of similar difficulties for the other two students. Maria's weaknesses in place value and the correct name of numbers reflect her severe learning difficulties and her weak learning profile, when taking into account her actual age. According to Critchley (1970; in Miles, 1992), students with dyslexia encounter difficulties in place value.

Both Peter and Maria, but also Alexis who improved in Mathematics, faced difficulties in WMPS. The most significant difficulty, which was common for all three of them, was with reading and understanding the WMPs, and choosing the correct solving strategy. The problem of understanding simple text or mathematical problems is a common difficulty of students with dyslexia, as referred to by many researchers (Chinn, 1995, Bath et al., 1986, Miles and Miles, 2013, Symeonidou, 2008, Gagatsis, 1999, Markou, 1993).

In addition, the students had difficulties handling complex WMPs involving more than one Maths operation, or other strategies. The difficulty in choosing the correct solving strategy was greater in WMPs involving other strategies than simple Maths operations. Even the more able students had difficulties with these types of WMPs, which was confirmed not only by the observations, the interviews and the pre-tests and post-tests, but also during the implementations. Such WMPs involved strategies such as creating a table, combinatorics, creating a drawing, etc. Even the problems involving simple Maths operations caused difficulties in choosing the most suitable Maths operation for the solution of the problem. Thus, some students chose Maths operations randomly, without thinking about them logically. These difficulties were taken into account in the design and choice of the WMPs for the implementations. According to Babbit and Miller (1996), solving WMPs is probably the most complex cognitive subject of Mathematics, involving the higher cognitive and deductive strategies, perception, attention and memory. If we bear in mind that the so-called by Mason (2003) anomalous problems cannot be solved in a routine way, it means that the complexity increases the involvement of high demanding cognitive deductive skills which might be insufficient in students with dyslexia.

Some strategies and techniques were implemented by the teachers in order to help the students overcome difficulties in WMPS. Such tactics and strategies were the simplification of the problems' numbers and text, the use of comprehension questions, the visualization of the problems, the use of educational material, the collaboration in groups for solving mathematical problems, the indication of keywords and other details of the problems, and so on, which are similar to those referred by Garofalo (1989). However, some of those strategies were mechanical procedures that do not always provide solutions for all problems (Mason, 2003). Nonetheless, all those strategies were helpful for the students in understanding and choosing the right strategy for solving the problems, and were taken into account in the design of the WBLEs.

The problem of understanding the WMPs was not a result of difficulties in Greek language, since all three students were native speakers of the Cypriot dialect of the Greek language. However, it is important to point out that the Cypriot dialect has significant differences with the Modern Greek language, which probably caused some difficulties in comprehension, especially when they had to deal with unknown terms or words (Trudgill, 2003, Pavlou and Papapavlou, 2004). The majority of students in Peter's classroom were non-Greek language native speakers, thus there was a major problem with understanding the language of maths problems. Therefore, the problem of understanding was due to the difficulty of students with dyslexia in reading instructions and detailed text with the deciphering of words, demanding much energy that reduced the chances of any understanding of the actual text (Symeonidou, 2008).

The lack of concentration and attention was one of the main reasons for difficulties in understanding WMPs. This point was mentioned by Alexis's teacher who pointed out his limited concentration that prevented him from understanding the problems. The same goes for Peter whose attention was usually disrupted and was occupied with off-task discussions with his next peer. It is important to note that the literature suggests high co-occurrence of attention deficit and developmental dyslexia, a fact that might influence the students' performance (Eden and Vaidya, 2008). Although the issue of limited concentration was present during the implementations, both Peter and Alexis were engaged with the process due to the game-like design of the WBLEs, the continuous feedback, and many other facilities that will be discussed later on, and the fact that they were working on the computer, which did not happen very often during the instructions. This goes with what Ota and DuPaul (2002) and Solomonidou (2004) stress, that game-like activities on the computer can improve students' performance in mathematics when they suffer from a lack in concentration, as mentioned above. Peter was also kept on track because of the need to collaborate in his group (Bryant and Bryant, 1998). Alexis regained his concentration easily as the implementations were individual, with my continuous presence and feedback.

The weak long-term and short-term memory of these three students, which is a common characteristic of people with dyslexia (Chinn and Ashcroft, 1995), prevented them maintaining information in their minds and recalling some terms and keywords that would be useful in understanding and solving the WMPs (Clements, 2000).

Despite attempts to design the WBLEs in such a way to help students in solving WMPs involving any kind of strategy, the students still had difficulties with the tricky problems during the implementations. However, the fact that the students managed to solve those problems, not only with the cooperation in the group or the guidance of the teacher, but also with the use of the helpful tips provided by the WBLEs, can be charged as an advantage of the project in helping students to overcome their difficulties and reach the solutions of the problems. This finding falls in line with what Montague (1992) discovered, that despite the difficulties of students with learning difficulties in solving word-based mathematical problems, a structional support involving cognitive and meta-cognitive solving strategies can enable students to cope with their difficulties and solve such problems. Also, Babbit and Miller (1996) add that those strategies can be taught with the use of digital technologies, a statement that is strongly associated with the findings of this study, that new technologies have the potential to enable students with dyslexia and with difficulties in WMPS to adopt skills and strategies to use towards the solution of such mathematical problems.

The fact that the students could listen to the word-based mathematical problems instead of just reading them helped them to overcome the basic obstacles of their potential reading difficulties, and allowed them to continue to the next important step of understanding the problem. Olson and Wise (1992) argue that that computer programs involving speech support enhance the ability of phonological decoding and word recognition for students with dyslexia, who obtain access by overcoming their reading difficulties through listening rather than reading the text. This agrees with what Malmer (2000) suggests, that it is preferable to provide an audio version of the texts for students with reading difficulties, especially in tests. It also fits well with the theory of Paivio (1971), that representations of information in multiple formats can provide better results in retention and retrieval. An additional theory related to the provision of an audio version of the text is the

Multimedia Principle of Mayer (2001). Individuals have preferences in terms of the use of animation, auditory, narration and text. In this case, the WBLEs were designed by bearing in mind the individual preferences of students with dyslexia who might prefer and benefit from listening to audio versions of the problems and instructions, rather than reading the texts.

An additional skill adopted by the students was the ability to narrate the problem's scenario in their own words. The narration of the problem's scenario is an indication that the students understand the problem which will enable them to continue to the next step of the solving process. This skill is also useful for the comprehension of any text apart from the word-based mathematical problems. Montague (1992) includes paraphrasing in the list of cognitive strategies and processes that should be mastered in order for the students to be able to understand and solve word mathematical problems. She explains that paraphrasing the problem's scenario involves narrations in her own words, and underlining important information which be useful for putting the problem into her own words and thus understanding it more clearly.

Furthermore, Peter and some of his classmates adopted the skill of the investigation of WMPs by highlighting the details and the question of the problems. Even if the students were doing the investigation because of my presence when they were doing the post-test, we can notice the behaviour as additional skill acquisition related to WMPS process. This skill is also suggested by Montague (1992) who puts it under the cognitive skill of paraphrasing the problem. The students were asked to underline the important details and questions of the problems, which is strongly connected with the implemented idea of the WBLEs followed in this research project. The idea of the problems' investigation also constitutes one of the solving steps suggested by other researchers such as Babbit and Miller (1996), Krulik and Rudnick (1987), Bennett (1982), Case et al. (1992), Miller and Mercer (1993) and Montague et al. (1993).

Maria also adopted some skills in terms of the indication of keywords at the stage of ‘Choosing the Suitable Solving Strategy’ and implemented it when she had to resolve the WMPs solved with the use of the WBLE, this time with the special teacher during the supporting lessons. Babbit and Miller (1996) and Garofalo (1996) put emphasis on the importance of keywords indication as an enabling strategy for WMPs decoding. However, Mahlios (1988) and Sowder (1989) criticized this approach because keywords are sometimes misleading and do not cue the suitable operation. In this case the indication of keywords constitutes an important skill, especially if we bear in mind that Maria was previously not able to solve any WMPs independently. Nonetheless, we do not have any indication whether or not Alexis adopted such skills, since the special teacher admitted that she never left him alone to solve WMPs. It seems that the teacher doubted his abilities to solve problems alone and felt the need to guide him in every single step. Therefore, Alexis did not stop being dependent upon his teacher being WMPs solver. On the other hand, the class teacher asserted that Alexis increased his participation levels and the abilities to solve the WMPs we had already solved in advance with the use of the WBLEs, during the individual implementations.

Interestingly, Maria became more independent word-based problems solver in some cases where the special teacher left her to resolve the problems we solved in advance during the implementations of the WBLEs. Of course this was not a permanent improvement but was a positive development, as her low-profile and insufficient self-confidence prevented her from working alone, most likely due to her fear of potential failure. This agrees with what Lawrence, (1996) asserts, that self-esteem affects learning and the performance of students with dyslexia, while the outcomes of learning and performance can affect self-esteem (Burden, 2005). The perception of school as a negative experience, due to failures of students with dyslexia, affects their self-confidence as well as self-esteem.)

Peter’s difficulties in solving mathematical problems were evident from the results of the pre-test and post-test. In essence, Peter scored the minimum mark out of his classmates, almost two standard deviations under the mean.

It is important to mention that Peter did not solve the two out of the four WMPs of the pre-test, which prevented us from drawing safe conclusions. Therefore, this low score was not only due to his difficulties, but also his slow pace since he did not manage to solve all the WMPs in the time frame allocated. It is important to note that the WMPs of the tests were chosen from the textbook, therefore they were likely to have had a relatively advanced level of abstraction. Also, some of the chosen problems had advanced formal demands that were not suitable for students' knowledge levels in Mathematics (Malmer, 2000).

In the post-test, Peter's score was significantly higher than the score on the pre-test. Yet, Peter scored close to but below the mean. The higher score on the post-test can be interpreted as a development due to the implementations, but still some other factors might have played a role. For instance, the pre-test was the same as the post-test, so Peter was experienced with solving such problems. In fact the experience, because of the similarity of the pre-test and post-test, played a less significant role than the maturation which occurred in the meantime (Papanastasiou and Papanastasiou, 2005). Peter adopted some skills and strategies that allowed him to understand the problem's scenario through the investigation of the problems' details, information and questions, and selecting the most suitable solving strategy through the indication of schemes and keywords. This was obvious from the significantly higher mark that he achieved for the selection of the suitable strategy in comparison with the mark he achieved on the pre-test for this part of the solving process. Peter also adopted the skill of indicating the details of the problem by underlining or highlighting them. This was apparent from the greater mark he achieved on the post-test for this section. This was something that he did on the post-test, although we cannot be sure whether this was because of my presence, while the students solved the post-test in the classroom. Those improvements in terms of the performance in WMPS can be charged as an advantage of the project, and confirms that ICT can help in prompting the process that aids students in successfully performing the various steps of WMPS (Way and Beardon, 2008).

10.3 SQ2: The extent that collaborative learning can be beneficial in solving word-based mathematical problems with the use of the computer

The second supplementary question (SQ2) focuses on the extent that collaborative learning in groups can help for a more beneficial use of computer-assisted learning environments for WMPS. This question was explored through the whole-classroom implementation where the students were put in mixed ability groups. In this section, I will discuss some of the advantages and weaknesses of collaborative computer-assisted learning, as presented in Chapter Seven. The discussion aims to explore the extent to which collaboration in groups that formed during the implementations was more or less beneficial in solving word-based mathematical problems with the use of the computer for Peter.

At this point, it is important to note that the initial purpose was the formation of pairs, with one computer per pair. Unfortunately, this aim was deemed utopic since the available and functional computers in the school's lab were few, thus the students sat in groups of three, and in some cases in groups of four. In essence, Peter's group was made up of three students in total. A further initial goal was the formation of mixed-abilities groups. This aim could not be achieved without collaboration with the class teacher who did not seem to be willing to collaborate in the formation of mixed-abilities groups in the first implementations. Therefore, we should bear in mind that some advantages or weaknesses concerning the strengths and limitations of the collaboration with the use of the computer for WMPS that occurred during the implementations could be different if the groups were smaller or better formed from the beginning. Evidence also supports that children with dyslexia need to be taught on an individual basis or within a small group, where the teaching will be differentiated and adjusted to its special educational needs (Wise and Olson, 1995).

Before the implementations, some students exploited the collaboration, and waited for their peers to work for the whole group. Peter was amongst those students, probably due to his difficulties or his laziness to think by himself. We can say that this mentality became a habit since Peter, and many other students, rested on the ready available answers, taken by the minority, and that this mentality should be taken into account because it occurred also in the collaboration groups during the implementations. This agrees with what Bryant and Bryant (1998) pointed out, that the great challenge of the teachers was to follow those adaptations in their instructions in order to allow everyone to benefit from the collaborative learning in groups. However, some students, for instance, students with dyslexia, may exploit the academic benefit deriving from collaboration and choose to hide behind the more able students of the group.

Interestingly the students had many opportunities to collaborate in their groups in the mainstream classroom, which helped them to understand and recognize the benefits deriving from collaboration, despite the minor problems such as frequent disagreements between the group-members, cheating, copying, and so on (Bryant and Bryant, 1998). The advantages deriving from collaboration were also recognized by Peter and the class teacher. The class teacher asserted that students did not usually raise their hand when they worked individually, but participation increased when they collaborated in groups. In general, there were many benefits as a result of collaborative learning in groups, especially when the more able students were few in the classroom - a reason that the teacher tried to form mixed abilities groups - so each group had at least one more able student. Also Peter understood the collaboration in groups as an opportunity for the students to help each other, especially those who had more learning difficulties. The teacher encouraged the students to work in groups or pairs during the instructions. Peter received significant support from his mixed-abilities group. However, he worked slowly and was rather dependent on the collaboration with his group mates. Johnson and Johnson (1985) who examined the learning process of students, with and without special educational needs through collaborative learning, discovered that collaboration was beneficial in academic performance and involvement for students with special educational needs. Amongst those factors involved is a longer-lasting involvement in the lesson which was achieved through collaboration, classroom conflict, controversy and debates between the group mates. The outcomes from individualised learning were less beneficial for students with SEN.

During the implementations, the groups had to use the computer in addition to the collaboration they had between the group members. Peter's group consisted of three boys. The first was one of the most able students of the classroom. Therefore, in some cases Peter and the third student accepted his opinions without question, which gave the impression of a guided-by-one collaboration. For the last two implementations, the students were re-allocated into new groups of mixed-abilities in cooperation with the teacher of the mainstream classroom. The different features and capabilities of the group's members were important in terms of healthy collaboration between them, because they helped each other to overlap any potential gaps in terms of knowledge, abilities and behavioural issues (Gillies and Ashman, 2000). Peter benefited from the collaboration with his new group mates.

