Mathematics, technology and homework for 11-14 year old pupils: comparing developments in formal-informal practice in Serbia and the UK (England)

A Working Paper

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Contents

1. EXECUTIVE SUMMARY

This working paper has been developed and created as a part of a study visit to the Centre for Technology Enhanced Learning in the Department of Educational Research at Lancaster University. This joint paper, written by the visiting researcher, Slaviša Radović, from the Faculty of Mathematics at the University of Belgrade, and Don Passey, the Director of the Centre of Technology Enhanced Learning, was made possible through an award from The British Scholarship Trust. This award enabled the researchers to work together over a month-long period, during October to November 2014.

The focus of this paper is concerned with mathematics education – its practice for the 11- to 14-year-old-age range, how technology can be used to support teaching and learning for this age group, and the roles of homework in this context. In Chapter 2, as an introduction to subsequent chapters and analysis, reasons for the importance and position of mathematics education in a national curriculum, the ways homework can be involved and play roles in mathematics education, and the ways technologies have supported those educational practices to date, are outlined and discussed.

Chapter 3 details a specific case study – mathematics education, uses of technology and the roles of homework in supporting pupils 11 to 14 years of age in schools in Serbia. An overview of the Serbian education system, how information and communication technologies (ICT) have been deployed and integrated into its schools, a detailed view of the mathematics curriculum, and the ways that homework are involved in teaching and learning, are presented. Some key issues are identified. Chapter 4 describes and details a research project exploring and seeking to address some of those key issues. It presents the development of a technologically-based platform called “eZbirka”, which hosts a large collection of mathematics tasks that can be selected by teachers to match their curriculum topics, providing pupils with individualised activities they can undertake at home. Not only does the system use ways to prevent copying by pupils, it also provides ways for pupils to record details of their solutions and a record of issues and problems they encounter. Teachers can pick up these details from the system, and can address issues in subsequent lessons. Early findings of studies exploring efficacy of the system indicate that benefits are arising: mathematics test scores indicate gain where pupils and teachers use the entire range of facilities; teachers are increasingly using the system; and pupils talk about advantages arising.

Chapter 5 provides a case study that details similar practices and developments in the United Kingdom (UK) (England). It provides an overview of the mathematics curriculum for 11 to 14 year old pupils, of technological developments in that context over the past 25 years, and considers the roles and practices of homework. From the details covering aspects of the same context in the case studies in Serbia and the UK (England), the paper takes a comparative analysis approach, to identify similarities and differences. These similarities and differences are then highlighted and explored in the context of existing theoretical frameworks, which are discussed in Chapter 6. This comparative analysis and a consideration of the relationships of findings to existing theoretical frameworks, highlight how current developments in Serbia are taking forward not only teaching and learning practices in mathematics education for 11 to 14 year old pupils and their teachers, but also the concepts of relationships between formal and informal learning.

There have been few studies that have explored homework practices in depth, few that have explored these practices within the context of mathematics education and for 11 to 14 year old pupils. This paper takes this exploration further, looking at these areas but also where technologies are being used. Findings indicate that ICT may well in this context be providing a more neutral medium, allowing pupils to reflect more ‘coldly’ on issues and challenges, which they might otherwise have difficulty in discussing in a face-to-face way. This medium takes an important step in moving concerns of pupils from ‘the need to produce right answers’ to ‘a focus on processes of working, enabling them to describe their issues to support their future learning’.

2. INTRODUCTION

2.1 Why is mathematics education important?

Smith (2004), in his report about mathematics education for the UK government department of education, entitled *Making Mathematics Count,* identified a range of key arguments for considering not just the importance of mathematics in a school curriculum, but also for promoting the continued study of mathematics by students beyond 14 years of age. Those arguments for the inclusion of mathematics into the school curriculum hold as much for the 11- to 14-year-old-age range as they do for the post-14-year-age range. He stated in his report that:

> *Mathematics is of central importance to modern society. It provides the vital underpinning of the knowledge economy. It is essential in the physical sciences, technology, business, financial services and many areas of ICT. It is also of growing importance in biology, medicine and many of the social sciences. Mathematics forms the basis of most scientific and industrial research and development. Increasingly, many complex systems and structures in the modern world can only be understood using mathematics and much of the design and control of high-technology systems depends on mathematical inputs and outputs. (p.11)*

> *The acquisition of at least basic mathematical skills - commonly referred to as "numeracy"- is vital to the life opportunities and achievements of individual citizens. Research shows that problems with basic skills have a continuing adverse effect on people's lives and that problems with numeracy lead to the greatest disadvantages for the individual in the labour market and in terms of general social exclusion. Individuals with limited basic mathematical skills are less likely to be employed and, if they are employed, are less likely to have been promoted or to have received further training. (p.13)*

> *Mathematics provides a powerful universal language and intellectual toolkit for abstraction, generalisation and synthesis. It is the language of science and technology. It enables us to probe the natural universe and to develop new technologies that have helped us control and master our environment, and change societal expectations and standards of living. Mathematical skills are highly valued and sought after. Mathematical training disciplines the mind, develops logical and critical reasoning and develops analytical and problem-solving skills to a high degree. (p.11)*

These arguments are echoed by others across the world. For example, shown in the statements that follow, within reports from the United States of America (USA), Australia, and China respectively:

> *What makes the math sciences so central? As Galileo put it, "The great book of nature can be read only by those who know the language in which it was written. And that language is mathematics." Math is the way to understand all sorts of things in the world around us. (Arnold, 2003)*

> *Successful mathematics learning lays the foundations for study in many disciplines at tertiary level and in the applications of those disciplines. Mathematics and numeracy provide a way of interpreting everyday and practical situations, and provide the basis for many informed personal decisions. (Commonwealth of Australia, 2009, p.4)*

> *"Above all, it is a cultural thing." Professor Lianghuo Fan is reflecting on the differences he has noticed between maths education in China and Singapore, where he lived and taught for 40 years, and in Britain, where he is now based. "In China, all parents know that maths is the number one subject in schools, and they expect that in a modern society everyone must be comfortable with maths, even if that means they have to work hard at it." (Stanford, 2014)*

2.2 How can homework be involved and play a role?

Homework is commonly used as an additional activity to learning in class lessons. But there has been controversy raised about homework practices. The Center for Public Education (2007) reviewed prior research findings and concluded that

> *Whether homework helps students—and how much homework is appropriate—has been debated for many years. Homework has been in the headlines again recently and continues to be a topic of controversy, with claims that students and families are suffering under the burden of huge amounts of homework. School board members, educators, and parents may wish to turn to the research for answers to their questions about the benefits and drawbacks of homework. Unfortunately, the research has produced mixed results so far, and more research is needed.*

The review goes on to indicate a useful set of summary statements arising from prior research:

- *The link between homework and student achievement is far from clear.*
- *Homework appears to have more positive effects for certain groups of students:*
  - *Older students benefit more from homework than younger students.*
  - *Students from low-income homes may not benefit as much from homework as those from higher-income homes.*
  - *Students with learning disabilities benefit from homework under certain conditions.*
  - *Asian American students may benefit more from homework than do students from other ethnic groups.*
- *Homework may have nonacademic benefits.*
- *Too much homework may diminish its effectiveness.*
- *The amount of homework* completed *by students seems to be more positively associated with student achievement than the amount of homework* assigned *by teachers.*
- *After-school programs that provide homework assistance may improve student behavior, motivation, and work habits but not necessarily academic achievement.*
- *The effect of parent involvement in homework is unclear. There is little research on connections between specific kinds of homework and student achievement."*

These findings indicate that forms and qualities of homework can make a difference. Three kinds of homework are commonly considered: practice (of tasks already undertaken in lessons previously); preparation (for tasks and topics that will come up in lessons, and sometimes now referred to as a 'flipped classroom' approach); and extension (taking further a topic or activity started in a lesson). It is clear that in the context of mathematics education, all of these kinds of homework are possible: practising more tasks done in a lesson; preparing for a new topic by watching an appropriate video; or extending activities by exploring how these are connected to real-life situations.