The implementations encouraged students to participate in the instruction, even those who did not participate previously very often, which produced encouraging results from the use of WBLEs in combination with the collaboration in groups of three students. The discussion in groups provided immediate feedback, which agreed with what Baker, Gersten and Dae-Silk (2002) and Koutselini and Theofilidis (2002) found, that students benefited when involved in discussions and debates for problem solving tasks and the investigation of complex topics. Students discuss with their peers and explain their way of thinking which can be considered as an immediate feedback, which is helpful especially for the weaker students of the group. This point can also be linked to the Vygotskian approach, where less capable peers and more capable peers operate within one another's proximal zone of development (Vygotsky, 1978). Interestingly, the features of WBLEs, other facilities provided by the computer, and also the fact that the students had the opportunity to work on the computer, which was previously associated with gaming in mind, helped the students of the target group, Peter included, to increase their participation level during the implementations. Therefore, the dependency on the most able student was reduced because the WBLEs per se provided facilities and helpful tips for the whole group, thus the less able students were not dependent on the more able ones. This also played a significant role on the enhancement of participation levels, performance and self-image of all group members, while the health collaboration with the parallel use of the computer eliminated the level of dependency on the more able students, through the compensation of equal learning opportunities. For instance, Peter was enabled to overcome some of his learning difficulties through the use of the WBLE, which enhanced the collaboration in his group. This agrees with what Sfard and Leron (1996) pointed out, that ICT likely equalizes learning opportunities for everyone, especially when the mathematical problems are difficult to be solved in one shot in real life. It also agrees with Bryant and Bryant (1998) who stress that the use of ICT in combination with collaboration in groups provides access to instructional activities to the same degree by circumventing latent limitations due to the learning difficulties of the students.

However, Peter and his group mates were occupied with off-task discussions when they were left to work totally independently. The arrangement of the computer lab, the inability for the teacher and myself to be continuously next to Peter’s groups, and the fact that the students were feeling freedom in the way they were using the computer and navigating the WBLEs, were giving opportunities to the students to get involved in discussions or even activities not related to the process. As mentioned above, the students might not collaborate well when they are left to work without being monitored by the teacher or receiving guidance (Maheady, 1998).

Another disadvantage of the implementations was the fact that collaboration in large groups was not productive and caused a noisy environment. This negative point was mentioned by many students, as well as Peter, in the interviews. The few available computers in the lab led to the formation of large groups which impeded the healthy collaboration. In contrast, the students were not able to listen to the audio instructions provided by the WBLEs, nor navigate the learning environment. In general, the arrangement was not functional at all, while the students talked loudly in an attempt to collaborate and coordinate the solving process, with the use of the computer. As a result the classroom's environment was noisy and annoying for the majority of the students. According to Rivera and Smith (1997) and Xin (1999), one crucial adaptation that the teacher should take into account, apart from teaching approaches and educational material, is the physical environment that promotes healthy collaboration. Furthermore, Stahl (1999) stresses that if technology itself is used intensively, as happened in this case where a restricted number of available computers has the students using technology intensively in relatively large groups, there may still be considerable difficulties in bringing about a healthy collaboration and transfer of knowledge. Similarly, Lou et al. (2001) stress that "group size may have to be small enough for all group members to sit comfortably around the computer in face-to-face collaborations in order to participate equally and actively".

After the implementations, Peter recognized the benefits of collaborative learning and admitted the significant help he received from his group mates during the implementations, although he expressed the desire to collaborate in groups of two or three students since the larger groups were dysfunctional. In addition, the class teacher confirmed that Peter received significant help from the collaboration with his group mates, in combination with the facilities provided by the WBLEs, such as the audio versions of WMPs which could be replaced by the oral explanation of the problem by one of the group mates which falls in line with what Malmer (2000) stresses, that a peer with good reading skills can replace the audio facility of the WBLE. This means that the teacher concedes the benefits deriving from the combination of problem solving with the use of the computer and collaboration in groups. Moreover, participation levels increased during the implementations. The discussions that the students had during the implementations about what the problem said, or how to solve the problem, were very helpful in comparison with individual work. Peter seemed to be surer of what he was saying and the usual hesitation reduced. This agrees with Bryant and Bryant (1998) who found that students with dyslexia can be enabled to function effectively in collaborative learning settings, because other group members can provide simplified explanations and encourage their group mates who struggle with learning difficulties.

After the implementations, the students continued in the same groups and the collaboration continued at the same level. The teacher maintained her view that collaborative learning helped Peter and the other students; and therefore tried to take advantage of the fact that the students were sitting in groups to ensure that the weaker students benefited from the more able students, through the collaboration. However, similarly to what took place before the implementations, some students, including Peter, exploited their group mates while collaborating in groups by resting and waiting for others to come up with the answers. This mentality was expected as it could not be controlled, because of many students and groups waited for guidance and feedback at the same time during the lesson. This is a disadvantage of collaborative learning which occurs under limited guidance (Koutselini and Theofilidis (2002). Furthermore, Webb (2009) examined the role of the teacher in promoting collaborative learning in the classroom which includes the preparation of students for collaborative work, forming groups, structuring the group-work task, and influencing student interaction through teachers' discourse with small groups and with the class. In this case, the groups were formed more recently and the students did not receive any particular preparation or clear role allocation which constitutes some of the reasons of collaboration malfunctions in cases where the students were left to work autonomously.

Another advantage of collaboration, either with or without the use of the computer, is the decrease of social rejection. Collaboration brought students closer together and improved levels of acceptance. The students helped and supported each other, and felt the importance of their contribution to the group. The design of the WBLEs provided a wide range of opportunities for collaborative learning in groups, and helped in compensating the students facing learning difficulties in WMPS, and Mathematics in general. Thus, the students who had underestimated their role in their group, due to their low profile or learning difficulties, gained self-confidence, and increased their contribution in their groups through the facilities and aids provided by the WBLEs. Therefore, the students became equal members and equal contributors of their groups, which decreased any traces of rejection as a result of low performance or participation. The same happened with Peter in the cases where the collaboration was healthy and guided by the teachers. There was no indication of Peter not being accepted in the groups in terms of friendship, but still his learning difficulties prevented him from being counted and accepted as a valuable member and contributor of his group. Johnson et al. (1994) highlight the importance of collaborative learning in groups which allows students to enhance not only their academic skills, but also to become engaged in social interactions and apply interpersonal skills in group settings. In addition, Putnam et al. (1996), Xin (1999), Gillies and Ashman (2000), Demetriadis (2001), Mavrou (2005) and Solomonidou et al., (2004) agree that collaborative learning with the use of the computer is beneficial in terms of acceptance in the classroom's community for students with special educational needs.

10.4 MQ: The extent of differentiated support

The main research question (MQ) of this project focuses on the exploration of the extent that computer-assisted environments provide differentiated aid and support for students with dyslexia, with difficulties in WMPS. The differentiated support of students was provided with the use of the designed learning environments. For the creation and design of the WBLEs, existing technological resources and software provided by the Ministry of Education, as well as various available free-downloadable or non-commercial internet resources, were used. No software was used that had to be purchased, or that demanded specialized knowledge for use by students with limited IT skills, or specialized knowledge by the mainstream classroom or special education teachers for the creation of learning environments.

In order to answer the main question I first discussed in detail the two supplementary questions (SQ1, SQ2). The answers to these two questions led to the answer of the main question. Through influence on performance, the degree of involvement and participation, attitudes towards Mathematics, and the use of new technologies, we can draw conclusions about the way that limited ICT resources in Cypriot schools can be used to help students with dyslexia overcome potential problems and difficulties in solving mathematical problems, through various facilities. Conclusions have also been drawn as to the extent to which these ICT resources can benefit students with dyslexia. Therefore, the greater part of the main question has already been answered. The fact that WBLEs were applied to two different settings allows us to make comparisons concerning when and how the students can maximally benefit from the use of WBLEs for solving WMPs.

Some advantages and disadvantages of the use of new technologies during the whole classroom implementations, at least in the manner utilized in conjunction with the class teacher, were recorded. The discussion of advantages can help us to draw conclusions about the extent to which students benefited from the implementations both during after the execution of the lessons. The discussion of disadvantages, as recorded during and after the implementations, or the statements of students and teachers, allows us to draw conclusions as to the individual barriers that could potentially affect the degree of the provision of differentiated support for students with dyslexia with difficulties in WMPS.

On the other hand, the implementations on an individual level were conducted in order to compare two different cases because some technical difficulties were recorded, mainly due to the limited available ICT resources in Cypriot schools during the whole-classroom implementations. The individual implementations highlighted some advantages and disadvantages that were not related to collaborative learning. Instead, individual implementations expunged the positive and negative influences of collaborative learning in large groups, as discussed under the second supplementary question (SQ2) in this chapter, and focused on advantages, disadvantages and the extent that students could be benefit from the implementations.

The WBLEs were designed to facilitate the learning process that supported the students in solving the WMPs. The provided facilities were - audio versions of the problems, the possibility of repeating listening to the audio version of the problems, text containing the problem's scenario, pictures, descriptive figures, tables, animations, downloadable material such as documents, etc., the use of calculators for checking answers, helpful tips, navigation buttons, the provision of immediate feedback, notifications and reminders. By solving the WMPs with the use of WBLEs, the three students benefited in many aspects, mainly during the implementations. Some of the benefits that derived from the use of WBLEs were the provision of additional help and explanations of WMPs in simpler words (Malmer, 2000), which helped in understanding the problems and thus reaching the solution more easily, which otherwise, might have been unreachable, especially for Peter, Alexis and Maria. Some of these features which are also referred in TTA (1999) facilitated the process to a further extent, while some of them to a lesser extent. In general, research suggests the use of several ICT tools for the visual representation of mathematical notions and concepts for students with learning difficulties (Babbitt and Miller, 1996; Baker et al., 2002; Bryant et al., 2008; Fuchs and Fuchs, 2001). This corresponds with Loveless and Ellis's (2001) argument, that ICT can be a tool for access to the curriculum for every learner.

For instance, the students' interest was attracted with the game-like design, as well as the use of some animations and pictures. Such features of the WBLEs excited the students and caught their interest while they were working either in their groups or individually. This goes with what Mioduser, Tur-Kaspa and Leitner (2000) pointed out, that game-like presentations maintain a child's interest. It is important to note that the students learned these features of the WBLEs easily and used them to facilitate the process of WMPS, showing that their design was favored the functional use and navigation by the students with limited IT skills.

Furthermore, one of the features of the WBLE that helped the students was the use of free tools from the internet for teaching and mastering particular notions that were difficult for them. For instance, Maria had difficulties with fractions. This agrees with Hegarty (2004), who found that the internet can constitute a dynamic tool for teaching enrichment. The exercises focused on the concept of a fraction as a part of the whole, by providing several colorful shapes in a game-like environment, which helped Maria to understand the fraction represented in each shape. Also, the tool provided immediate feedback. According to Hattie and Timperley (2007), computer-assisted feedback is one of the most effective forms of feedback because it helps students to build cues and recover erroneous believes. Maria seemed to enjoy the game-like activity, and learned to understand the concept of fractions. According to the special teacher of the school, fractions were a big deal for Maria, but after this exercise on the computer, she appeared to have been helped to understand the concept behind the fractions. The use of the WBLE helped her to understand the idea of fractions and solve the WMP involving fractions, which otherwise would not been solved.

Nonetheless, some other issues were recorded in the list of disadvantages of the design of WBLEs, such as repeated steps with similar design which potentially caused the students to become bored. According to Gifford and Rockliffe (2012), the fact that children need to return repeatedly to earlier stages of a remediating teaching programme is not a disadvantage, but in fact might cause more notable progress. Also some WMPs were relatively easy for the students who were willing to solve them in their own way, without following the process suggested by Krulik and Rudnick (1987). Moreover, some of the pictures and animations were misleading for the problems' understanding, and some were disrupting for the students' concentration.

The three students pointed out positive comments about the WBLEs in the interviews after the implementations. They referred to the benefits and also the pleasant climate of the learning process with the use of the computer. Also, Seo (2008) found that students who participated in a survey involving the use of ICT for learning cognitive and meta-cognitive strategies for word mathematical problem solving, were excited about learning using a computer. We can, of course, be suspicious as to whether the students found the lessons more pleasant because of the benefits they had in terms of support, or whether they enjoyed the fact that they had the opportunity to work on the computer, as they did not have such an opportunity very often. Their positive attitude towards the implementations and the WBLEs was obvious from the fact that the students understood the WBLEs as a combination of gaming and lesson, and from the fact that they were eager to use the computer for WMPS again. This agrees with Aşkar et al. (1992), who found out that students had positive attitudes towards the use of the computer-assisted learning environment with no or limited previous experience in using ICT for school subjects. Similarly to this study, the students' attitudes correlated with their opinions and perceptions regarding the use of ICT for gaming, and also for learning.

The students also agreed that the design of the WBLE, which was based on the 5-step model for WMPS, made the procedure easier than solving the same problems in the textbook. Therefore, the three of them chose the computer for word-mathematical problem solving, rather than the textbook. Again, that fact that the students did not use the computer very often might have played its role for this choice.

In addition, the participant teachers recognized the benefits derived from the design and the features of the WBLE in understanding and solving the WMPs for their students. They also recognized the capabilities of ICT to support students with dyslexia, and other students with difficulties in Mathematics in general, WMPs in particular, and the potentiality of the differentiation of the instruction. Although they did not all participate in the collaboration for the design of the WBLEs, they did all admit that the implementations were beneficial for their students with an emphasis in understanding the WMPs, and the structured navigating process for the solving procedure. The positive attitudes of Cypriot teachers towards the use of ICT in instruction and the potential benefits for their students are also referred by many researchers (Charalambous and Ioannou, 2008; Papaioannou and Charalambous, 2011; Vrasidas, 2014), regardless of whether they put their beliefs into practice during their instructions or not.

Furthermore, the implementations helped the students to improve their self-confidence. It is clear that the three students were used to failure, which was catastrophic for their self-esteem and self-confidence, in terms of their abilities and attributes to succeed (Burden, 2005). In addition, there is evidence that overcoming reading difficulties has a significant effect in Mathematics. According to Ashcraft and Kirk, (1998) such difficulties cause weak confidence, which leads to anxiety in Mathematics as well as the prevention of learning by blocking working memory space (cited in Gifford and Rockliffe, 2012). The WBLE might have been the main reason that simplified a problem which otherwise might have been difficult for them. As a result, the students felt better about themselves after their achievements in solving some WMPs, without significant difficulties, a fact that potentially improved their self-image and boosted their self-confidence. This agrees with what Antonelli and colleagues (2014) pointed out, that in students' with dyslexia, self-esteem can be empowered through opportunities to succeed. Especially for Maria, it is important to mention that after the implementations she abandoned some of her insecurities, thus less guidance was needed by the special education teacher while she solved WMPs alone.

Another important benefit deriving from the implementations and the use of the WBLE was logical thinking and the creation of WMPs schemes through logicality. That is to say, the students were able to understand the similarity of some WMPs in terms of their contents, keywords, syntax and structure, which enabled the students to put such problems under the same category. This also was reached with the use of particular diagrams suggested by the national curriculum for Maths, but also the literature. Way and Beardon (2008) assert that ICT can be useful in teaching cognitive and meta-cognitive strategies, which can help in creating generalized schemes and patterns in WMPS. Therefore, when the students faced problems that fulfilled the criteria of a particular scheme, they could recall and understand immediately the procedure for the solution of such WMPs, with less difficulty and effort. This made the students become more independent WMPs solvers, but also significantly increased the opportunities to succeed, and decreased the possibilities to fail.

The novelty of the implementations made some teachers reluctant to collaborate to a more desirable extent. For instance, Peter's class teacher kept a cautious attitude towards the role she was asked to perform during the first implementations of WBLEs on a whole-classroom level. The teacher was reluctant to form mixed-ability groups with the pretext that valuable time would be lost. Therefore, the students were free to sit wherever they preferred, which caused misunderstandings, exclusions, and a waste of more valuable time. The teacher would only intervene for procedural and technical issues at first, and was not willing to undertake the role as coordinator of the lesson. This attitude changed after the first implementations, when the teacher became more cooperative in the organization and coordination of the lesson, and the guidance of the groups. A possible explanation of her initial attitude is her potential doubts or concerns about the successful upshot of the first implementation. Another possible explanation could have been the makeshift collusion that we had with the teacher before the first implementation, despite the cooperation we had for the choice of WMPs and the designing of WBLEs. After the first implementation, the teacher seemed to be more willing to cooperate and undertake the coordination of the lessons in the computer lab. However, it is important to mention that the teacher offered only the last session of the school day for the implementations, probably because she was put more emphasis on her obligations to cover the requirements of the national curriculum, and less emphasis on my project which was optional for her. Nonetheless, the students were clearly tired by the last session of the day, which played significant role in the success of the implementations. This attitude of the teacher confirms what Vrasidas (2014) and Charalambous and Ioannou (2008) point out with respect to the gap between the teacher's beliefs and acts regarding the incorporation of new technologies during instruction in Cypriot mainstream classrooms. In this case, the teacher was positive about the idea and collaborated for the design and creation of the WBLEs, but when the time came to put them into practice, her concerns concerning the limited available time surfaced.

Two of the main reasons referred by the teachers for not embedding the new technologies in their instruction, were a lack of time and the high demands of the curriculum. An additional reason for not embedding the new technologies in the instructions referred by the teachers was the lack of suitable software and a lack of educational computer resources. Although the teachers recognized the benefits from using the computer for the differentiation of the instruction, as mentioned above, they were not willing to design their own WBLEs for their students for the same reasons. However, they were willing to use any ready-to-use software and embed new technologies in a more interactive way in their instructions. This confirms what Vrasidas (2014) discovered, that the top four factors reported by teachers for not intergrading new technologies in the instructions were the curriculum, the time required to implement technology-based lessons, the time required to prepare ICT-based lessons and activities, and the lack of infrastructure (p.6-7).

Furthermore, the teachers agreed that the use of ICT is not a solution, and that the presence and role of the teacher is deemed to be vital in the whole process for guidance and the provision of continuous support and feedback, which agrees with what Wise and Olson (1995) pointed out, that computer-based instructions allow more individualized training but cannot replace the interactive relationship between teacher and student. It was proved that when the students worked totally independently, the WBLE was unable to control the process that they followed, and therefore the presence of the teacher was deemed to be necessary. According to Gifford and Rockliffe (2012), the replacement of the teacher with computer programmes in isolation is not recommended in general.

The extent that computer-assisted environments can support students with dyslexia with difficulties in WMPS can be examined through the outcomes after the implementations. The implementations did not have any long-lasting outcomes since the students did not adopt all of the strategies taught in the whole-class or individual sessions. The only tactics adopted by the students were the enhancement of narrating skills, and the indication of given details and questions of WMPs, which were helpful strategies helping in understanding the problem's scenario. Furthermore, it is important to mention that Maria expanded some of the strategies taught in investigating texts not necessarily related to Mathematics. The students were also more aware about some keywords revealing the right maths operation and strategy, a fact that makes the selection of the solving strategy much easier for the students. In addition, the students adopted the habit of checking the correctness of their answers by the end of the process, although most of the time they were not left alone to solve the problems. Therefore, they continued to solve problems with the teachers' guidance. As mentioned above, the duration of an interventional teaching approach constitutes a core factor for the achievement of long-term outcomes (Gomby et al., 1995). For practical reasons, this project could not be continued for a longer period of time.

It is a matter of fact that the improvements observed during the implementations did not continue, to the same extent, after the implementations. For example, the students were not able to remember and recall the 5-step model for WMPS, or other Maths terms taught and explained during the instructions. One of the possible reasons for the short-lasting outcomes is the short time period of the implementations. Only six implementations took place in Peter's class, and only four individual implementations took place for Alexis and Maria correspondingly. Short-lasting training periods do not allow students, either with or without dyslexia, to automatize and integrate the taught skills (Wise and Olson, 1995).

This project aimed to explore whether the limited ICT resources available in the majority of Cypriot primary schools can be used to facilitate WMPS for the students with dyslexia. The available ICT resources were few, especially in Peter's school where the whole-classroom implementations took place. Thus, the restricted ICT resources impeded the successfulness of the whole-classroom implementations. The few computers led to the formation of large groups. As a result, collaboration between the group members was difficult, and the learning environment was noisy. In addition, some technical issues arose due to old ICT equipment. On the other hand, the individual implementations eliminated those issues, although some unexpected technical issues arose here as well. For instance, some features of the WBLE were not accessible during the last implementation, for example, audio players, which took place at Alexis's home, because of no internet connection. Therefore, the WBLE was dependent on an internet connection.

In general, despite the restricted ICT resources in the majority of Cypriot primary schools, this project proved that the limited ICT resources are not an insurmountable obstacle. The teacher can use the available resources and some internet tools in order to design and create simple WBLEs, in accordance to their students' needs. This can be achieved without the teacher having advanced IT skills or any programming language. Time and motivation are the only requirements for a teacher to embed new technologies in their instruction, when there is no suitable software available for their students' features, needs and learning difficulties. The project played its role in changing the attitudes of the teachers towards innovating and integrating the new technologies in their instructions with the creation of simple WBLEs, which confirms that the teachers that are provided with opportunities to collaborate with experts, learn and feel more prepared in integrating ICT in their classrooms (Vrasidas, 2014).

10.5 Discussion of the study's implications on classroom practice

In this section, the implications of this study with respect to the classroom practice of teachers and theoretical underpinnings will be discussed.

Previous research examples focusing on the teaching of word-based mathematical problem solving for students with learning difficulties reported positive outcomes in terms of the improvement of their solving skills through the acquisition of several cognitive and meta-cognitive skills, as well as helpful solving strategies (Case et al., 1992; Cassel & Reid, 1996; Hutchinson, 1993; Montague, 1992; Montague et al., 1993). Nonetheless, the majority of these studies do not suggest the incorporation of new technologies in the instruction for this purpose. In addition, research yields that teachers do not invest the time to enhance the performance of their students with difficulties in word-based mathematical problems through the promotion of cognitive and meta-cognitive strategies due to limited available time (Busch et al., 2001; Schumm et al., 1995; Vrasidas, 2014) and limited suitable resources and support (Cawley & Parmar, 1992; Jitendra & Hoff, 1996, Vrasidas, 2014).

Although the Cypriot mainstream schools are equipped with some educational computer programmes, most of them are not suitable for the special educational needs of particular students, or they do not apply to their own situation (McKeown, 2000). Apart from the unsuitability of software for the whole student population, including those who have been diagnosed as having dyslexia, most educational programmes are quite expensive and not always available in different languages.

One of the practical implications of this study with respect to classroom practice is that despite the limited time and limited available resources, the teachers can design and create their own WBLEs without the need to purchase expensive software, neither to have a good command of advanced IT skills. For instance, this research suggests that teachers can use free website designing tools in order to design and create WBLEs, with no need to learn advanced IT skills, or invest a massive amount of money and time.

Another implication of this study concerning classroom practice is the evidence that the potential of ICT makes it a valuable tool for the differentiation of the instruction, which constitutes a trend element and trademark in contemporary curriculums. Higgins and colleagues (1999) claim that the wide range of SEN challenging teachers in the classroom do not make the teaching process non-straightforward, but intentional. Therefore, individual children will need educational programmes suited to their own particular needs. This implies that teachers should provide different support systems and activities as well different kinds of access to various hardware and software at their disposal (Smith, 1999). The idea introduced by this study supports the philosophy that teachers can provide differentiated support by creating and using their own dyslexia-friendly learning tools suitable for their students, including those with dyslexia.

An additional practical implication is related to the theory suggesting that when some criteria are fulfilled, such as particular characteristics and special educational needs of the students with several learning difficulties in literacy and mathematics, a single pedagogical approach combining numerous features can be effective for every student (Gifford and Rockliffe, 2012). Hence, a dyslexia-friendly computer-assisted single approach can be implemented successfully in both the mainstream classroom and individualised settings for students with dyslexia as well as students without dyslexia. The WBLEs can be designed in a simplistic manner which agrees with what Gifford and Rockliffe (2012) point out, that teaching models involving reasoning strategies which do not demand high memory resources, facilitation of understanding, and an increase of confidence, have a high success rate with students facing difficulties in mathematics. This involves two different pillars that play their role in the effectiveness of the incorporation of new technologies in classroom instruction, with the purpose of supporting students with dyslexia to overcome their difficulties in word-based mathematical problem solving. The first pillar is how the teacher can design and create learning environments in order for them to be usable and helpful, and the second pillar refers to how to successfully implement them.

The first pillar refers to another implication of this study with respect to the design of the WBLEs. Teachers can design and create their own WBLEs by using several available internet tools and numerous facilities that can be provided by new technologies. According to Papert (1993), the use of the computer for learning mathematics should be in such a way as to produce the most learning for the least teaching. Therefore, teachers have to design their WBLEs in such a way as to facilitate the learning difficulties of their students with dyslexia, which relate to reading and understanding instructions and texts. Thus, the teachers should provide any written text, instructions, examples and problem scenarios in different ways, such as audio, text, visual representations diagrams, and figures, as was done in the WBLEs designed for the purposes of this study. This idea is associated with the theory of Paivio (1971), who suggests the representation of information in multiple formats in order to provide better results in retention and retrieval. It is also associated with the multimedia principle of Mayer (2001) which refers to some individual preferences in terms of the use of animation, auditory, narration, and text.

An additional implication of this study, with respect to the classroom practice of the teachers, is referred to in the second pillar concerning how to successfully implement the WBLEs. This study suggests two different ways of implementation: whole-classroom and individual implementations. Due to the limited number of available computers in the mainstream classroom of Cypriot primary schools, the use of the computer lab was suggested. However, in many Cypriot schools the lab is not very well equipped, or in many cases the available computers are either few or broken, thus the use of the available computers in small mixed-ability groups is suggested. This agrees with Kasoulides (2001) who discusses the *"prospect of a restriction"*. According to the author, the restricted resources in teaching should be used in a more efficient way. For instance, the single computer in the classroom can be used for students with special educational needs, or more practically, using the computers for working in groups of students, because of the relative scarcity of equipment (Mavrou, 2005).

Nonetheless, working in groups has additional advantages for learners. According to Papert (1993), individuals learn better when talking and doing, and negotiating knowledge with adults (two individual implementations of this study) or peers (whole-classroom implementations) through social interaction. This is strongly connected with the socio-cultural learning theory of Vygotsky (1978). Students, either working in groups or individually with a peer or a special teacher, are involved in discussions and interact in a framework of guidance and collaboration with more such capable peers or adults. Vygotsky (1978) introduces the notion of zone of proximal development which refers to the difference between what a learner can do without help and what they can do with support. Socio-cultural learning depends on such interactions where the individuals involved operate within one another's proximal zone of development. This means that students have their own beliefs, and the interactions help them to move to more scientific knowledge through the learning process.

At this point the use of the computer enhances collaborative learning which constitutes one of the strongest implications of this study with respect to classroom practice of the teachers. The design of the WBLEs was based on the principle of the realistic mathematics education approach. This approach is based on the idea of contextualised mathematical problem solving through the provision of visual and verbal access to mathematics. Therefore, students develop their mathematical understanding through meaningful contexts (Dickinson and Hough, 2012). According to Gifford (2006), visual and verbal access can be achieved with the use of the computer, and can be enhanced with collaborative learning, which helps students become involved in extended discussions and verbal reasoning. In this study, students were actively involved in discussions and verbal reasoning through collaboration in groups for the whole-classroom implementations and through interaction with me in individual implementations. Nonetheless, the use of the computer intervenes and enhances the discussions and verbal reasoning through collaboration. Hence, the guidance and instructions provided by the WBLEs, as well as the structured sequence of word mathematical problems solving steps, suggested by Krulik and Rudnik (1987) on which the design of WBLEs was based on, operate as an additional more capable entity which somehow undertakes the role of the more capable peer or adult in Vygotskian socio-cultural learning theory, as one could assert. Of course, the computer is not a human entity but it can constitute the stimuli that urge and involve the students in such discussions and socio-cultural interactions that operate within one another's proximal zone of development more actively through provided guidance and feedback. It can also be asserted that the computer can operate as an additional tutor, as well as a simulator (contextualised mathematical problem solving), and a tool that makes the learning process easier (Briggs and Pritchard, 2002). These additional roles of the computer can raise the upper level of the zone of proximal development that indicates when and where the less capable student will need additional support from his peers. This means that less capable peers can learn not only through the interactions with the more able peers, but also through interaction with the computer.

In addition, the computer helps students to move on to more scientific knowledge by involving the students in discussions and verbal reasoning in a way that the teacher could do through the provision of guidance and feedback, during the instructions. However, the teacher cannot be continuously present for guidance and feedback, especially in classrooms with many students and thus many groups. Therefore, the computer could be considered here as an additional source of guidance which potentially counterbalances the limited guidance and feedback provided by the teacher due to several reasons. Nonetheless, the computer cannot replace the role of teacher, but as mentioned previously, can enhance the teacher's guidance when the groups are left to work autonomously. The limitations of the capabilities of the computer as instructor or guide were obvious when the students were left to work totally independently. Some behavioural issues arose and the collaboration was not healthy. As mentioned above, Gifford and Rockliffe (2012) stress that the replacement of the teacher with a computer in isolation is not recommended in general.