Cooper (2014), in his report for the National Council of Teachers of Mathematics, stated that:

> *In the literature, we found six studies conducted between 1987 and 2003 that compared homeworkers with no-homeworkers, and equated students by using either* (a) *random assignment of students to conditions or* (b) *statistical controls or by matching a student in one group with a similar student in the other group while eliminating students who did not have a good match. The results provided a clear picture that homework can be effective in improving students' scores on unit tests, that is, the class tests that are administered at the end of a topic unit. Second-grade students who did homework did better than no-homework peers on number places.*

However, as Omlin-Ruback (2009) says: "Given the continued practice of assigning homework to elementary students, and the gap in literature regarding research that investigates type of homework and its relationship to achievement, as well as the paucity of research at the elementary level, there is a need for further study" (p.4). Omlin-Ruback's study focused specifically on homework in mathematics, for fifth-grade students, in six elementary schools in one school district, but with only 28 students involved. In terms of numbers of homework tasks, the author stated that: "The average amount of homework interactions collected for each student over this 9-week study was 220 total interactions. In other words, on average, each participating student had about six math problems a night" (p.40). But, as she said: "My findings suggest that deeper conceptual understanding, and not rote memorization or the practice of traditional algorithmic processes, is the main focus of homework for these participating students. Especially in the area of Algebra, where I found the highest correlation between homework and state tests score *(r* = .36), students in my sample appear to be working with more complex, direct practice mathematics problems in this strand" (p.42), although "nearly 60% of the homework collected in the strand area of Calculations and Estimations is categorized as Access Skills Practice. This finding appears to support the claim that homework is mostly rote and a waste of time made by critics of assigning homework" (p.43). The author goes on to conclude, importantly, that:

> *I found that the strongest positive relationship between homework type and achievement existed between Direct Contact Practice homework and students' RIT score on the statewide assessment (r = .36), a negligible relationship between Access Skills homework (r =.01), and a weak negative correlation between "Other" type of homework and students' RIT score on the same statewide assessment (r = -.28). Although the two significant correlations in my study are small, they are comparatively much higher than what prior researchers have reported, using other independent variables related to homework. Most of those studies (Cooper, 1989; Cooper, 2001; Cooper et al., 2006) have reported correlations near zero when examining the relationship between homework and achievement. In this case, and I suspect in most cases, the type of homework students interact with is more relevant to the relationship of homework to student achievement than the time that it takes for students to complete homework or whether they had homework or not. (pp.44-45)*

2.3 How can technologies support mathematics education?

A key question for this working paper is whether there is a role for digital technologies in supporting mathematics education, and the homework of mathematics education in particular. Certainly there has been a long history of digital technologies being developed and used to support mathematics education. Tinsley and Johnson (1998) edited early conference proceedings focused on *Information and Communication Technologies in School Mathematics.* From that date, there were technological developments that led to computer-based resources that covered an entire mathematics curriculum, notably integrated learning systems (with studies reported by, for example, Underwood, Cavendish, Dowling and Lawson, 1997) and on-line digital resource systems (Passey, 2011). A report for the Joint Mathematical Council of the United Kingdom (2011) listed a range of technologies that had been applied to the study of mathematics: dynamic graphing tools; dynamic geometry tools; algorithmic programming languages; spreadsheets; data handling software and dynamic statistical tools; computer algebra systems; data loggers, such as motion detectors and GPS; and simulation software (p.6). Most technologically-based resources to support mathematics learning, however, have not been developed for use in homework contexts, although there have been examples of resources used in these contexts (such as *MyMaths, Mathletics, Education City* or *Espresso Education*).

The focus of this working paper is to explore further this latter under-developed area; how technologically-based resources can be created and used to support mathematics learning through homework practices. The working paper will explore this area in the following four chapters: an overview of the educational system, mathematics education and homework practices in Serbia; a more in-depth review of a specific research development in Serbia to provide facilities to support mathematics education through homework practices; a comparison of the practices and developments with those in the UK (England); and the drawing out of conclusions from the findings of the four previous chapters in the context of existing literature.

3. MATHEMATICS, TECHNOLOGY AND HOMEWORK IN SCHOOLS IN SERBIA

3.1 Overview of the school system

The education system in Serbia is composed of pre-primary (up to the age of 7 years), primary (from the age of 7 to the age of 14 years), and secondary education (gymnasium or vocational school, from the age of 14 to the age of 18 years). The eight grades of primary school are compulsory. Also, participation in a pre-school programme for one year is mandatory (OECD, 2012). The members of national minorities have the right to education in their own language in pre-primary, primary and secondary education (Albanian, Hungarian, Romanian, Ruthenian, Slovak and Croatian languages) (Ivić & Pešikan, 2012).

An overview of the school system is shown in Table 1. The table shows when national tests are undertaken, as well as the age ranges and grades in the different sectors of the education system.

Education sector	Age in years	Grade	Tests that are undertaken and in which subjects
Pre-primary education			
Nursery	0-3		
Pre-school preparatory	3-6		
Compulsory pre-school preparatory	6-7		
Compulsory primary education			
Class instruction	7-11	1-4	National Testing in mathematics is conducted at the beginning of the fourth grade.
Subject-based instruction	11-14	5-8	National Testing in mathematics is conducted at the beginning of the sixth and eighth grade. At the end of the eighth grade all pupils have to pass the final examination for mathematics and the Serbian language for enrolment in secondary school.
Secondary education			
General secondary school and Vocational schools	14-18	1-4	Pupils have to pass general Matura after the fourth grade of general secondary education or vocational education and training. Matura consists of a test of the Serbian language and mathematics (or Serbian language and English language) and the final paper.
Vocational schools	14-17	1-3	Pupils have to pass Matura after the third grade of vocational education. Matura consists of theoretical and practical work, depending on the profession.

Table 1. Structure and organisation of the education system (MoESTD, 2009)

The Ministry of Education, Science and Technological Development of the Republic of Serbia (MoESTD) issue a unique curriculum for all schools. The curriculum includes compulsory and optional subjects, their schedule by grades, weekly and annual number of lessons and other specific details about educational processes. The curriculum defines the contents of each subject, including teaching aims and objectives, as well as guidelines on how to attain them (Halaz, 2003). They are mandatory for all schools, without any possibility of choice by the pupils or teachers. School boards (the managing bodies of schools), have a role to organise the work of the school and to make regulations and general acts which can improve school work. After having consulted the municipality, school boards make decisions on which optional subjects and foreign languages (both compulsory and optional ones) will be taught in school. The curriculum is inflexible and there is a very small topic connection between different subjects (Cvjetićanin et al., 2008). Schools publish "School Programmes" and "Annual Work Plans" based on the curriculum, in accordance with the law. Within these are stated specified details of educational, cultural and sporting activities as well as special programmes important for teacher professional development (MoESTD, 2009).

According to the Law on the Foundations of the Education System (MoESTD, 2009), the aim of primary education in Serbia is to create the base for the realisation of the primary mission of the education system as a whole: to provide for all its citizens a good education of a high quality. Primary education has a function to give pupils the basic knowledge across all areas, to prepare the young people for their further education and to create their mindset, capabilities, attitudes and values which are important and needed for daily life in a modern world.

Primary education is free and available to all categories of the population in all parts of the country; it lasts eight years and it is divided into two cycles. Children are divided into classes on the first day of school and stay in those classes until their graduation from primary school. Lessons take 45 minutes. The first part of the education in the primary school lasts from the first to the fifth grade (from the age of 7 to the age of 11 years), during which period all main subjects are taught by one teacher. Pupils have 4 lessons per day, which might be learning to read/write both Cyrillic and Latin letters, mathematics, English, history, geography, music, and art. The second part of the primary school education lasts from the fifth grade up to the eighth grade (from the age of 11 to the age of 14 years). In this period, pupils gain the knowledge within the framework of the curriculum in which it is stated that for each subject one qualified teacher should be provided (MoEaS, 2004). The teaching takes place in 3,429 schools, which are evenly distributed in both urban and rural areas in Serbia (Republic Statistical Office, 2014). At the end of primary education all pupils have to pass the final examination for mathematics and the Serbian language for enrolment in secondary school. Ranking for enrolment in secondary schools is based on the number of points from these two final examinations and the average score during the second part of primary school (the maximum of points is 100). All marks in primary school, from the sixth, seventh and eighth grades, bring a maximum of 60 points, and the final examination provides up to 40 points (20 points each for the Serbian language and mathematics tests) (The Institute for Education Quality and Evaluation, 2014).

Furthermore, pupils during primary school participate in National Testing, whose aim is to provide valid and reliable information regarding applied knowledge and skills at a certain grade during the process of education. National Testing examines and determines various factors which have an influence on the pupils. Accomplishments in mathematics are tested at the beginning of the fourth, sixth and eighth grades of primary school (The Institute for Education Quality and Evaluation, 2014b). In this way the accomplished aims of the education system are followed. This testing is conducted by the MoESTD, in order to examine the effects of the education strategy. The results of the testing can be used by schools individually, if those schools want to follow the advancement of their pupils and thus, needed actions which are realised at the level of primary schools can be taken.

Secondary education continues after completing primary education and it is not obligatory, but it is free for most pupils (there are fees only for private schools). They are divided into gymnasiums and vocational schools that last for 3 or 4 years and the school develops the necessary profiles and occupations for work in society - appropriate occupations of workers that can be employed in industry, labour, trades, etc. (MoE, 2008). Nowadays, there is large disproportionality between needs and completed skills by pupils in vocational schools regarding the country as a whole and at a local level (MoESTD, 2012). Serbia is a country with high unemployment, especially among young people. This problem includes unemployment in terms of how they acquire knowledge, skills and abilities useful in getting a job. This is especially important, because the needs of the labour market are continuously changing, and the need for well-trained staff is increasing (Dimov, 2007). With the help of European Union (EU) funds (European Commission, 2001) in Serbia in the past years, there are initiatives to reform secondary vocational education in which new experimental profiles are introduced (a baker, a butcher, a cook, a car electrician, a veterinary technician, a cosmetic technician, etc.). These pupils will then gain high qualifications to work through the reformed curricula. Also, they now are involved in work practices through teaching not only in workshops but also with employers directly, in real work situations. However, this practice is limited to a relatively small number of schools in a small number of cities, and also the number of occupations is limited (Dimov, 2007).