Moreover, Putnam et al. (1996), Xin (1999), Gillies and Ashman (2000), Demetriadis (2001), Mavrou (2005) and Solomonidou et al., (2004) support that students with SEN working together with their peers are motivated, more involved in tasks, and more accepted in their classroom community. This is an additional implication of this study concerning classroom practice which is the promotion of the ambiance of inclusion and the parallel reduction of exclusion. According to the Piagetian view of social-arbitrary knowledge development, concepts of morality, values, and acceptance develop through interaction. As a result, when more capable students collaborate with less capable students (students with dyslexia in this case), the former will develop skills of social acceptance, morality and values, especially related to disability (Mavrou, 2005). Similarly, Xin (1999) states that computer assisted learning can be a promising way to adapt instruction to individual differences. It can also increase the potential to meet individual needs as well as enhance on-task social interactions of heterogeneous groups of students.

An additional practical implication of this study which relates to acceptance by peers and the contribution to the team is the enhancement of self-confidence and self-esteem of students with dyslexia through the opportunities to succeed. The use of the computer and the features of the WBLEs can help students with dyslexia to overcome some of their difficulties, and counterbalance the disadvantage of their difficulties that prevent them from offering equally to their groups. According to Rahamin (2004) and Blamires (1999), ICT can compensate the difficulties of students with SEN while working in the mainstream classroom, and allows physical access to learning, cognitive access with a multimedia approach, on-going assessment and development of self-esteem, as well as acceptance and inclusion. Therefore, students' self-confidence can be enhanced since the WBLEs can transform students with dyslexia from inactive group-members into equal contributors. This is also associated with what Slavin (1987) points out that "when students are working together toward a common goal, academic work becomes an activity valued by peers. Just as hard work in sports is valued by peers because a team member's success brings credit to the team and the school, so academic work is valued by peers in cooperative learning classes because it helps the team to succeed" (p.9). Opportunities to succeed seem to be crucial, especially with learners who got used to learning failures, and can undoubtedly increase their self-confidence and self-esteem which will subsequently help them to overcome insecurities, become involved in the learning process, overcome some of their learning difficulties, and improve their academic performance.

Furthermore, WBLEs can be designed for individual implementations with a special teacher in the framework of remediating lessons in separated settings, interventional approaches, or even for homework with parents. Individual implementations will reduce some potential disadvantages of collaboration in large groups such as noisy environment, involvement in off-task discussions, or dependency on more capable students in more complex word mathematical problems. Individual implementations can be more beneficial for students with dyslexia and with more severe learning difficulties that prevent them from equally contributing to their groups, despite provided support by the computer. In such cases, the WBLEs with the special needs teacher or parent will provide enhanced support for the acquisition of the appropriate cognitive and meta-cognitive skills that will enable the students to master word mathematical problems solving abilities. As discussed above, the Vygotskian theory of human development fits well here, where interactive and socio-cultural learning will depend on adult guidance while they will operate in one another's proximal zone of development. Again, the computer will raise the upper level of the zone of proximal development of the student with difficulties in word mathematical problem solving that indicates when and where they will need additional support from the special teacher or parent. This means that the student will become a more independent learner while the features of the WBLE will counterbalance some of their difficulties.

10.6 Summary

Chapter Ten aimed to discuss the main findings of this study. The structure of the discussion was based on the research questions and the presentation of findings from previous chapters. The main points of the discussions were the impact of computer-assisted learning in solving WMPs on students with dyslexia in the mainstream classroom and on an individual level, the extent that collaborative learning in groups can help for more beneficial use of computer-assisted learning environments for WMPS, the extent that computer-assisted learning environments can provide differentiated support for students with dyslexia with difficulties in WMPS and the implications of this study with respect to classroom practice for teachers. The next chapter summarizes the full study, identifies its contributions to the field of research, and addresses some limitations and suggestions for further research.

Chapter Eleven
Conclusions

11.1 Introduction

In the last chapter of my thesis I present a brief summary of the full study, identify its contributions to the field of inclusive education, and address the limitations of the study. Also, some suggestions for further research are addressed. The final section includes the general reflections and conclusions.

11.2 Summary of the research and its findings

This study was designed to explore how the use of limited ICT resources can facilitate and make accessible WMPS for students with dyslexia in Cyprus with the use of the computer, given that the available ICT resources in Cyprus, including computers and software, are somewhat restricted, and the IT skills of the majority of students and teachers are limited. The study aimed to explore the potential and impact of using restricted facilities of ICT for the differentiation of instruction for students with dyslexia who encounter difficulties in word mathematical problem solving in Cypriot mainstream classrooms, in two different settings: the whole-classroom of the student with dyslexia, and on an individual level.

For this end, web-based learning environments were designed in collaboration with the participating teachers, with the use of simple tools that do not demand specialized IT knowledge. For the design of the WBLEs, several word-based mathematical problems were chosen in collaboration with the participating teachers. Each WBLE consisted of two to four WMPs, and the structure of the solving process was based on the 5-step model as suggested by Krulik and Rudnik (1987) for WMPS. The WBLEs guided the students following the five steps to understand the problem, choose the right solving strategy, implement the strategy, and finally check the solution. The guidance was facilitated by navigation buttons for the navigating through the solving steps, audio, pictures, diagrams, etc. Six whole-classroom implementations were conducted where the students, including a student with dyslexia, collaborated in groups with the use of the computer. Also, eight individual implementations were conducted with two other students with dyslexia (four individual implementations for two students respectively).

Before and after the implementations, data were collected through observations and interviews concerning the use of ICT, the opinions about ICT, Mathematics and WMPs, and the general and particular learning difficulties of the participating students, as well as the performance, interest, level of participation, and behaviour of the students with dyslexia. The collected details before the implementations were taken into account in the design of the WBLEs. Especially, for the whole-class implementation, similar pre-tests and post-tests were administered for the evaluation of students' performance in word-based mathematical problems involving several strategies. The scores of the pre-tests were taken into account in the design of the WBLEs. During the implementations, the sessions were recorded, and the computer screens were captured. The data collected before, during, and after the implementations were analysed by following thematic analysis.

Supplementary question one was to explore the impact of computer-assisted learning in solving WMPs for students with dyslexia. It seems that the students benefited by the use of WBLEs, which facilitated the learning process through several features. The audio version of the problems and the instructions were mentioned as the most helpful features. The performance of the students with dyslexia, either in the whole-class or individual implementations, was notably developed. The students were able to master unknown mathematical notions, and overcome difficulties related to problem understanding, choosing the suitable solving strategy, and overcoming several difficulties deriving from developmental dyslexia. The participation level significantly increased, especially for the student with dyslexia who was a part of a mixed-abilities group. The game-like design of the WBLEs was attractive for the students whose interest was maintained during the lessons, as well as concentration abilities improving for the student with dyslexia and concentration problems. In addition, the students became more positive towards Mathematics and WMPs, both during and after the implementations.

Nonetheless, the impact was somehow short-lived. The improvements were noted during the implementations, where the students were using the WBLEs, but not after. Yet, they adopted several tactics and strategies that were useful for WMPS without using the WBLEs. Also, the opportunities they had to succeed during the implementations and their active involvement in the process functioned positively in improving their self-confidence, and enhancing their personal participation level and performance, and they obtained a more active role as members of their mixed-abilities groups in the mainstream classroom.

The second supplementary question was to explore the extent to which collaborative learning in groups can help for a more beneficial use of computer-assisted learning environment for WMPS. The student with dyslexia that was member of a mixed-abilities group benefited from the collaborative learning with his peers. The student also had many opportunities to participate in cases where he had difficulties, which were compensated through the WBLEs facilities, and the direct support and feedback from group mates and teachers. That is to say, the use of the WBLEs gave a voice and a more active role to the student with dyslexia in his group. Also, the level of acceptance increased through the collaboration. However, aside from the benefits, the collaboration was exploited by some students when they worked independently in their groups, which eliminated the positive impact of collaboration in groups with the use of the WBLEs for WMPS. On the other hand, the two students who participated in the individual implementations, did not benefit from collaborative learning, and were dependent on the guidance of the teacher, with a less active role in the process. However, those two students had significantly developed performance and increased participation levels, not only during the implementations, but also after, in comparison with the student with dyslexia who participated in the whole-class implementation.

The main research question of this study was to answer to what extent computer-assisted learning environments can support students with dyslexia with difficulties in WMPS. From the answers of the two supplementary questions, the answer to the main question is that the computer-assisted environment can support students with dyslexia in WMPS to a great extent. The facilities and tools provided by the WBLEs, the benefits of collaborative learning, the benefits of individualized learning support with the use of WBLEs, continuous guidance, support and feedback provided by the teacher, peers and the WBLEs, can provide differentiated support for students with dyslexia in such tasks. The short-lasting impact is an indication of the need for more frequent use of the computer for WMPS for students with dyslexia. It was also proved that despite the limited available ICT resources, the lack of suitable software for WMPS for students with dyslexia, and a lack of IT skills on behalf of students and even teachers, the former can embed new technologies in their instruction with additional learning value for the students, by creating simple WBLEs, by bearing in mind the particular characteristics and educational needs of their students for differentiated support, with no need to invest large funds for purchasing expensive educational software. Nevertheless, the time-demanding process for the design of the WBLEs and the demanding curriculum act as a constraint, while the teachers prefer to use ready-available WBLEs, rather than creating their own.

From my study, I have identified what I consider to be its main contributions to knowledge, which I highlight in the next section.

11.3 Contributions

In this section I highlight the key contributions of my study to the field of inclusive education in general, and to teaching and approaching WMPS for students with dyslexia in particular.

11.3.1 Contribution to knowledge about dyslexia in Cyprus

I have not come across many research studies focusing on the difficulties of students with dyslexia in Mathematics in general and in WMPS in particular, in the Cypriot context. Therefore, my study contributes in an almost unexplored area of difficulties for students with dyslexia, in understanding and solving WMPs in the way such problems are approached in the Cypriot curriculum. This study verified the major difficulties described in the literature, but in an empirical way through the implementation and collection of data before and after the implementations. Based on this, I would say that my study contributes empirical research-based evidence that will be useful in the exploration of learning difficulties of students with dyslexia in WMPS, for purposes of assessment and diagnosis, but more importantly in the design of suitable interventional programs.

11.3.2 Contribution to knowledge about the use of ICT for WMPS for students with dyslexia in Cyprus

This study sheds light on the level of ICT usage for students with dyslexia in Cypriot mainstream schools. Students with dyslexia have limited opportunities to use the new technologies either in the mainstream classroom or during the supporting lessons. The same applies to other students. In addition, the schools are not equipped with educational computer programs suitable for WMPS for students with dyslexia. The main usage of the computer is the use of some tools for the facilitation of instruction, screenings, and gaming, but without additional learning value for the students. The teachers stressed that the demanding curriculum, lack of time, restricted ICT resources, and limited IT skills are the main reasons that they do not integrate new technologies in a more interactive way for the students.

Nonetheless, this study proves that any teacher can design and create their own WBLEs without the need to purchase expensive software, or have a good command of programming languages, or advanced IT skills. For instance, emphasis should be given to the example of this study where Weebly was used in cooperation with Cypriot teachers who managed to create and design WBLE, with no need to learn advance programming languages. The teacher knows well the particular characteristics and features of their students, a fact which enables them to create more suitable computer-assisted learning environments, than any purchased software that can be found on the market, and at no cost. This is probably the main contribution of this study.

It was proven that a single pedagogical approach can combine numerous of features and can be effective, if several criteria are fulfilled for children with different learning difficulties in Mathematics. It is even more advantageous the fact that such a dyslexia-friendly approach can also be effective for mainstream classroom instructions. Teaching models involving reasoning strategies that do not demand high memory resources, facilitation of understanding, and an increase of confidence, have a high success rate with students facing difficulties in Mathematics (Gifford and Rockliffe, 2012).

11.3.3 Contribution to teaching WMPS with the use of ICT

This study makes significant contributions to teaching approaches for WMPS. The most common strategy in teaching WMPs in the Cypriot mainstream classroom is to ask students to read and solve WMPs. Of course some useful and supportive strategies are taught, but most of the times these are not very effective for students with dyslexia, who face significant difficulties in reading and understanding problems, and have problems choosing and implementing the suitable strategy or maths operation. This study suggests an alternative approach to WMPS, with the integration of new technologies for students with dyslexia, for students with difficulties in WMPS, but also for students without special educational needs. The approach is based on the 5-step model for WMPS suggested by Krulik and Rudnik (1987) which was used for the structure of each WMP transferred to the computer-based learning environments. The tools of the computer were used to facilitate and enrich each step by bearing in mind the particular features and difficulties of the students, and mainly the participating students with dyslexia. There is a scarcity of research exploring and developing alternative dyslexia-friendly teaching sequences to WMPS with the use of new technologies, not only in Cyprus but also worldwide, a fact that makes this study innovating.

In addition, we can claim that two different teaching approaches are suggested in this study: the use of computer-assisted learning environments for solving WMPs in groups or individually. That is to say, the benefits deriving from the use of the designed WBLEs were examined in collaborative settings but also on an individual level. Although, advantages and disadvantages were recorded in both settings, this study makes contributions to the way that the WBLEs can be used for every student in the whole-classroom and on an individual level for students with dyslexia. Especially for the Cypriot schools with limited available computers, this study suggests the exploitation of benefits deriving from collaborative learning in small groups as an alternative solution for the effective use of restricted available ICT resources.

11.3.4 Contribution to the field of inclusive education

There are many studies aiming to prove that ICT can be used in such a way that facilitates instruction and provides equal learning opportunities to students with learning difficulties. This research is included in such studies that have proved that ICT can be a tool for promoting inclusion. The proper use of ICT can be used for the design of resources that are based on universal access principles which can counterbalance the limited access and engagement to the curriculum due to their learning difficulties.

11.3.5 Implications of the study for Cyprus Educational System

The findings of this study suggest that Cypriot students should be given more opportunities to use computers during the lesson, in a more interactive manner and in a way that provides additional learning value. This can be achieved with the introduction of ICT as a compulsory and basic subject of the curriculum for Cypriot primary schools. At the same time, teachers who are not well trained in integrating new technologies in their instruction should be offered training courses for their personal development. Teachers also expressed a willingness to use readymade computer-assisted learning environments, rather than creating their own ones. This could be taken into account as a suggestion to the educational technology section of the Ministry of Education for the design and creation of, but not limited to, dyslexia-friendly web-based learning environments, for the facilitation of WMPS for students facing difficulties in understanding and solving such problems in the traditional way.

11.4 Limitations

The present study has some methodological and theoretical limitations.

The main methodological limitation of this study relates to the length of the implementations, and hence the claims regarding its long-lasting effectiveness can be questioned. The limited available time, and the time that the teachers were willing to dedicate for the implementations, did not allow reaching a saturation of data. That is to say, if there was unlimited time, there would have been more implementations, and the outcomes might have been different.

In addition, the sample size was small. Only one classroom with a student with dyslexia, and two individuals with dyslexia with their teachers and special education teachers, participated in this study. This means that any attempt to interpret and generalize the findings should be taken with caution due to the limited representativeness of the sample. It is a matter of fact that the limited potentiality of generalizability of case studies may perpetuate weakness to produce general or universally applicable outcomes. The purpose of such studies is to probe deeply and to analyse intensively the different phenomena that constitutes the life-cycle of the unit or individual, with a view to establishing generalizations about the wider population to which that unit or individual belong. In this study, generalizations about the potential impact of the use of limited ICT resources for differentiation of the instruction in WMPS for students with dyslexia cannot be made safely because the available ICT resources were different in each school, and the characteristics and difficulties differ from student to student. Although the case studies are not wholly representative, the findings of the case studies can reveal a reality in other similar settings, situations or circumstances in the Cypriot context.

Another limitation of this study is the methods followed for the choice of the sample. Apart from the amount of time wasted because of bureaucratic procedures, access was gained through the Special Education Inspector. However, the Inspector did not provide details about the students’ learning difficulties due to confidentiality policies. As a result, the sample was not reached randomly but after long-lasting negotiations with the schools and parents, and was limited only to the suggestions and guidance of the Special Education Inspector. We cannot be sure whether the choice of such sample was biased or not.

In addition, another limitation was on the design of the implementations. For instance, the idea of a whole-class implementation was initially designed for using one computer per pair of students. Nonetheless, the available computers were few in that particular school's computer lab, hence the students had to work in larger groups. The large groups and the few functioning computers created unexpected problems. In addition to this, the teacher was unwilling to form mixed-ability groups at the beginning. Such incidences potentially affected the outcomes, and could be avoided with better organization in advance. The outcome may have been different in different schools with different available ICT resources, different teachers and even different students.

Similarly, the individual implementations were initially designed to take place in the students' homes, to run parallel to the whole-classroom implementations. This could allow comparisons between the two different settings for the same student in terms of his performance, participation level, and so on. However, the implementations at home were not easily feasible because of the daily schedule of the student and his mother. This plan changed after the whole-class implementation which was a long-lasting and exhausting process, so it was decided to try individual implementations with two further students. The limitation lying on that decision was the fact that the students interacted with the WBLE and were dependent somehow on my guidance. The students might have had different interactions and outcomes if left alone to solve the WMPs with the WBLEs, or even if they worked with a more capable peer.

11.5 Suggestions for future research

From the discussion of the study findings, and the above limitations that were identified in the design and the implementation of the present study, some suggestions can be made for future research into the use of ICT for supporting students with dyslexia in WMPS, as follows:

a. Due to the small sample, similar research needs to be conducted in other schools in Cyprus so as to obtain a broader picture of the impact and potential of available ICT resources in schools in supporting students with dyslexia in the mainstream classroom. The available ICT resources differ from school to school, thus it would be interesting to explore the situation in settings with a better or inferior ICT infrastructure.
b. This study shows that the teachers admit to the usefulness of ICT for supporting students with and without learning difficulties, but they would not put this into practice. Although there are some studies exploring the attitudes of Cypriot teachers towards the integration of new technologies in their instructions and the actual integration of new technologies in their instructions, it would be interesting to explore the opportunities that students with dyslexia have to use the computer during differentiated instructions or individual supporting lessons.
c. Further research could be conducted in exploring the willingness and capabilities of Cypriot teachers to create their own WBLEs for their students, and the factors preventing them from doing this so far. This study indicates some of those factors.
d. In this study, the individual implementations were conducted between the student with dyslexia and myself, with the use of the computer in an isolated place at school, while the students were withdrawing from the lesson. Further research could be conducted with a slightly different design of individual implementations. It would be interesting to explore the impact of using the WBLEs for WMPS in pairs, where the student with dyslexia will collaborate and interact with a more capable peer. Alternatively, further research could be carried out focusing on the use of WBLEs for solving WMPs at home as homework, either individually or with the support of parents or other family members.

e. General outcomes concerning the impact of using computer-assisted learning environments in solving WMPs arose. Particularly, the way difficulties related to understanding the WMPs can be overcome with the use of computer-assisted learning environments, should be explored in more depth.
f. The WBLEs were designed by taking into account some general designing features referred to in the literature as suitable for people with dyslexia. The features that new technologies can provide are unlimited, while they are constantly changing and developing. Further research could be carried out to investigate the variety of features of computer-assisted learning environments that are more suitable for students with dyslexia, and the impact of each feature to this end.
g. Technology advances at a swift pace. A rapid technological development is noted across several domains. These changes influence the use of ICT in education to great extent. Therefore, it would be interesting to explore the use of the WBLEs with the use of tablets, and other devices and equipment with touchscreens, either in groups or individually in a future research. The use of tablets has already been introduced in secondary education in Cyprus which means that it is only a matter of time before we see the use of tablets in Cypriot primary schools.
h. The process of WMPS was based on the 5-step model suggested by Krulik and Rudnik (1987). Further research needs to be conducted by examining alternative solving models.

11.6 Conclusions

This study aimed to explore the impact of computer-assisted learning environments in WMPS for students diagnosed as having dyslexia in Cyprus. Given that the available ICT resources in terms of computers and educational computer programs are limited, it was interesting to explore how teachers use such resources, and their IT knowledge and skills, in order to support students with dyslexia in WMPS. It is a matter of fact that the majority of studies on dyslexia focus on difficulties in reading and writing, while there are very few studies exploring the difficulties in Mathematics.

Nonetheless, there is scarcity of research focusing on difficulties of students with dyslexia in WMPS.

This study is based on three different pillars: students with dyslexia facing significant difficulties in WMPS; new technologies have the potential to help for the compensation of those difficulties; and finally, the way that restricted ICT resources (available computers and suitable educational software) in Cypriot schools can be used in order to support those students to overcome such difficulties.

Reviewing recent literature I have found growing interesting in the use of computer-mediated interventions, not only for students with dyslexia or other learning difficulties and special educational needs, but also for the differentiation of teaching for every learner. The facilities and tools provided by new technologies can help the students not only to overcome some of their learning difficulties, but over the time they can help in compensating disadvantages due to difficulties, and at the same time in equalizing the learning opportunities of the students who gain access to the curriculum to a greater extent than without using new technologies.

By bearing in mind the promising outcomes of using new technologies for students with learning difficulties, I started designing this research from 2010, and conducted it between 2011 and 2013. Despite the time-wasting procedure for gaining access to the schools and the participants, and then the design and the implementations of WBLEs, I managed to collect a massive amount of data from three different cases of students with dyslexia. Six whole-classroom implementations with a student with dyslexia integrated in the mainstream classroom and eight individual implementations, four implementations for two students with dyslexia separately, were carried out during this time period.

The analysis of data yields promising outcomes regarding the ways that the teacher can use the limited available computers in order to help students with dyslexia overcome difficulties related to WMPS. The WBLEs were designed in collaboration with the participating teachers who were not IT experts, and with the use of simple and easily accessible internet tools. The students with dyslexia, either in groups or individually, were enabled to solve some WMPs with the use of the computer, which they would not have been able to solve without any support. The impact on their performance, participation levels and behaviour during the lesson was positive; however, the outcomes lasted only partially after the implementations. The students continued to have difficulties in handling the WMPs without the use of the computer, but some strategies and tactics were adopted that were useful in investigating and understanding the WMPs, and then choosing and implementing the right solving strategy and maths operation. In addition, the implementations improved the students' attitudes towards WMPS, since the students improved their self-image as WMPs solvers through the opportunities to succeed and avoid the continuum of failures, a fact that increased their participation in the lesson after the implementations.

In addition, the study shows that the available ICT resources in Cyprus can be used for the design and organization of lessons with the integration of new technologies, without the need to invest large amounts of money to buy expensive educational software, nor is there a need to have a good command of IT skills. However, the long-term investment for the design of WBLEs made the teachers quite sceptical about creating their own WBLEs for their students. The teachers admitted that readymade WBLEs would be preferable. The teachers argue that the demanding curriculum, limited ICT resources, limited IT skills, and a lack of time are the main reasons for not using new technologies in their lessons. The outcomes confirmed what the literature yields, that the teachers' views are not associated with their acts concerning the use of ICT in their instructions.

Beyond the difficulties in the conduction of this study and the massive amount of the collected data that was analysed but omitted in favour of space and time restrictions, we can claim that it makes important contributions in the field of research in inclusive education, to the difficulties of students with dyslexia in WMPS, and for the use of new technologies as a tool for the promotion of inclusion.

As this study shows, ICT can be used to fulfil a wide range of functions in dyslexia learning settings in Mathematics. It can be used as a teaching and learning tool and as a learning environment (Watkins, 2004). As an Irish teacher commented:

> The amazing potential of ICT as a multi-sensory and motivating teaching tool for pupils with SEN cannot be underestimated. It has been the magic key for so many of our pupils who have struggled in the past, unlocking the door to increased self-esteem, improved communication skills and more independent learning (Austin & Anderson, 2008; p.112).

That is not to say that technology is a solution. ICT cannot and will not replace the role of the teacher, although it could serve as an ultimate medium for enhancing the pedagogical procedure in inclusive settings. Thus, the target is not to use new technologies in Mathematics exclusively, but to use them in order to facilitate “long-term monitoring of a variety of key number aspects which might be the most effective way of identifying, remedying and preventing mathematics difficulties” (Gifford and Rockliffe, 2012; p.5).

In this study, I explored the different aspects of ICT potential in providing access and equal learning opportunities for learners with dyslexia with difficulties in solving WMPs in Cypriot primary schools. The most common situation is the vast number of facilities of ICT for the education of pupils with dyslexia, a fact that is met with general acceptance. However, beyond the benefits and a substantial number of usages of ICT in education, some obstacles, barriers and threats have been observed, especially when ICT is not being used correctly. Also, not all available software, hardware and other technological equipment is adequate for learners with dyslexia, or other SEN in education. As a consequence, teachers must be aware of this and be in a position to decide which of the available ICT facilities can meet the individual needs of their students in the most effective way (Moseley et al., 1999), or even to design and create their own WBLEs by bearing in mind the peculiarities and special educational needs of their students. “In order to take a significant step forward, e-tools need to be carefully selected and their use needs to be appropriately planned and conceptually well integrated in mainstream activities” (Benigno et al., 2007; p.9).

So far, the assumptions that ICT would change the face of education have not been realised (Smith, 1999), especially in Cyprus. The world of ICT is developing rapidly and teachers need to put aside any feelings of technophobia, and approach ICT as a more effective way of working instead of regarding it as a menace. It is worth noting that when we refer to the future school we mean a single school which will integrate all learners without any exceptions whatsoever. The successfulness of school integration will be judged from the school's potential to resort to adjustments and differentiations of the curriculum in relation with individual needs, learning environments and teaching subjects (Benigno et al., 2007). Such an adjustment in mainstreams schools is only half the work needed in order to guarantee equal educational opportunities for everyone. The second half is covered by providing several particular appropriate services that are indispensable for individuals with learning difficulties (Padeliadou and Kotoulas, 1997).

By means of conclusion, the accomplishment of the ulterior purpose set by the contemporary sciences of education will be fulfilled only when we can speak of an inclusive education which provides equal learning opportunities for everyone, and of course not only in WMPS. The effectiveness of teaching will depend on teachers who should research the desirable means in order to offer equal opportunities. The use and the implementation of ICT in education probably constitutes the most dynamic means for the accomplishment of such an audacious, perhaps very optimistic, but nevertheless feasible purpose.

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List of Abbreviations

A: Alexis (Interviewee)

ADHD: Attention Deficit Hyperactivity Disorder

CDA: Cyprus Dyslexia Association

CD-ROM: Compact Disc-Read only memory

ICT: Information Communications Technology

IND: Individual Implementation

IT: Information Technology

K: Kyriakos (Interviewer)

M: Maria (Interviewee)

MoEC: Ministry of Education and Culture

NNC: New National Curriculum

OBS: Observation

P: Peter (Interviewee)

POST: Post-Implementation

PRE: Pre-Implementation

RAM: Random Access Memory

RoC: Republic of Cyprus

SEN: Special Educational Needs

SD1: Student with Dyslexia 1 (Peter)

SD2: Student with Dyslexia 2 (Alexis)

SD3: Student with Dyslexia 3 (Maria)

ST1: Special Teacher 1 (Whole-classroom)

ST2: Special Teacher 2 (1st Individual Implementation)

ST3: Special Teacher 3 (2nd Individual Implementation)

T1: Mainstream classroom Teacher from the whole-classroom Implementation

T2: Mainstream classroom Teacher from the 1st Individual case study

T3: Mainstream classroom Teacher from the 2st Individual case study

UoL: University of Leeds

WBLE: Web-based Learning Environment

WC: Whole-classroom Implementation

WMP: Word-based mathematical problem

WMPS: Word-based mathematical problem solving

Appendix A
Information Letter for Parents (Translated in English)

UNIVERSITY OF LEEDS

SCHOOL OF EDUCATION

Limassol, October 2011

Dear Sir/Madam,

I am a PhD student at the University of Leeds and I have undertaken the initiative of conducting a qualitative research within the framework of my research study.

The main aim of this research is to explore the potential of using restricted facilities of Information Communication and Technology for differentiation of instruction for students attending a mainstream classroom and students with dyslexia who encounter difficulties in mathematics problem solving and they are integrated in Cypriot mainstream classrooms.

Your co-operation will contribute substantially in the success of the research and your willingness for the participation of your child will be particularly appreciated. It is essential to underline that this research does not focus on individuals. The providence of your name and the name of your child will have no essential effect on the results of the research and will be never mentioned somehow. Please acknowledge that you will be informed about the outcomes of the research.

After the information meeting, please kindly fill-in the Informed Consent Form attached to this letter.

Thank you for your co-operation.