Pedagogical-psychological services exist in most schools, which are important as mechanisms for improving the quality of teaching and learning processes. Besides regular primary and secondary education in Serbia, there is an educational provision concerned with persons with special needs - so-called special education (MoESTD, 2012; UNICEF, 2010). This kind of education includes all those pupils who could not complete regular primary or secondary school because of their mental or physical disabilities. But, there is an inadequate disposition of schools in this respect; teachers are insufficiently trained for this kind of teaching (Jablan & Kovačevič, 2008).

Although the Law on the Foundations of Education in the Republic of Serbia created the frame for and gradual adjustment to a new concept of professional teachers' advancement, the old concept of teachers' education is still dominant. Although primary teachers in grades 1 to 4 are educated at faculties of pedagogy, subject teachers from grade 5 upwards are educated at faculties for their respective academic discipline. The study programme which is offered at these latter faculties covers 4 years of bachelor-level studies and 1 year of master-level studies. Although all universities in Serbia are educating subject teachers, the organisation of subject teacher education varies both at faculty and at university level, involving a broad range of possibilities: from enrolling in a department for teacher education at the faculty for the respective academic discipline (e.g. Department for Biology Professors at the Biology Faculty at Belgrade University), through selecting a teacher education track later in the course of one's study (e.g. the Chemistry Teacher Track at the Chemical Faculty at Belgrade University), or just adding a set of teacher-track courses (Pedagogy or Education Psychology) to the academic curriculum as a compulsory or as an optional subject (Cerović, 2004). Subject didactics are usually offered at the end of the study programme and are disconnected from education sciences (Pešikan et al., 2010).The new conception is concerned with an appropriate selection of future teachers, their scholarships, mentor work and constant monitoring (Šurkalović, 2003). Serbia is one of the few countries where no faculty of education or education sciences exists – consequently, there is no way to gain a specialisation or a master's or doctoral degree in a variety of important areas such as education policy, comparative education, education administration and management, etc. (Cerović, 2004).

By introducing the Law on Textbooks, certain standards of book quality have been adapted and the monopoly in the sector of publication has been removed. In this way, a new market was opened and the opportunity to create good books of high quality in a competitive surrounding was made, which is based on clear professional standards. Teachers have the freedom to choose the textbook publishers (which were previously approved by the MoESTD) for their pupils.

Cultural and public activities organised by a school are rare; also co-operation with local communities for organising literature evenings, concerts, book promotions, exhibitions, charity actions or human nature protection are also not that frequent. Additional classes are rare in the schools; in some they do not even exist; there is no planned cultural-entertainment, sporting events, ecological activities or excursions, and there is no teaching activity which is applied to the surrounding and local character of the place where pupils live. The cultural role of the school has been lost, and the role of the artistic contents in the primary school has also been lost. All this has, as its consequence, prevented pupils from developing basic cultural needs and habits (Mrđa, 2011).

Driven by a strong commitment to EU integration, the authorities have announced and launched numerous reforms in an effort to move the education system from the traditional to new approaches when it comes to classroom practice and system management. The education system in Serbia is undergoing major changes; these changes are broad and systematic and devised with intended long-term goals (Ivić & Pešikan, 2012; Šurkalović, 2003).

3.2 ICT in schools in Serbia

The potential of technology enhanced education in primary school has been widely recognized (Voogt & Knezek, 2008). Models and methods of successful integration of ICT in the educational process are still a challenge and depend on many factors (Goos et al., 2009; Heid & Blume, 2008). Due to the complexity of successful integration of ICT into the education system in Serbia, the National Education Council (2011, 2013) acknowledges the potential of ICT for education and defines guidelines for providing support for quality work. The national document "Guidelines for the promotion of the role of information-communication technologies in education" emphasises that the knowledge and skills in ICT are one of the preconditions for social inclusion in contemporary society and the labour market. Digital literacy has become an important factor in the socialisation of every citizen and it is added to a set of key competencies of modern man, which are necessary for life based on a knowledge society (European Commission, 2010).

Improving the quality of teaching and learning, as well as the integration of ICT into the education system, depends on curriculum development, teacher practice evolution and purposefully-designed educational software and ICT infrastructure (Radović et al., 2014a). National documents in Serbia emphasise the need for making the conditions appropriate in order for ICT to become an integral part of teaching practices in all subjects (MoESTD, 2012). In the planned measures, there has been included the statement "to train all teachers to use ICT in teaching or its preparation" (p.30).

Documents issued by the MoESTD (2012) and the Ministry of Tourism, Trade and Telecommunications (MoTTT, 2010) encourage and facilitate the uses of ICT and innovative methods in teaching. Teachers are encouraged and motivated to use computers in all forms and types of learning activities, but there is a lack of knowledge about adequate methods, materials and teaching practices. In a survey conducted about the use of ICT in schools in Serbia, Džigurski (2013) emphasised that the basic motives for teachers are - raising the quality of teaching, and encouraging pupils' motivations for the subject, as well as the improvement of pupils' concentration and attention in class. Teachers by themselves already now develop materials in electronic form and make them available on the internet, usually in the form of blogs (Ristic, 2011).

Over the past few years, through many projects, efforts have been made in order to modernise schools and information systems in Serbia. In the framework of the MoEaS project "Modernization of the vocational school system in Serbia" (2002) modern information technology (IT) equipment worth 1.5 million Euros was purchased during 2011. Secondary schools (87 of them) have obtained a fully-equipped computer room or a classroom for vocational courses where lectures can be implemented using educational software. The MoTTT implemented, through the framework of the project "Digital School", fully-equipped computer classrooms in 2,808 elementary schools in Serbia during 2010. In that way, basic infrastructural conditions have been acquired for using ICT in teaching.

However, to foster the learning potentials with ICT, teachers in primary and secondary schools need support in the following areas: developing appropriate teaching strategies, using appropriate available resources and creating interactive resources (Passey, 2000). There has been an implementation of a programme called "Creative School" within the Institute for the Advancement of Education over the past eight years in Serbia (http://www.kreativnaskola.rs/). The programme is a sort of contest which motivates teachers to submit their work, to show how they are applying ICT in their teaching. So far the contests have involved approximately 5,500 teachers from 972 primary and secondary schools. All of the 1,166 teaching resource materials were included in the so-called "Knowledge base" – a base with interactive materials which show good practice (The Institute for the Advancement of Education, 2014b). Materials are mostly slide presentations, without a high level of interactivity, made by teachers for the purpose of teaching practice.

The MoTTT from 2013 announced a public call to fund programmes in the field of the information society in Serbia, with an annual budget of 0.4 million Euros. The priority of this programme is to support activities in the field of ICT application in teaching practice. One of the projects financed by this public call was “Platform Zbirka in supporting effective teaching” (Marić et al., 2014). With the help of this project, an educational platform for communication and collaboration between pupils and teachers was created.

3.3 Mathematics curriculum at age 11 to 14 years

Mathematics as a subject in school is defined by contents, aims and tasks which are assigned to certain teaching programmes. In the curriculum in all grades in the primary school, mathematics and the mother tongue language are the most common subjects. Within the overall number of classes, (144 a year), pupils have one class of mathematics, four times a week. The Ministry of Education and Science do recognise mathematics as an important subject for personality and skills development among pupils and an integral part for their further education. An overview of the number of lessons in each subject area at each of grades 5 to 8 in primary schools is shown in Table 2.

Subject	Number of weekly teaching periods in each grade			
	5 (11 years)	6 (12 years)	7 (13 years)	8 (14 years)
Mathematics	4	4	4	4
Serbian Language	5	4	4	4
Foreign Language	2	2	2	2
Art	2	1	1	1
Music	2	1	1	1
History	1	2	2	2
Geography	1	2	2	2
Physics	-	2	2	2
Biology	2	2	2	2
Chemistry	-	-	2	2
Technical Education	2	2	2	2
Physical Education	2	2	2	2
Total weekly periods	**23**	**24**	**26**	**26**

Table 2. Second cycle of primary education weekly lesson timetable, where each teaching period lasts 45minutes (The Institute for the Advancement of Education, 2014a)

The aim of the mathematics curriculum in the primary school is for pupils to apply elementary mathematics knowledge needed for understanding phenomena and rules in nature and in society itself. Also, the aim is to prepare them for the application of the adapted knowledge when it comes to solving various tasks from everyday life. Mathematics as a subject is intended to represent the base for successful mathematics learning and education in general which will follow. Also, it should be a base for development of mental skills, forming a scientific view onto the world and development of pupil personality as a whole (Petrović et al., 1997; The Institute for the Advancement of Education, 2014a).