Kyriakos Demetriou

PhD Student

Appendix B
Informed Consent Forms

B.1 Parents' of student with Dyslexia Informed Consent Form (Translated in English)

Subject Consent Form for a Research Study

Parent's Full Name:…………………………………………………………

1. I have read the research information sheet and feel that I have received enough information about this study YES/ NO
2. I have had the opportunity to ask questions about the study, and I am satisfied with the answers YES/NO
3. I understand the purpose of this study and how my child and I will be involved YES/NO
4. I understand that this is a research project and that there will be no direct benefit to my child or me from taking part YES/NO
5. I understand that my child and I were chosen for the classroom-based and home-based parts of the research because the particular project focuses on difficulties encountered by students with dyslexia YES/NO
6. I am willing to participate to this project as a parent of a student with Dyslexia for the homework part of the project at home YES/NO
7. I understand that the data obtained will be held in confidence and that, if it is presented or published, all personal details of my child or mine will be removed YES/NO
8. I understand that the researcher will use audio and video recording tools (e.g., audio recorder, camcorder, computer's screen recorder), thus my child might be filmed or audio recorded during his/her participation to this project YES/NO
9. I understand that my child and I are free to withdraw for the study at any time without giving any reason YES/NO
10. I agree to take part in this research study and I give my consent for the participation of my child as well YES/NO

Signature: ……………………………………
Name (Block capitals): ……………………………………………
Date: ………………………………………………......
(Adapted from University of Leeds Faculty Form 12/02/2008)

B.2 Parents' Informed Consent Form (Translated in English)

Subject Consent Form for a Research Study

Parent's Full Name:…………………………………………………………………

1. I have read the research information sheet and feel that I have received enough information about this study YES/ NO
2. I have had the opportunity to ask questions about the study, and I am satisfied with the answers YES/NO
3. I understand the purpose of this study and how my child and I will be involved YES/NO
4. I understand that this is a research project and that there will be no direct benefit to my child or me from taking part YES/NO
5. I understand that the data obtained will be held in confidence and that, if it is presented or published, all personal details of my child or me will be removed YES/NO
6. I understand that the researcher will use audio and video recording tools (e.g. audio recorder, camcorder, computer's screen recorder), thus my child might be filmed or audio recorded during his/her participation to this project YES/NO
7. I understand that my child and I are free to withdraw for the study at any time without giving any reason YES/NO
8. I agree to take part in this research study and I give my consent for the participation of my child as well YES/NO

Signature: ……………………………………
Name (Block capitals): ………………………………………….
Date: ……………………………………………………………..
(Adapted from University of Leeds Faculty Form 12/02/2008)

Appendix C
Approval Letter from AREA Faculty Research Ethics Committee – UoL

Performance, Governance and Operations
Research & Innovation Services
Charles Thackrah Building
101 Clarendon Road
Leeds LS2 9LJ Tel: 0113 343 4873
Email: j.m.blaikie@leeds.ac.uk

UNIVERSITY OF LEEDS

Kyriakos Demetriou
School of Education
University of Leeds
Leeds, LS2 9JT

AREA Faculty Research Ethics Committee
University of Leeds

8 December 2011

Dear Kyriakos

Title of study: **The potential of restricted Information Communications Technology resources for supporting students with Dyslexia with difficulties in word mathematical problem solving in the mainstream primary schools in Cyprus.**
Ethics reference: **AREA 11-076**

I am pleased to inform you that the above research application has been reviewed by the ESSL, Environment and LUBS (AREA) Faculty Research Ethics Committee and following receipt of your response to the Committee's initial comments, I can confirm a favourable ethical opinion as of the date of this letter. The following documentation was considered:

Document	*Version*	*Date*
AREA 11-076 Ethical_Review_Form_V3-Kyriakos_Demetriou.pdf	1	22/10/11
AREA 11-076 ethics comittee reply.pdf	1	21/11/11

The Committee made the following comments:

- The Committee supports the suggestion that is made to evaluate potentially sensitive relationships using teacher views rather than peer judgements, this change would need to be incorporated into the relevant documentation.
- There is some inconsistency in the parent letter 'dyslexia' and 'dyslexic type' and 'diagnosed as having dyslexia' – this may be potentially confusing so just one term should be used.
- It is assumed that the parents will be aware prior to the project taking place that their child has dyslexia.

Please notify the committee if you intend to make any amendments to the original research as submitted at date of this approval. This includes recruitment methodology and all changes must be ethically approved prior to implementation.

Please note: You are expected to keep a record of all your approved documentation, as well as documents such as sample consent forms, and other documents relating to the study. This should be kept in your study file, which should be readily available for audit purposes. You will be given a two week notice period if your project is to be audited.

Yours sincerely

Jennifer Blaikie

Appendix D
Approval Letters from the Minister of Education and Culture – Republic of Cyprus

ΚΥΠΡΙΑΚΗ ΔΗΜΟΚΡΑΤΙΑ
ΥΠΟΥΡΓΕΙΟ
ΠΑΙΔΕΙΑΣ ΚΑΙ ΠΟΛΙΤΙΣΜΟΥ

ΔΙΕΥΘΥΝΣΗ
ΔΗΜΟΤΙΚΗΣ ΕΚΠΑΙΔΕΥΣΗΣ

Αρ. Φακ.: 7.19.46.4/9
Αρ. Τηλ. : 22800661
Αρ. Φαξ : 22428277
E-mail : dde@moec.gov.cy

17 Φεβρουαρίου, 2012

Κύριο
Κυριάκο Δημητρίου
Βασιλέως Ευαγόρου 17^Α
Απόστολος Ανδρέας Χαράκη
3061 Λεμεσός

Θέμα: Άδεια για διεξαγωγή έρευνας με εκπαιδευτικούς, γονείς και μαθητές δημοτικών σχολείων της επαρχίας Λεμεσού

Αγαπητέ κύριε Δημητρίου,

Έχω οδηγίες να αναφερθώ στη σχετική με το πιο πάνω θέμα αίτησή σας προς το Κέντρο Εκπαιδευτικής Έρευνας και Αξιολόγησης, που υποβλήθηκε στις 30 Ιανουαρίου 2012, και να σας πληροφορήσω ότι εγκρίνεται το αίτημά σας για διεξαγωγή έρευνας με εκπαιδευτικούς, γονείς και μαθητές δημοτικών σχολείων της επαρχίας Λεμεσού που αναφέρονται στην αίτησή σας, με θέμα *«Η χρήση περιορισμένων πόρων των Τεχνολογιών της Πληροφορίας και Επικοινωνίας (ΤΠΕ) για την υποστήριξη μαθητών με δυσλεξία με δυσκολίες στην κατανόηση και επίλυση μαθηματικού προβλήματος σε δημοτικά σχολεία στην Κύπρο»* την παρούσα σχολική χρονιά 2011-2012, νοουμένου ότι θα ληφθούν υπόψη οι παρατηρήσεις του Κέντρου Εκπαιδευτικής Έρευνας και Αξιολόγησης, οι οποίες σας αποστέλλονται συνημμένα για δική σας ενημέρωση.

2. Νοείται, βέβαια, ότι πρέπει να εξασφαλιστεί η άδεια των διευθυντών/ διευθυντριών των σχολείων, εκ των προτέρων, ώστε να ληφθούν όλα τα απαραίτητα μέτρα για να μην επηρεαστεί η ομαλή λειτουργία τους. Η έρευνα θα πρέπει να διεξαχθεί με ιδιαίτερα προσεγμένο τρόπο, ώστε να μη θίγεται το έργο των εκπαιδευτικών, το σχολικό περιβάλλον ή οι οικογένειες των μαθητών και όλες οι δραστηριότητες που θα αναπτυχθούν πρέπει να εμπίπτουν μέσα στο πλαίσιο που καθορίζεται από το Αναλυτικό Πρόγραμμα. Οι εκπαιδευτικοί πρέπει να λάβουν μέρος στην έρευνα στο μη διδακτικό τους χρόνο. Η έρευνα θα διεξαχθεί νοουμένου ότι η απώλεια του διδακτικού χρόνου των μαθητών θα περιοριστεί στον ελάχιστο δυνατό βαθμό, ενώ για τη συμμετοχή των μαθητών και τη χρήση συσκευών καταγραφής εικόνας και ήχου χρειάζεται η **γραπτή** συγκατάθεση των γονιών τους. Οι γονείς πρέπει να γνωρίζουν όλες τις σχετικές λεπτομέρειες για τη διεξαγωγή της έρευνας, καθώς και τα στάδια μέσα από τα οποία θα εξελιχθεί. Σημειώνεται, επίσης, ότι τα

Υπουργείο Παιδείας και Πολιτισμού, 1434 Λευκωσία
Τηλ.: 22800600 Φαξ: 22428277 Ιστοσελίδα: http://www.moec.gov.cy

πορίσματά σας κρίνεται απαραίτητο να είναι ανώνυμα και οι πληροφορίες που θα συλλέξετε να τηρηθούν απόλυτα εμπιστευτικές και αποκλειστικά και μόνο για το σκοπό της έρευνας.

3. Η παρούσα έγκριση παραχωρείται με την προϋπόθεση ότι τα πορίσματα της εργασίας, θα κοινοποιηθούν μόλις αυτή ολοκληρωθεί, στη Διεύθυνση Δημοτικής Εκπαίδευσης για σχετική μελέτη και κατάλληλη αξιοποίηση.

Με εκτίμηση,

(Ελπιδοφόρος Νεοκλέους)
για Γενική Διευθύντρια

Κοιν.: Π.Λ.Ε. Λεμεσού
Επαρχιακό Γραφείο Παιδείας
: Ε.Δ.Ε. Ειδικής Εκπαίδευσης
Επαρχιακό Γραφείο Παιδείας Λεμεσού

AT/AT EREVNES

ΚΥΠΡΙΑΚΗ ΔΗΜΟΚΡΑΤΙΑ
ΥΠΟΥΡΓΕΙΟ ΠΑΙΔΕΙΑΣ ΚΑΙ ΠΟΛΙΤΙΣΜΟΥ

ΔΙΕΥΘΥΝΣΗ ΔΗΜΟΤΙΚΗΣ ΕΚΠΑΙΔΕΥΣΗΣ

Αρ. Φακ.: 7.19.46.4/9
Αρ. Τηλ. : 22800665
Αρ. Φαξ : 22509813
E-mail : dde@moec.gov.cy

1 Αυγούστου, 2012

Κύριο
Κυριάκο Δημητρίου
Βασιλέως Ευαγόρου 17Α
Απόστολος Ανδρέας Χαράκη
3061 Λεμεσός

Θέμα: Άδεια για διεξαγωγή έρευνας με εκπαιδευτικούς, γονείς και μαθητές δημοτικών σχολείων των επαρχιών Λεμεσού και Πάφου

Αγαπητέ κύριε Δημητρίου,

Έχω οδηγίες να αναφερθώ στη σχετική με το πιο πάνω θέμα αίτησή σας προς το Κέντρο Εκπαιδευτικής Έρευνας και Αξιολόγησης, που υποβλήθηκε στις 3 Ιουλίου 2012, και να σας πληροφορήσω ότι εγκρίνεται το αίτημά σας για διεξαγωγή έρευνας με εκπαιδευτικούς, γονείς και μαθητές των δύο δημοτικών σχολείων των επαρχιών Λεμεσού και Πάφου που αναφέρονται στην αίτησή σας, με θέμα *«Η χρήση περιορισμένων πόρων των Τεχνολογιών της Πληροφορίας και Επικοινωνίας (ΤΠΕ) για την υποστήριξη μαθητών με δυσλεξία με δυσκολίες στην κατανόηση και επίλυση μαθηματικού προβλήματος σε δημοτικά σχολεία στην Κύπρο»*, την προσεχή σχολική χρονιά 2012-2013, νοουμένου ότι θα ληφθούν υπόψη οι παρατηρήσεις του Κέντρου Εκπαιδευτικής Έρευνας και Αξιολόγησης, οι οποίες σας αποστέλλονται συνημμένα για δική σας ενημέρωση.

2. Νοείται, βέβαια, ότι πρέπει να εξασφαλιστεί η άδεια των διευθυντών/ διευθυντριών των δύο σχολείων, εκ των προτέρων, ώστε να ληφθούν όλα τα απαραίτητα μέτρα για να μην επηρεαστεί η ομαλή λειτουργία τους. Η έρευνα θα πρέπει να διεξαχθεί με ιδιαίτερα προσεγμένο τρόπο, ώστε να μη θίγεται το έργο των εκπαιδευτικών, το σχολικό περιβάλλον ή οι οικογένειες των μαθητών και όλες οι δραστηριότητες που θα αναπτυχθούν πρέπει να εμπίπτουν μέσα στο πλαίσιο που καθορίζεται από το Αναλυτικό Πρόγραμμα. Οι εκπαιδευτικοί πρέπει να λάβουν μέρος στην έρευνα στο μη διδακτικό τους χρόνο. Η έρευνα θα διεξαχθεί νοουμένου ότι η απώλεια του διδακτικού χρόνου των μαθητών θα περιοριστεί στον ελάχιστο δυνατό βαθμό, ενώ για τη συμμετοχή των μαθητών και τη χρήση συσκευών καταγραφής εικόνας και ήχου χρειάζεται η **γραπτή** συγκατάθεση των γονιών τους. Οι γονείς πρέπει να γνωρίζουν όλες τις σχετικές λεπτομέρειες για τη διεξαγωγή της έρευνας, καθώς και τα στάδια μέσα από τα οποία θα εξελιχθεί. Σημειώνεται, επίσης, ότι τα

πορίσματά σας κρίνεται απαραίτητο να είναι ανώνυμα και οι πληροφορίες που θα συλλέξετε να τηρηθούν απόλυτα εμπιστευτικές και αποκλειστικά και μόνο για το σκοπό της έρευνας.

3. Η παρούσα έγκριση παραχωρείται με την προϋπόθεση ότι τα πορίσματα της εργασίας, θα κοινοποιηθούν μόλις αυτή ολοκληρωθεί, στη Διεύθυνση Δημοτικής Εκπαίδευσης για σχετική μελέτη και κατάλληλη αξιοποίηση.

Με εκτίμηση,

(Ελπιδοφόρος Νεοκλέους)
για Γενική Διευθύντρια

Κοιν.: Π.Λ.Ε. Λεμεσού και Πάφου
Επαρχιακά Γραφεία Παιδείας
: Ε.Δ.Ε. Ειδικής Εκπαίδευσης
Επαρχιακό Γραφείο Παιδείας Λεμεσού

AT/AT EREVNES

Appendix E
Basic Questions for the Interviews

a. Before the implementation

i. Student with dyslexia

(a) What do you think about mathematics? Do you like it or not? Why?

(b) What do you think about the mathematical problems? Do you find them easy or difficult? Why?

(c) Do you use the computer? Do you know how to use it?

(d) Does your teacher give you the chance to use the computer in the classroom during the instruction?

(e) Do you use the computer at home for homework or pleasure? Do your parents help you to use the computer at home?

(f) How is your relationship with your classmates? Are you friends with them? Do you spend time with them? Do you collaborate with them? Would you collaborate with them if you had the chance?

ii. Students without dyslexia

(a) What do you think about mathematics? Do you like it or not? Why?

(b) What do you think about the mathematical problems? Do you find them easy or difficult? Why?

(c) Do you use the computer? Do you know how to use it?

(d) Does your teacher give you the chance to use the computer in the classroom during the instruction?

(e) Do you use the computer at home for homework or pleasure? Do your parents help you to use the computer at home?

(f) How is your relationship with your classmates? How is your relationship with X (classmate with dyslexia)? Are you friends with him/her? Do you spend time with him/her? Do you collaborate with him/her? Would you collaborate with him/her if you had the chance?

iii. Teacher

(a) What do you think about word mathematical problem solving? Do the students face difficulties in understanding and solving mathematical problems? What do you do in order to help students who face difficulties in this discipline?

(b) What do you think about the ICT facilities in your classroom?

(c) Are you trained in how to embed ICT in your instruction? Do you command good ICT skills?

(d) Do you use ICT during the instruction? If yes, how do you embed it? If not, why do you not embed it?

(e) What do you think about using ICT for differentiation of the instruction for mathematics? How about word mathematical problem solving for the whole classroom or the students with difficulties in this discipline?

(f) What do you think about collaborative learning?

(g) What is your opinion about the students with SEN in the mainstream classroom? How about students with dyslexia?

(h) What do you do to help students with dyslexia or students with general learning difficulties?

b. After the implementation

i. Student with dyslexia

(a) What do you think about mathematics? Do you like it or not? Why?

(b) What do you think about the mathematical problems? Do you find them easy or difficult? Why? Is there anything that helps you to understand and solve them?

(c) What do you think about the use of the computer in the classroom? Do you like working with the computer in mathematics? Can you explain?

(d) Do you like collaborating with your classmates? Do they help you? What do you think about them?

(e) Do you prefer working on the computer or without the computer during the instruction? Why?

(f) Do you think the computer can help you to cope with difficulties in word mathematical problem solving?

(g) What do you think about using the computer for doing homework in mathematics with your parents at home?

ii. Student without dyslexia

(a) What do you think about the use of the computer in the classroom? Do you like working with the computer in mathematics? Can you explain?

(b) Do you like collaborating with your classmates? Do you like collaborating with X (student with dyslexia)? Does he/she need your help? Do you help him/her? What do you think about him/her?

(c) Do you prefer working on the computer or without the computer during the instruction? Why?

(d) Do you think the computer can help you to cope with any difficulties in word mathematical problem solving?

iii. Teacher

(a) What is your attitude towards using ICT in mathematics for the whole classroom?

(b) What is your attitude towards using ICT for word mathematical problem solving?

(c) Do you think that ICT can facilitate the difficulties encountered by students with dyslexia in word mathematical problem solving?

(d) Do you think it is easy for a teacher to differentiate his/her instruction in mathematics using the available ICT resources?

(e) Do you think that collaborative learning in pairs helps students with dyslexia to increase their participation and performance in word mathematical problem solving activities? Explain.

(f) What is your opinion on the role that ICT can play towards an inclusive environment in the classroom?

(g) Will you embed ICT in your future lesson plans?

iv. Parent

(a) What is your opinion about using ICT for doing homework by your child?

(b) Did you find any difference in your child's attitude towards homework, between doing homework with and without the computer?

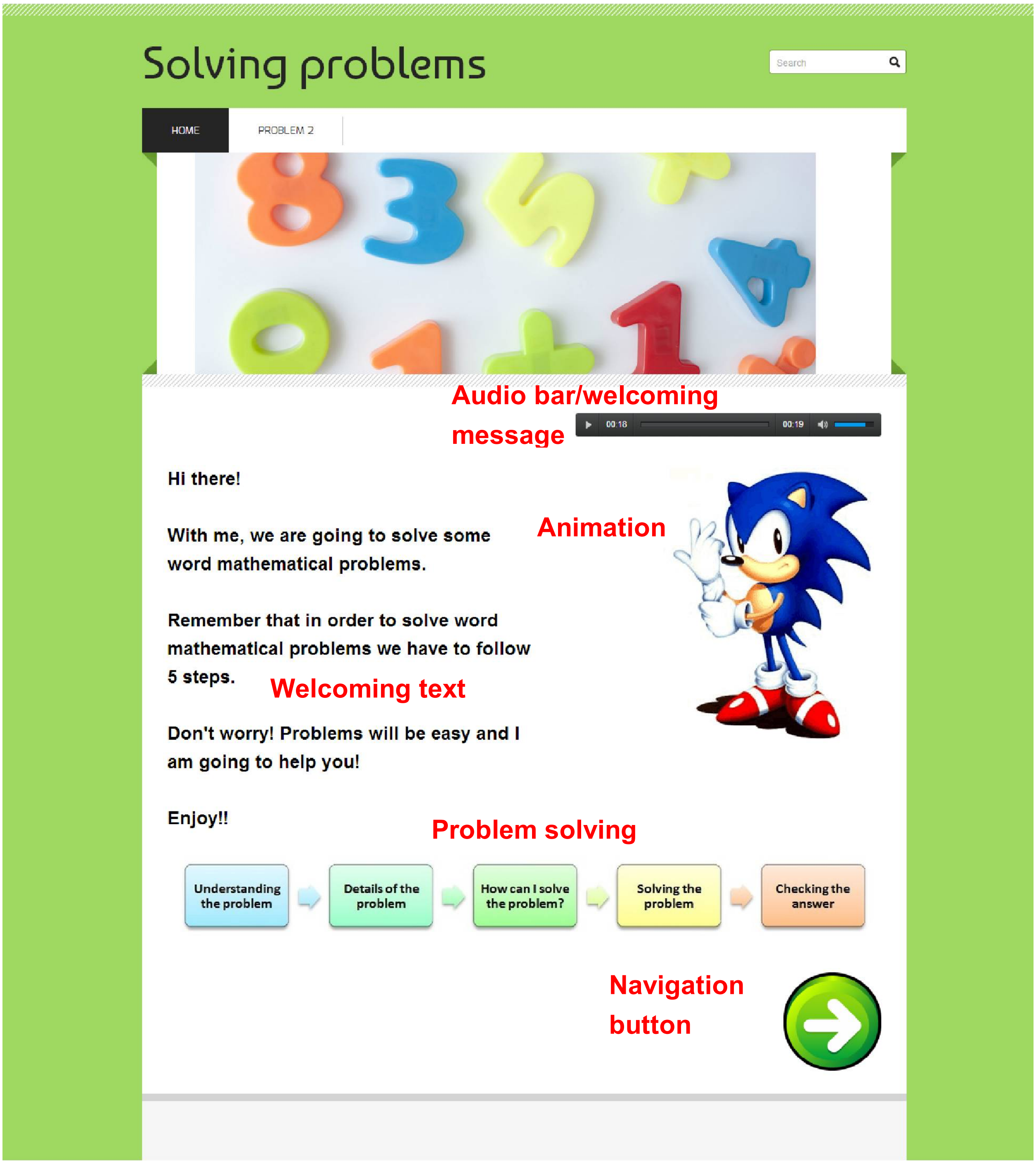
(c) Was it easier or more difficult for you to collaborate with your child using a computer for homework at home?

Appendix F
Example of WBLE translated in English

Online example can be accessed at http://wmpsenglish.weebly.com/

More examples in Greek can be accessed at http://provlima2.weebly.com/ http://provlima3.weebly.com/ and http://provlima4.weebly.com/

Webpage Screenshot



http://wmpsenglish.weebly.com/ Mon Jun 30 2014 20:03:42 GMT+0300 (GTB Daylight Time)

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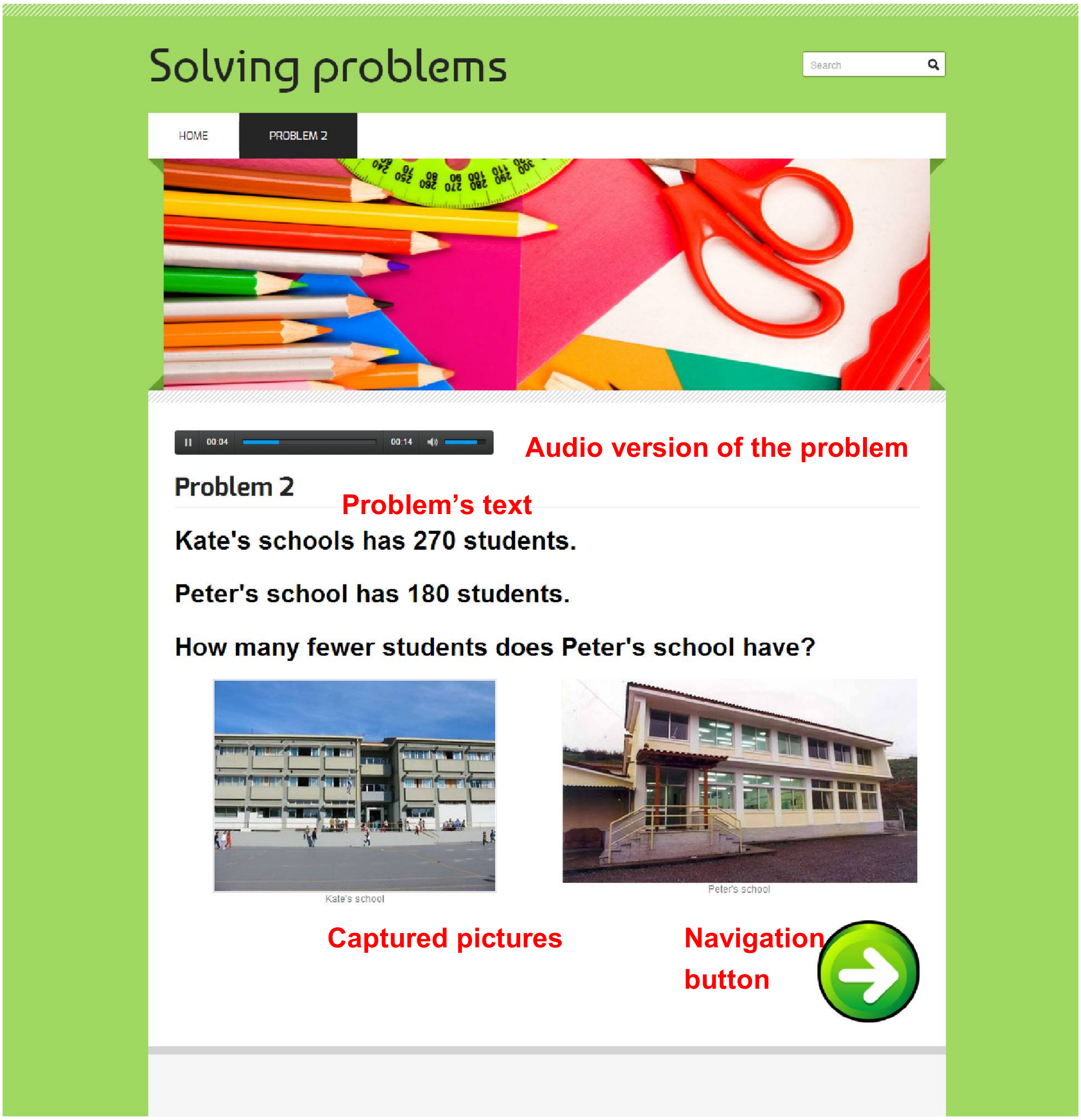

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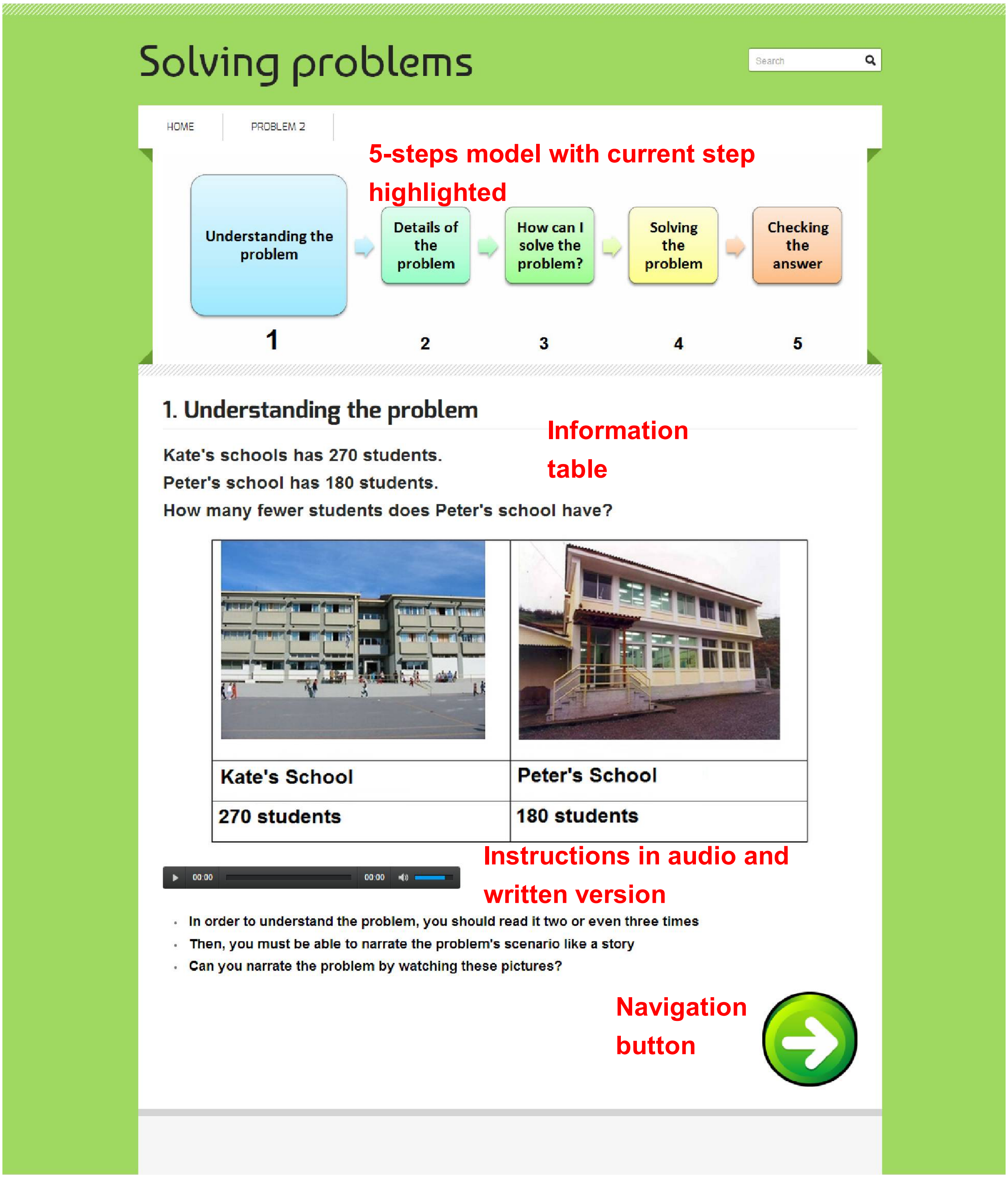