The tasks of mathematics are concerned with gaining a basic mathematics culture needed for examining the role and mathematics application to various areas of daily life (mathematics modelling), for successful education which will follow and integration into work, for the development of pupils’ abilities of observing and noticing, and developing logical, critical and analytical opinion (The Institute for the Advancement of Education, 2014a).

After the first four-year cycle, pupils should have mastered the basics of mathematical thinking and be familiar with the set of natural numbers, successfully mastering the reading, writing and displaying of integers on number rays. They should notice correlation between the results and the components of mathematical operations. They should be able to solve simple equations and inequalities, apply the properties of arithmetic operations by transforming numeric expressions and to read, write and understand the meaning of fractions. They should be familiar with the units for surfaces and apply them in calculating the area of squares, rectangles and cubes (The Institute for the Advancement of Education, 2014a).

After the eight-year cycle of elementary education pupils are tested at the national level, sitting the final examination (The Institute for Education Quality and Evaluation, 2014). Mathematical knowledge is assessed by a test of 20 questions which contain five subject areas, chosen from three achievement levels: basic, intermediate and advanced (Pešikan, 2012). In Table 3, the description of each subject topic, and the definition of expectation from the basic and advanced levels, are shown.

Attainment target	Description of attainment at basic level	Description of attainment at advanced level
Numbers and operations with them	Can read and write different types of numbers (natural, whole, fraction); convert decimal numbers to fractions and the other way; compare the numbers of the same type; perform a basic arithmetic operation with the same types of number; divide numbers and know when a number is divisible by another; use whole numbers and simple expressions with them	Can determine the value of compound number expressions; operate using the concept of divisibility in problem situations; use numbers and numeric expressions in real situations
Algebra and functions	Capable of solving linear equations in which the unknown appears only one time; knows basic operations with powers and can calculate the power of a given number; can add, subtract and multiply monomers; can determine the value of a function given by a table or formula	Can solve linear equations and inequalities and systems of linear equations with two unknowns; uses equations and systems of equations in solving complex problems; uses the properties of powers and roots; transforms algebraic expressions; distinguishes direct and indirect proportionality; graphically interprets properties of a linear function
Geometry	Understands the terms: straight line, plane, angle (observes their models in real situations and knows how to draw them using accessories); distinguishes between different types of angles and parallel and vertical lines; understands the terms and properties of 2-D and 3-D figures (observes their models in real situations and knows how to draw them using accessories; able to calculate the circumference and area of figures); knows how to apply the Pythagorean theorem; intuitively understands the concept of congruent figures (moving up to the matches)	Can make conclusions using properties of parallel and normal lines, and different types and positions of angles; uses properties of 2-D and 3-D figures, accounts for their volumes and surfaces based on elements that are not necessarily directly given in the formulation of the task; knows how to construct 2-D figures; can apply properties of congruent and similar triangles, linking the various properties of geometric objects
Measuring	Uses a wider range of metric units; chooses and uses appropriate units and instruments in a variety of situations; converts larger units of measure in less	Converts units of measurement, counting with them; estimates and rounds numbers given information, and works with such approximate values; expresses estimation errors

Attainment target	Description of attainment at basic level	Description of attainment at advanced level
Data processing	Can determine the position of points in the first quadrant of the coordinate system when given coordinates; can read and understand information from graphs, charts or tables, and specify minima or maxima; shows data in a table or in a chart; determines the percentage of a quantity	Can determine position (coordinates) of points that satisfy the complex requirements; interprets graphs and tables of data; collects and processes data, presents them on a diagram or table; can apply properties of percentage in more complex situations

Table 3. Attainment targets and the basic and advanced attainment levels expected for 11-14 year old pupils (Institute for Education Quality and Evaluation, 2014)

Pupils are expected to be able to handle decimal numbers and fractions and perform the calculations. Also, they are expected to compare numbers and solve linear equations and systems of equations, to observe the dependence between variables and transform algebraic expressions. They should be familiar with concepts, elements and properties of geometric objects and figures and know how to construct them, understand concepts of coinciding figures and observe their symmetry, use the appropriate units of measurement and successfully determine the approximate value, read charts and process the data collected by presenting them graphically or in tables, and use numeric expressions in real situations (The Institute for the Advancement of Education, 2014a).

3.4 Homework

According to the teaching method instructions *Guidelines for the implementation of mathematics curriculum for primary schools in the Republic of Serbia* issued by MoESTD (The Institute for the Advancement of Education, 2014a), regarding homework it says: *"Homework assignments are an important component of the teaching process. They not only test how much the pupils have mastered certain materials, but they present an introduction of independent work and self-education to pupils. Tasks should be varied, and by difficulty should be balanced, in accordance with the knowledge and skills of all pupils"*.

The role of such distance learning is that pupils stay in contact with the education material, to prolong the learning process (Passey, 2013). The goal of doing homework can be repetition and consolidation of educational content, broadening and deepening knowledge, preparing for the adaption of new material, training and creating work habits. Homework tasks should be associated with the work of pupils in the class, so that school and home activities make didactic unity. By analysing the pupils' work on homework tasks, teachers have the opportunity to be informed about the level of pupils' knowledge (Kuka, 2005). In that way, they can transform teaching practices and adjust course materials to the needs of pupils.

In the book, *The Battle Over Homework* (2007), Cooper states that in experimental research, the average pupil gains benefit by doing homework. Parents believe that homework can inform them about the curriculum and provide them the opportunity to increase their involvement with their childrens' learning processes (Passey, 2013). Involving parents in distance learning, pupils are aware of the connection between school and home, and parents have an insight into the progress of their children (Cooper, 2007; Epstein et al., 1997).

The benefits of homework can be divided into four categories: a current academic benefit, long-term academic benefit, non-academic benefit, and parental involvement. The most frequent reason for giving homework is the current academic benefit, and the main reason is to increase pupils' time spent learning (Cooper et al., 2006). Positive effects that are directly related to learning are: improved retention of knowledge; and better understanding of the subject matter. Relationship between time spent doing the homework and pupils' achievement cannot be taken as clearly evidenced in the form of a statement that more time spent doing the homework necessarily leads to better results in school. In other words, the idea of "more is better" is not related to all subjects, at all levels of education and at all levels of pupils' knowledge (Epstein &Van Voorihis, 2001).

Tasks for homework are present in every textbook of mathematics in Serbia, and they form an integral part of the class. Also, they are located in the teachers' methodological preparation for all classes. At the outset of every lesson, teachers begin by asking pupils if they had trouble with previous homework - and answers from pupils there are used as feedback about their understanding of the previous teaching.

A common occurrence in primary schools in Serbia is that most pupils just copy solutions of tasks from their peers prior to the class. Thus, an important part of the educational process loses its meaning and the teachers lose an instrument with which they can better plan the teaching process. The platform "eZbirka", which was developed within the MoTTT project, serves as an aid to teachers in the assignment of homework to pupils, reviewing pupils' responses and further planning of teaching activities (Radović et al., 2014b).

4. THE eZBIRKA PROJECT

4.1 “eZbirka” – electronic collection of mathematics tasks

The educational platform eZbirka is publicly available and gives access to a free electronic collection of mathematics tasks. The design of the platform is such that it meets the needs of pupils and teachers, improves the flow of learning activities and contributes to a better achievement of the objectives of teaching units and improves the quality of teaching.

The platform eZbirka is intended to promote and support the process of doing homework in the upper grades of primary schools. Teaching materials have been added to the platform; about 13,000 mathematics tasks have been created and adapted to the curriculum. Tasks are divided into four grades (for pupils aged from 11 to 14 years), arranged by curricular fields and teaching units so that they correspond exactly to the curriculum prescribed by the MoESTD. Each teaching unit consists of 6 tasks, and each task is selected from a group of similar tasks. The overall structure of the platform is shown in Figure 1. Tasks in the same groups differ in their initial data or the formulation of the problem, but for their solution the same level of knowledge is required.

In order to support a more flexible use of digital classrooms in schools for the purpose of teaching activity and to improve usage of computers for home learning, the project “Platform eZbirka to support effective teaching” organised professional development of teachers to use the ICT platform eZbirka. Primary school teachers (800 of them) were trained to use the platform in various types of learning activities (Radović et al., 2014b). Teachers were taught and trained how to use the platform eZbirka in order to provide homework for their pupils.

Pupils are able to access the tasks in a range of ways. The resources can be accessed through different devices that have internet connection, including mobile devices as well as desk-top and laptop machines. If pupils do not have ICT access at home, then teachers can print out hard copies for pupils to complete.