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Webpage Screenshot

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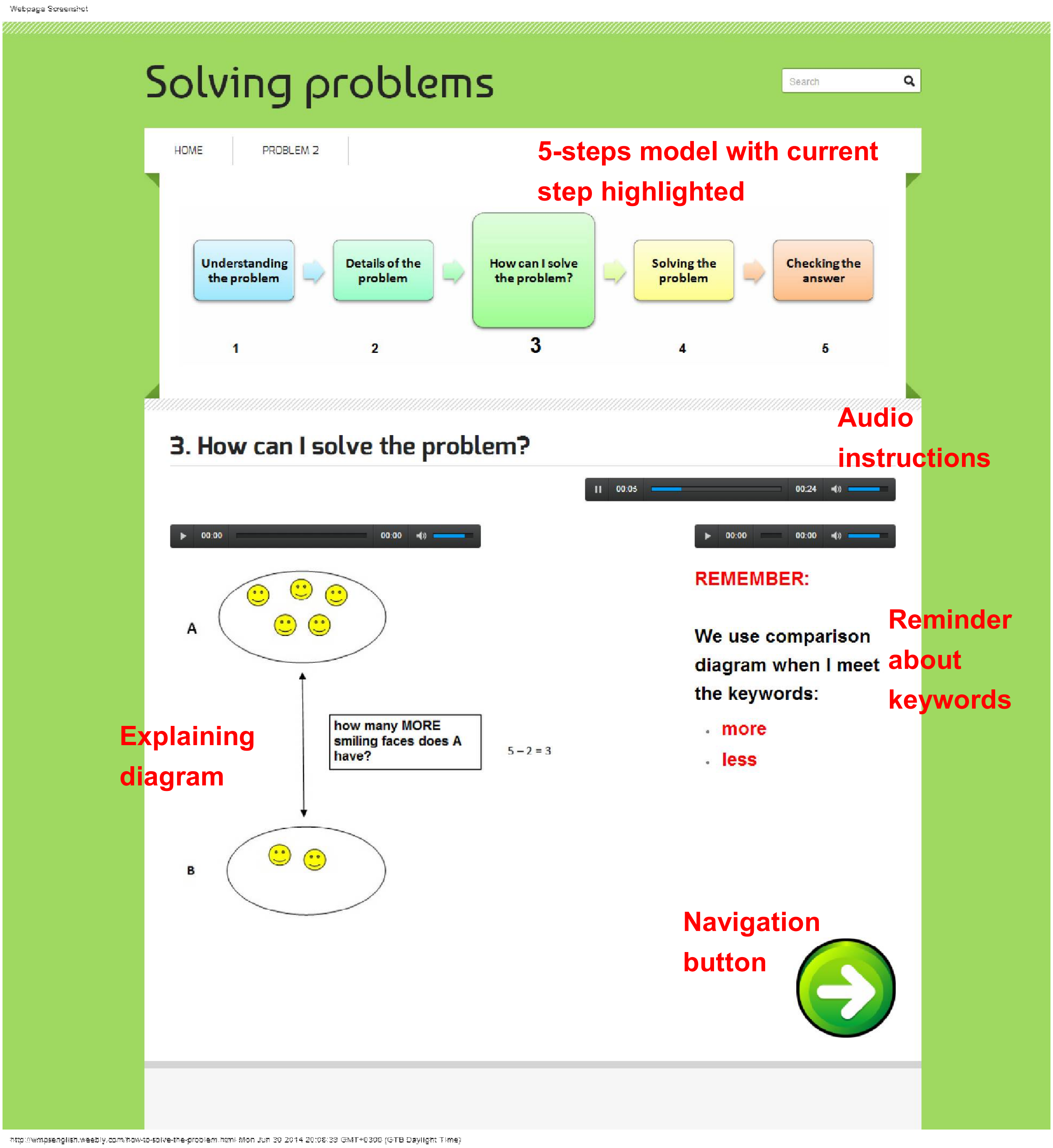
Webpage Screenshot
Solving problems
Search
HOME
PROBLEM 2
5-steps model with current step highlighted
Understanding the problem
Details of the problem
How can I solve the problem?
Solving the problem
Checking the answer
1
2
3
4
5
3. How can I solve the problem?
Audio instructions
A
B
how many MORE smiling faces does A have?
5 – 2 = 3
Explaining diagram
REMEMBER:
We use comparison diagram when I meet the keywords:
more
less
Reminder about keywords
Navigation button
http://wmpsenglish.weebly.com/how-to-solve-the-problem.html Mon Jun 30 2014 20:08:33 GMT+0300 (GTB Daylight Time)

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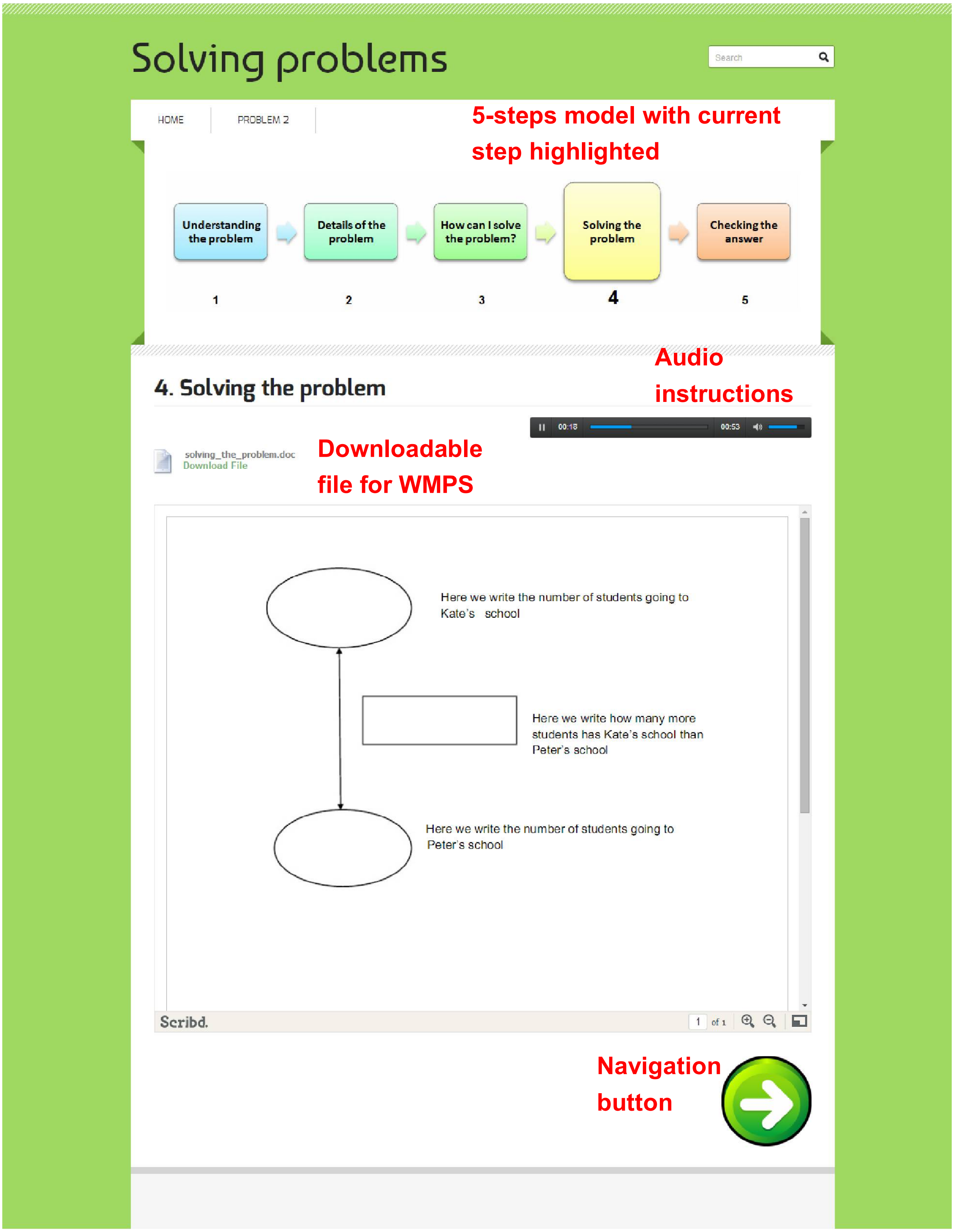

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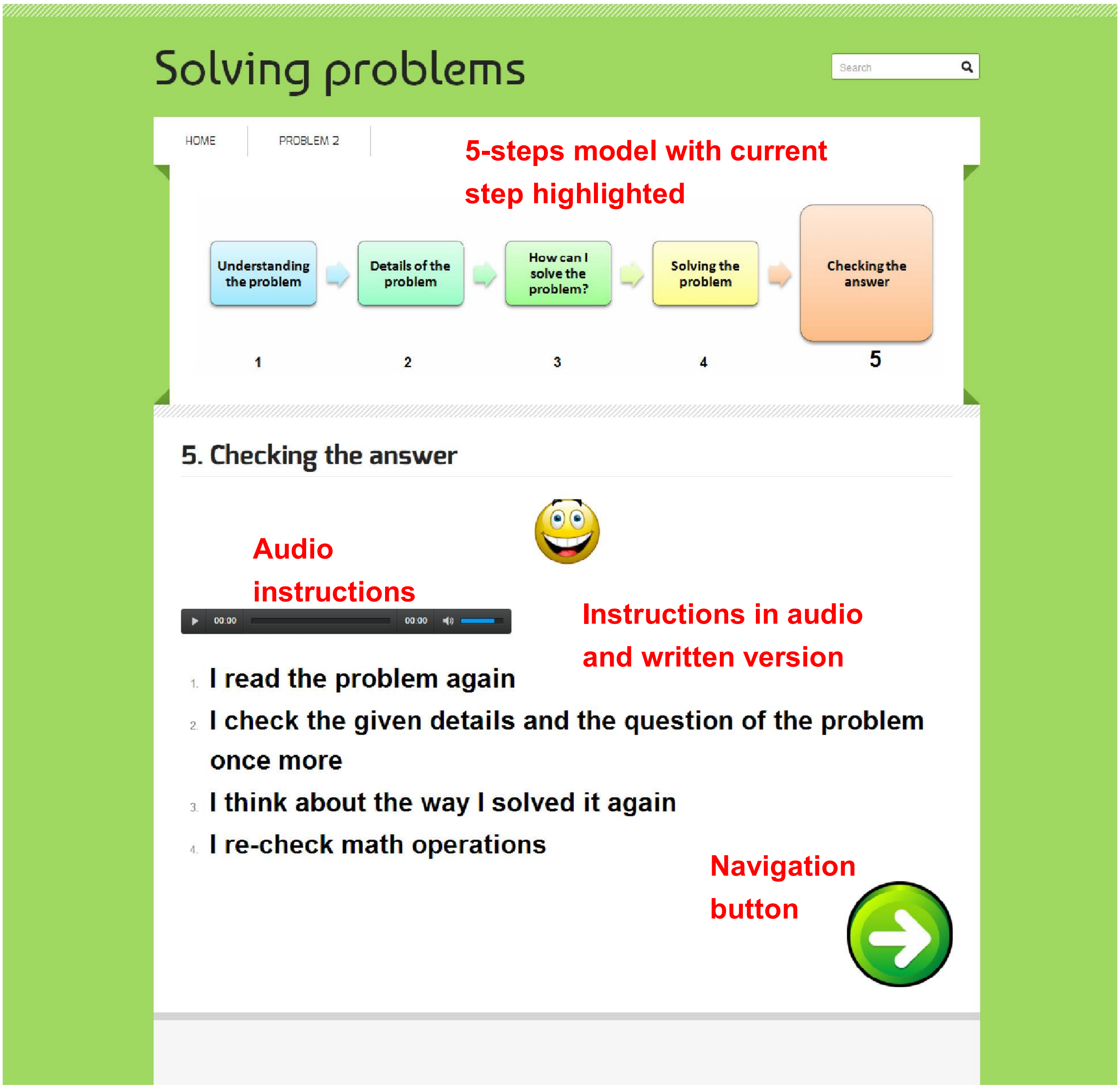

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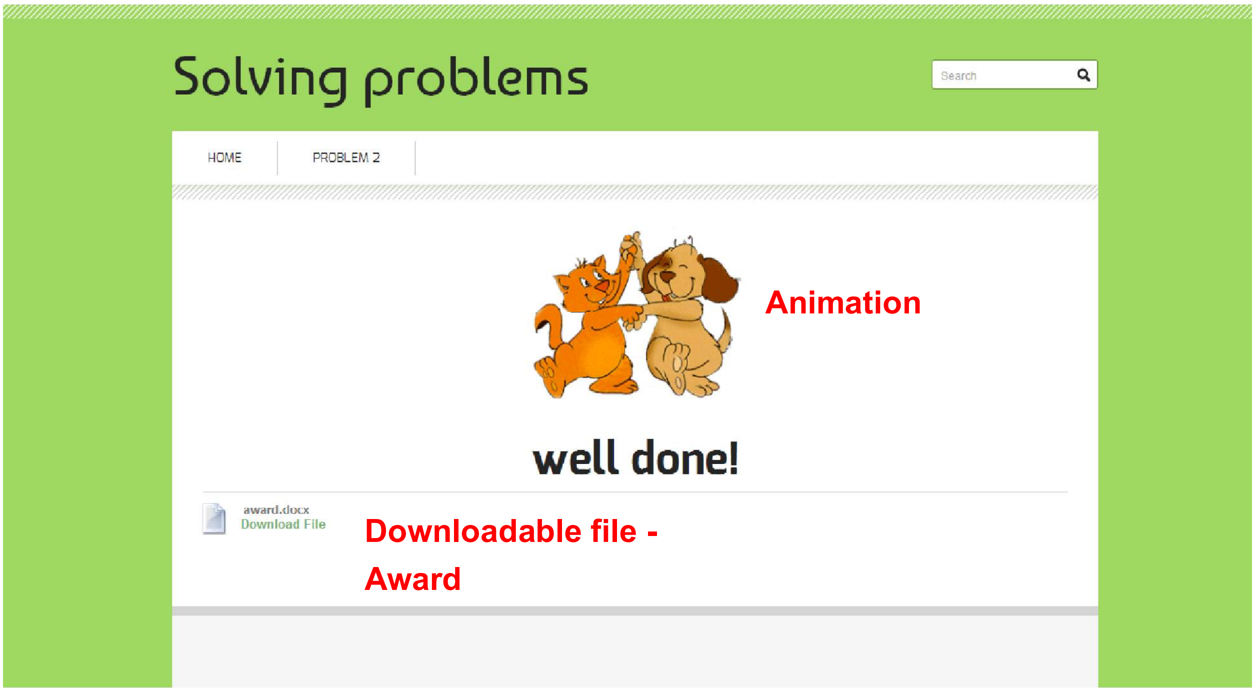

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