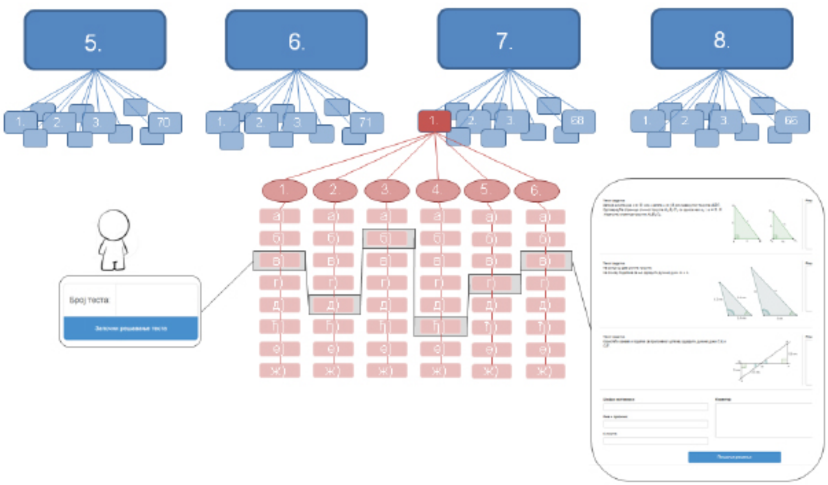


Figure 1. Task and teaching units schedule (Radović, 2014b)

The platform enables variability and dynamic change of tasks, preventing pupils from having prescribed ready-made solutions, but encouraging them to actively solve problems and collaborate between each other. All of the pupils receive the same test, but the tasks are different (initial data and the conditions are changed and the numerical values are different in all the tasks). Having completed the tasks, the platform enables analysis of pupil performance, which teachers can monitor. An overview of how the platform activities fit with teaching practices is shown in Figure 2.

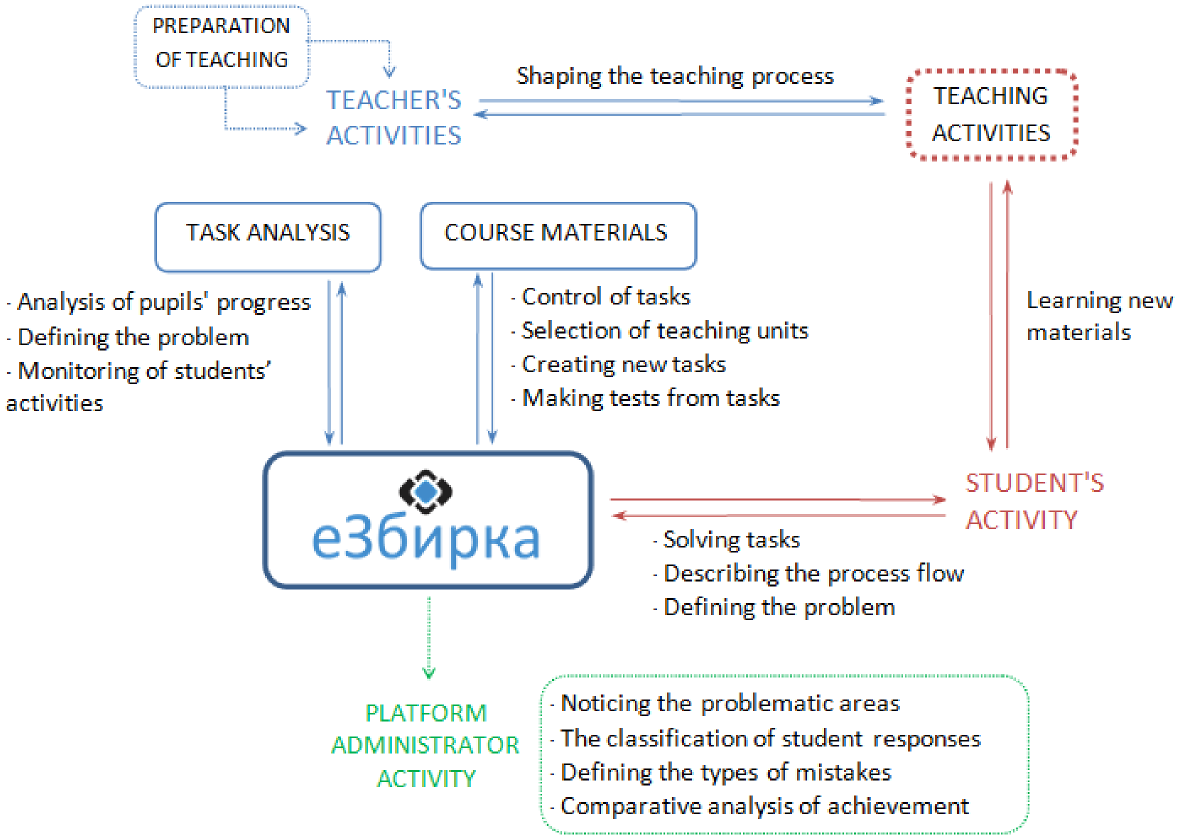


Figure 2. Model of impact on the teaching process by using the platform eZbirka

The platform eZbirka serves as a communication tool as well, which helps a teacher in defining problems that pupils face when solving the tasks. On the right-hand side of each task in the test, there is a field where the solution is placed, where a pupil is supposed to enter the final solution and the solution steps, or explain to a teacher why she/he was not able to solve the task. Figure 3 shows an example of a set of tasks, and the structure of the online environment that allows pupils to enter comments for the teacher. With detailed planning of learning activities based on feedback from students, eZbirka can contribute to raising the quality of teaching. Furthermore, comparative analysis of solutions and responses of all students can be used for analysis of the state of the whole education system and curriculum.

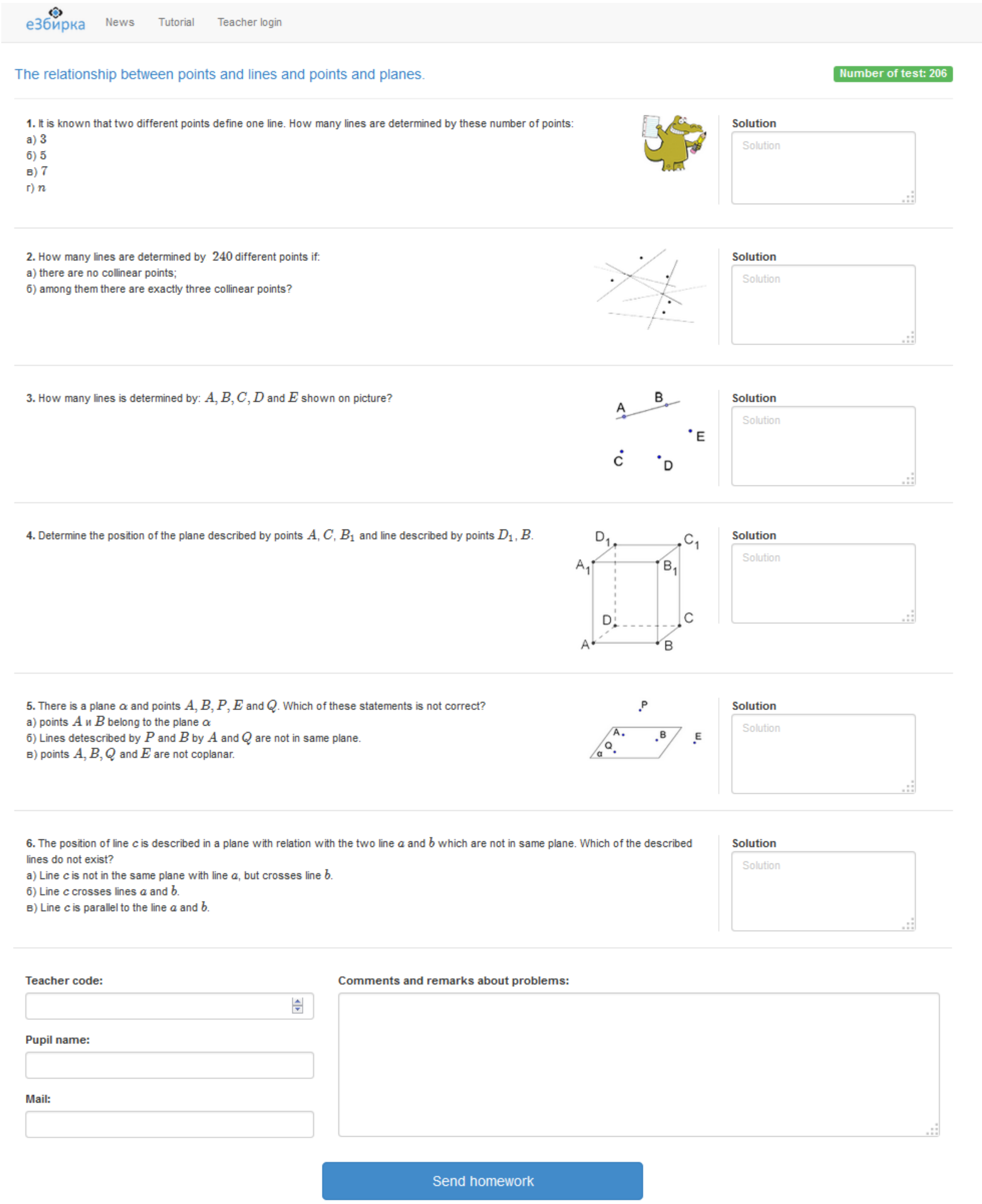


Figure 3. An example of homework for the teaching unit "The relationship between points and lines and points and planes" for pupils in the eighth grade

4.2 Pilot results

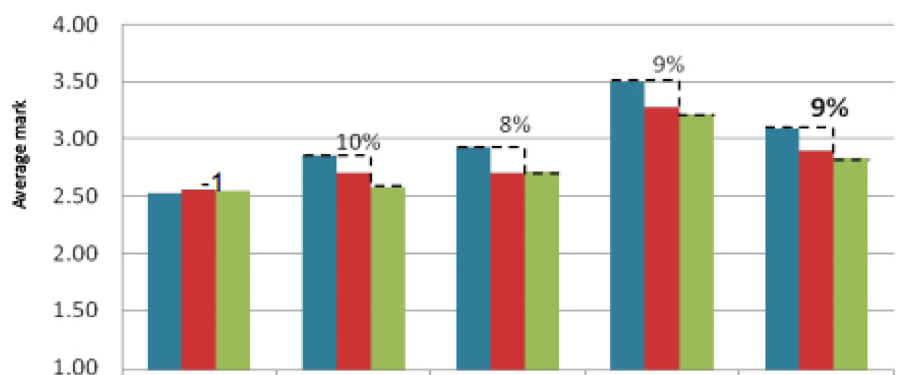
The results of the pilot testing indicate an increasing knowledge for students after using the platform eZbirka (Dramićanin, 2014). During the pilot study, students (88 of them) were divided into three different groups for a period of two months, in order to determine the effect of the platform eZbirka on students' knowledge. Students were divided into groups based on homework activity (Radović, 2014c):

1. The first group used the platform eZbirka after each teaching unit. Into the box for entering a solution, students were obliged to write, not only a final solution, but also to describe their

problem solving of the task. When they did not know how to solve the problem, then they could write what the obstacle was in solving the tasks. Then, after each unit, the teacher used those comments in order to improve her/his practice and to correct any misunderstandings in the knowledge of students.

2. The second group also used eZbirka in homework activities, but they wrote only the final solution. The teacher was able to see whether they were doing homework or not, but the teacher could not find the cause of the problem (for example, whether it was only a computation error or whether students misunderstood mathematical concepts and relationships).
3. The third group was the control group, with the teacher working with students without using the eZbirka platform .

At the beginning of the experimental study, the pupils did a test, in order to measure their knowledge (results are shown in the ‘I mark Test’ column, in Figure 4). During the experimental work they had two written test assessments, after the fourth (shown as the ‘II mark Test’) and after the seventh week (shown as the ‘III mark Test’) of the study. Both tests were made up of five tasks, with 45 minutes given to solve these problems. At the end of the experimental period, the teacher assessed the activity of students in class (shown as ‘IV mark Activity on class’). The overall results are shown in Figure 4.



	I mark Test (before)	II mark Test	III mark Test	IV mark Activity on class	Average mark
1. Experimental group	2.52	2.85	2.93	3.50	3.09
2. Experimental group	2.56	2.70	2.70	3.28	2.89
3. Control group	2.55	2.58	2.71	3.21	2.83
	-1%	10%	8%	9%	9%

Figure 4. Graphical presentation of the average mark increases for classes that were using the platform eZbirka in different ways (Dramićanin, 2014)

Students who did their homework using eZbirka, and who, next to their solutions, also wrote feedback about the proces of doing the task, gained better results by 9% in a test compared with students who did homework in the traditional way (Dramićanin, 2014). Also, 90% of students who used eZbirka completed every homework.

4.3 Pupil and teacher responses to the system

After studying the results of pupil knowledge improvement, Dramićanin (2014) gathered results of surveys conducted among pupils who used the platform eZbirka for homework activities, in order to explore the impact of the application of the platform eZbirka in teaching from the perspective of pupils. The survey involved pupils from the experimental groups 1 and 2 who responded to 17 statements. Based on their responses, the acceptance of homework practice on the platform eZbirka was identified as being successful, any aversion to the new ways of learning were eliminated, and they believed that eZbirka was useful for them (in the case of 90% of pupils). When pupils sent homework to the teacher, the platform then helped them to compare their solutions with the accurate solution of every task. Pupils recognised the benefits of detecting errors and comparing solutions after sending homework to the teacher (for 78% of pupils). So, in this way, they said they could learn something from their mistakes and they could re-do and send new homework again to the teacher. Dramićanin (2014) found that eZbirka helped pupils to recognise the level of their knowledge (for 71% of pupils). Pupils appreciated that they all received different tasks (and only 10% of pupils did not agree with this). They liked to work with homework on eZbirka (52% of pupils) more than the traditional way of working (although 18% of pupils still appreciated the traditional way of working).

A second survey was conducted to investigate teacher attitude about the effect of the platform eZbirka in mathematics teaching. The study included 80 mathematics teachers from primary and secondary schools who were using the platform eZbirka (Radović et al., 2014d; Golubović, 2014). The survey showed that teachers believed that the use of the platform eZbirka for educational activities had a positive impact on the motivation of students in the learning process (stated by 98.75% of respondents). Teachers believed that, in addition to improving the teaching process, the use of interactive materials from the platform eZbirka were associated with an increase in students' knowledge. Feedback from students after each homework session gave them the opportunity to discover misunderstandings in knowledge in the earliest stages of learning (stated by 97.5% of respondents). Regarding the motives for the use of ICT in teaching, the respondents stated that the most important thing was raising the quality of teaching, greater student involvement and better achievement of the goals of the class. Teachers pointed out that the students used the materials and completed quests with a lot of enthusiasm (96.25% of respondents), and this is cited as one of the key successes of the platform (Golubović, 2014, pp.30-34).

Based on the width of results so far, the educational platform eZbirka provides a successful example of adapting electronic material to the needs of modern teaching and learning. In addition to improving the teaching process itself, using the platform provided an opportunity for comparative analysis of students' achievement and misunderstandings (Golubović, 2014). The platform is used also by teachers from Montenegro, the Federation of Bosnia and Herzegovina, Macedonia and Croatia, but they cannot use the same organisation of the teaching materials (because their curricula are different), but they write their own tasks and use the information system. All users of the platform eZbirka share the opinion that integration in learning can be of great importance for improving the quality and efficiency of the entire teaching process.

5. How this project compares to practices and developments in the United Kingdom (England)

5.1 The mathematics curriculum

As will be shown in this chapter, a large number of topics and details contained within the mathematics curriculum of the UK (England) coincide with those in Serbia, for the 11 to 14 year-old age range. Pupils of this age follow a curriculum that is taught by subject teachers. Although prior to this age they have been taught largely by a single teacher, at 11 years of age they have moved to secondary schools. In terms of the entire mathematics curriculum, pupils of this age in the UK may be working with a few additional elements, for example: “Design and use an appropriate questionnaire with three or more possible responses to each question; collate and analyse the results to test an hypothesis”. However, there is a large overlap in terms of the subject content and its intentions.

The mathematics curriculum in the UK (England) has been developed over the past 24 years, through a succession of policy documents that have been created and published by government departments and their agencies. In 1990, an initial National Curriculum was created, which was statutory, in that teachers were required by law to provide a curriculum for pupils stated within the programmes of study of the National Curriculum document. The original documents were revised in 1995, followed by the publication of a National Strategy Framework for teaching mathematics in 2000 (DfEE, 2000). All of these previous documents and their content have helped to create the current shape of the mathematics curriculum, as it is defined in 2014.

In terms of the 11- to 14-year-old age range, which is the lower secondary age range in England, the documents have identified for teachers two main strands:

- Attainment targets – the mathematical targets that pupils should be able to attain.
- Programmes of study – the content that teachers should cover for that age range.

In 1990, the National Curriculum for Mathematics was described through 14 separate attainment targets, and for the 11- to 14-year-old age group, possible attainments were defined at levels 3 to 8. In Table 4, the description of each attainment target, and the definition of the lowest and highest levels are shown.

Attainment target	Description of attainment at level 3	Description of attainment at level 8
Using and applying mathematics	Select the materials and the mathematics to use for a task; check results and consider whether they are sensible; explain work being done and record findings systematically; make and test predictions	Devise a mathematical task and make a detailed plan of the work; work methodically, checking information for completeness; consider whether the results are of the right order; make statements of conjecture using ‘if ...then ...’; define, reason, prove and disprove
Number	Read, write and order numbers to at least 1000; use the knowledge that the position of a digit indicates its value; use decimal notation as the conventional way of recording in money; appreciate the meaning of negative whole numbers in familiar contexts	Express numbers in standard index form using positive and negative integer powers of 10; use index notation to represent powers and roots

Attainment target	Description of attainment at level 3	Description of attainment at level 8
Number 1	Know and use addition and subtraction number facts to 20 (including zero); solve problems involving multiplication or division of whole numbers or money, using a calculator where necessary; know and use multiplication facts up to 5x5, and all those in 2, 5 and 10 multiplication tables	Calculate with numbers in standard form (with positive and negative powers of 10); substitute negative numbers into formulae involving addition, subtraction, multiplication and division; calculate with fractions
Number 2	Recognise that the first digit is the most important in indicating the size of a number, and approximate to the nearest 10 or 100; understand 'remainders' given the context of calculation, and know whether to round up or down	Make use of estimation and approximation to check that the results of calculations are of the right order
Number/algebra	Explain number patterns and predict subsequent numbers where appropriate; find number patterns and equivalent forms of 2-digit numbers and use these to perform mental calculations; recognise whole numbers which are exactly divisible by 2, 5 and 10	Understand the relationships between powers and roots; understand the role of a counter-example in the context of rules for sequences and in disproving hypotheses
Algebra 1	Deal with inputs to and outputs from simple function machines	Manipulate simple algebraic expressions; solve a variety of linear and other inequalities; understand and use a range of formulae and functions
Algebra 2	<no indicators stated>	Know the form of graphs of quadratic functions and simple reciprocal functions; use straight-line graphs to locate regions given by linear inequalities
Measures	Use a wider range of metric units; choose and use appropriate units and instruments in a variety of situations, interpreting numbers on a range of measuring instruments; make estimates based on familiar units	Carry out calculations using length, area and volume in plane and solid shapes; distinguish between the formulae for perimeter, area and volume by considering dimensions
Shape and space 1	Sort 2-D and 3-D shapes in different ways and give reasons for each method of sorting	Use sine, cosine and tangent in right-angled triangles in two dimensions
Shape and space 2	Recognise the (reflective) symmetry in a variety of shapes in 2 and 3 dimensions; understand eight points of the compass; use clockwise and anti-clockwise appropriately	Understand and use mathematical similarity; know that angles remain unchanged and corresponding sides are in the same ratio; understand and use vector notation
Handling data 1	Extract specific pieces of information from tables and lists; enter and access information in a simple database	Design and use an appropriate questionnaire with three or more possible responses to each question; collate and analyse the results to test an hypothesis; construct a cumulative frequency table

Attainment target	Description of attainment at level 3	Description of attainment at level 8
Handling data 2	Construct and interpret bar charts; create and interpret graphs (pictograms) where the symbol represents a group of units	Construct a cumulative frequency curve using the upper boundary of the class interval; find the median, the upper quartile, the lower quartile and the interquartile range; interpret the results
Handling data 3	Place events in order of 'likelihood' and use appropriate words to identify the chance; understand and use the idea of 'evens' and say whether events are more or less likely than this; distinguish between 'fair' and 'unfair'	Understand that when dealing with 2 independent events, the probability of them both happening is less than the probability of either of them happening (unless the probability is 0 or 1); calculate the probability of a combined event given the probability of 2 independent events and illustrate combined probabilities of several events using tabulations or tree-diagrams

Table 4. Attainment targets and low and high attainment levels expected for 11- to 14-year-old pupils (Mathematics in the National Curriculum, 1989)

By 2001, a more extensive framework for mathematics teaching and learning had been created and was published by the then government department for education (*Key Stage 3 National Strategy Framework for teaching mathematics: Years 7, 8 and 9*). This framework specifically covered the 11- to 14-year-old age range. This document highlighted the need to: "spend a high proportion of each lesson in direct teaching, often of the whole class, but also of groups and of individuals" (p.26). The guidance stated that:

> *... good direct teaching is achieved by balancing different teaching strategies: directing and telling; demonstrating and modelling; explaining and illustrating; questioning and discussing; exploring and investigating; consolidating and embedding; reflecting and evaluating; and summarising and reminding." (pp.26-27)*

In this document the mathematics curriculum was described through six strands:

- "Using and applying mathematics to solve problems (problem solving and applications in a variety of contexts to develop reasoning, thinking and communication skills).
- "Numbers and the number system (place value, ordering and rounding; integers, powers and roots; fractions, decimals, percentages, ratio and proportion).
- "Calculations (number operations and the relationships between them; mental methods and rapid recall of number facts; written methods; calculator methods; checking results).
- "Algebra (equations, formulae and identities; sequences, functions and graphs).
- "Shape, space and measures (geometrical reasoning: lines, angles and shapes; transformations; coordinates; constructions and loci; measures and mensuration).
- "Handling data (specifying a problem, planning and collecting data; processing and representing data; interpreting and discussing results; probability)." (p.45)

This 290-page document provided teachers with detailed examples, and suggestions for plans of how to implement this curriculum within a school timetable. By 2013, the government department of education had reduced the document providing details of the mathematics curriculum to, by comparison, a mere 9 pages. The aims are clearly stated, that all pupils:

- *"...become **fluent** in the fundamentals of mathematics, including through varied and frequent practice with increasingly complex problems over time, so that pupils develop conceptual understanding and the ability to recall and apply knowledge rapidly and accurately.*

- ***"reason mathematically** by following a line of enquiry, conjecturing relationships and generalisations, and developing an argument, justification or proof using mathematical language.*
- *"can **solve problems** by applying their mathematics to a variety of routine and non-routine problems with increasing sophistication, including breaking down problems into a series of simpler steps and persevering in seeking solutions." (p.2)*

Subject content is grouped in this latest curriculum into six strands: number; algebra; ratio, proportion and rates of change; geometry and measures; probability; and statistics.

5.2 Technological developments to support mathematics education

Just as the curriculum documentation and guidance for teachers and for teaching have shifted over the last 25 years, so has the focus and integration of technology (ICT). At the outset of the national curriculum, a range of small-scale software programs were developed, and some of these became used widely across schools. Some programs were developed by the Shell Centre for Mathematical Education at Nottingham University (2013) and by the SMILE project (Secondary Mathematics Individualised Learning Experiment, which collected resources from the 1970s onwards). Harris and Preston (1993) conducted a survey of how software was being used in schools at that time, and their study showed that, for mathematics in secondary schools (11- to 16-year-old pupils):

- 36% of teachers had access to a single computer, 21% to multiple units, and 43% to networks.
- Over 70% were using word processing software, and about 30% were using desk-top publishing software.
- Nearly 90% were using database software, and about 90% were using spreadsheets.
- Nearly 60% were using adventure or simulation software.
- Nearly 80% indicated that software was 'useful' or 'very useful'.

The development and use of software in mathematics teaching and learning, therefore, was initiated at a quite early stage in the UK. By the mid-1990s, much larger-scale programs had been developed, covering the entire width of a mathematics curriculum. Called integrated learning systems (ILSs), they were first developed and used within schools in the United States of America (USA), and then later used within schools in the UK (explained in more detail in Underwood and Brown, 1997). By 2001, the publication of the *Key Stage 3 National Strategy Framework for teaching mathematics: Years 7, 8 and 9* (DfEE, 2001) was coupled with initiatives to develop wide-scale online resources to support the entirety of a curriculum. RM was the company responsible for developing this range of resources to support the teaching of the mathematics curriculum for 11- to 14-year-old pupils. The difference between this latter resource and ILSs was basically in terms of the focus of the user - for ILSs, the user was the learner; for the RM *MathsAlive* resources, the user was the teacher:

> *The digital resources ... provided teachers with video openers (for watching and listening to), mental starters (tackling short problems with quick-fire or timed responses), specifically created interactive whiteboard screens (covering a specific topic or mathematical problem using features such as cover and uncover), main activities (up to about an hour in length and using additional physical resources such as counters or bricks), worksheets (mainly of a textual nature, for printing off and completion), games (using full multimedia and involving groups or teams competing against the clock or each other), and assessment exercises (designed to identify attainment levels). The resources were designed for easy access and use on interactive whiteboards, as well as for use in computer suites or computer clusters where learners could access resources more individually. Some graphical calculator activities were also available, and schools could set up pupil access beyond the school. Access to all resources was supported through an ICT-based management system, a virtual teaching and learning environment through which teachers could select digital resources. (Passey, 2011, p.47)*

Other significant technological developments since that time have sought to support the teaching and learning of mathematics. For example, there has been wide deployment of interactive whiteboards in many schools, and across many classrooms, and a range of authors have reported on the affordances provided by interactive whiteboards in supporting the learning of mathematics (for example, Hennessy, 2011) and those from uses of games consoles (for example, Miller and Robertson, 2011). There have been more recent technological developments too, such as those arising through the Economic and Social Research Council (ESRC)-funded TEL programme, that have focused on development of software to support generalisation of thinking about algebra (Mavrikis, Noss, Hoyles and Geraniou, 2012), and uses of touch-table environments to enhance collaborative learning (Higgins, Mercier, Burd and Joyce-Gibbons, 2012).

If the range of resources that have been developed and used in mathematics education for the 11- to 14-year-old age group is compared to the categories of technologically-based resources that are accessible to teachers, learners and parents (identified by Passey, 2014), then it is clear that some categories of resources to support mathematics teaching and learning have been developed to greater extents than have others (as shown in Table 5).

Category of digital resource	Author estimates of resource development	Examples
Topic-specific resources and software	A great deal of these forms of resource have been developed, from the 1970s onwards, and are still used today	Mathematix NovoMath, Cabri
Curriculum-wide learner-centred software	Some large-scale packages were commonly used in the mid-1990s, but their use has diminished over time	Plato, SuccessMaker, SuccessMaker Enterprise, Cognitive Tutor software
Curriculum-wide teacher-centred software	Few large-scale packages have been produced, used in some schools	MathsAlive
Software involving and supporting parents	The resources that exist tend to be online resources that can be used in homes, but are not largely designed to support home activities	EducationCity, Mathletics, PurpleMash
Online resources supporting curriculum-wide needs	These forms of resources, accessible in the forms such as MOOCs, are increasing in number	Espresso Education KhanAcademy,
Online resources supporting revision needs	There was wide development of these resources around the mid-2000s, and some have persisted in use	BBC Bitesize, SAM Learning, Zombie Division, BuzzMath
Online learner support	These forms of facility are increasing in number and range	K12, Maths Doctor
Project and after-school club activities involving digital technologies	Few activities and facilities of this type exist, that focus specifically on mathematics	-

Table 5. Categories of digital technologies and author estimates of levels of development

From an overview of these forms of resource, it is clear that most resources have focused on uses by either learners, or by teachers. Few resources have been developed that have focused on collaborative learning, whether this is with peers, or at home, with peers or family. Similarly, these resources have not appeared to link aspects of school and home activities dynamically.

5.3 Mathematics and homework

Homework has been a traditional form of support practice in schools in the UK. Indeed the *Key Stage 3 National Strategy Framework for teaching mathematics: Years 7, 8 and 9* (DfEE, 2001) stated that, for mathematics, teachers should: "set regular homework, modifying its presentation for any pupils who need this. Homework will usually be short and focused, with varied and interesting tasks that motivate pupils, stimulate their learning and foster different study skills" (p.30). In offering guidance on types of tasks that could be undertaken, the document went on to say that:

> *...not every piece of homework needs to be written work that has to be marked, though it still needs an acknowledgement to show pupils that their efforts are valued. For example: you could discuss a problem briefly in the plenary part of a lesson and ask pupils to tackle it in preparation in the next lesson...; in preparation for the next lesson you could ask pupils to gather data from secondary sources or the Internet, or they could take a set of measurements. (p.31)*

Websites now exist that provide specific guidance and sources to support and encourage mathematics homework (see eHow, 2014, for example). Some schools now openly display their websites and digital resources that focus on mathematics homework for their learners (see Toot Hill Online, 2014, for example). In the context of learning arising from homework, a fairly recent white paper (Herrig, n.d.) reviews the research evidence about the value of homework on learning, stating that:

> *The general conclusions from multiple research studies suggest that although there is some positive correlation between homework and achievement, it varies by grade level, amount, and type of homework assigned. Generally, the positive effect homework has on achievement appears to be almost nil at the elementary levels, increasing slightly for upper elementary and middle school-age students, with the greatest impact for high school students. While no clear pattern emerged from these studies that homework is more effective in some subjects than others, although some studies showed homework is more effective for math. (p.3)*

What is clear from this review, and other previous reviews, is that age, amount and types of homework have an effect on outcomes. Looking at research about the outcomes of digital technologies on learners and learning across a broad spectrum, a conclusion that can be drawn is that the support mechanisms that are in place are important, and not just the presence of the technologies themselves. This being the case, therefore, it is not surprising to find that younger learners can gain from use of digital technologies when they work with their parents, exploring through activities subjects such as reading and mathematics (see, for example, the outcomes of uses of online resources such as *Mathletics* with younger learners and their parents, described in Passey, 2014). What is important in this case, is that there can be value gained when learning can happen through forms of participation, and where there can be linkage to and feedback from teachers when issues or problems are identified, or to reinforce success.

6. CONCLUSIONS

This paper has considered the ways that mathematics education for 11- to 14-year-old pupils is defined, described and undertaken in two different countries, Serbia and the UK (England). This paper has described the initiatives that have enabled teachers and pupils to have access to technologies and to be involved in homework practices, as well as the forms of technologies that enable this. By comparing the situations in the two countries, a range of key points arise.

Mathematics as a subject in school is considered internationally to be important. Homework is considered in many countries to offer benefits for pupils and their education. However, there have been comparatively few studies that have focused specifically on homework in mathematics. Similarly, the use of technologies has been considered to offer benefits to pupils in their learning of mathematics.

There are similarities in the school systems in Serbia and in the United Kingdom (England). Subject-based instruction is common for the 11- to 14-year-old age group in both countries. The testing of pupils in mathematics now occurs more regularly in Serbia than it does in the UK. However, teacher training is rather different; in Serbia teachers are trained largely in a subject domain, while in England teachers are taught about education and teaching practice to a greater extent. However, the school system in Serbia is undergoing a range of reforms and initiatives that are concerned with modernisation.

ICT in schools has been relatively recently introduced in Serbia, while in England schools have been involved in using ICT for the past 25 years or more. However, in both countries, technologies are still being used to explore and address key educational problems. The later uptake of technologies in Serbia does not mean that creative developments are not happening. Indeed, the eZbirka development has focused on mathematics education and homework, while developments in technologies in other counties including England have not addressed this concern in the same way.

What makes the eZbirka platform different from other technological solutions is the facilities that provide opportunities for pupils to record their solutions online, and the ways that these are then accessible to teachers, so that they can gain feedback about how well pupils are performing, and pick up on issues and problems that they face. The issues and problems that pupils identify can be referred to by teachers in subsequent lessons, so that misunderstandings or lack of techniques do not continue. In this way, reference to pupil issues and problems by their teachers is enhancing a vital need for learning. Pupils are asked to detail their learning as it is happening (importantly – at the point of trialling learning), and then they, with their peers or with their teachers, can reflect on this learning in order to support success and to address weaknesses. Pupils can also contact each other and participate in deriving answers to problems they are set, so joint working is being encouraged; peer learning is being enhanced as a positive mechanism.

The use of the eZbirka platform compares dramatically with the processes involved in the integrated learning system (ILS) approaches of the mid-1990s, where feedback and links to teachers and other in-class learning was not easily made. In an ILS, pupils produced answers to problems, but they were not asked to detail their solutions, or provide comment to their teachers on issues they faced. Teachers had access to a reporting system that indicated correct or incorrect responses, but no detail of where issues arose was collected at the time the problems were undertaken.

The use of the eZbirka platform is clearly supporting concepts and practices of how formal and informal learning settings can be integrated rather than just linked. The value of this integration of informal and formal needs and practices is beginning to be identified through pilot research studies, and results to indicate that both pupils and teachers see value and benefits in the system. A small-scale pilot research study also suggests that mathematical results in tests are improving.

Using the categories of technological resources considered earlier (Passey, 2014), it is clear to see that the ways in which eZbirka is supporting mathematics education leads to an overlap across a number of these technology resource categories. More than one of these categories is involved, as shown in Table 6.

Category of digital resource	eZbirka facilities
Topic-specific resources and software	The platform provides many subject topic resources that can be selected by teachers for pupils
Curriculum-wide learner-centred software	The platform provides curriculum-wide coverage, but the pattern of use and access is determined by the teacher rather than by the management system, although the management system provides randomised tasks at a pupil level
Curriculum-wide teacher-centred software	The platform is designed for use by teachers, and to cover a wide curriculum
Software involving and supporting parents	Although it is not necessary for parents to be involved, parents could be involved when pupils undertake tasks at home
Online resources supporting curriculum-wide needs	These resources are accessible online, through desk-top as well as mobile systems, and can also be printed out by teachers if pupils do not have ICT access at home
Online resources supporting revision needs	The resources are designed to support practice as well as revision, and tasks ask for more detail about pupil approaches to solutions where possible
Online learner support	The support provided by teachers happens in class rather than online, but teachers gain details through the online system
Project and after-school club activities involving digital technologies	This category is not covered by the facilities

Table 6. Categories of digital technology resources where eZbirka provides learning facilities

This platform provides resources that cover 7 out of the 8 categories, which indicates that the resources from eZbrika consider support for learning through a wide range of approaches, rather than through a narrow set. The linkage provided, for teachers, pupils, and potentially parents, means that the platform goes further than providing a means of communication. The platform is addressing an issue of homework practice, and at the same time is capturing success and issues with mathematics at the time tasks are attempted, and enabling these to be viewed at a pupil and group level by teachers, so that they can consider and address these in subsequent lessons. Figure 5 illustrates how the eZbrika platform is enabling this shift – from a connection of formal and informal learning settings and practices, to a linking of practices through the formal and informal settings.

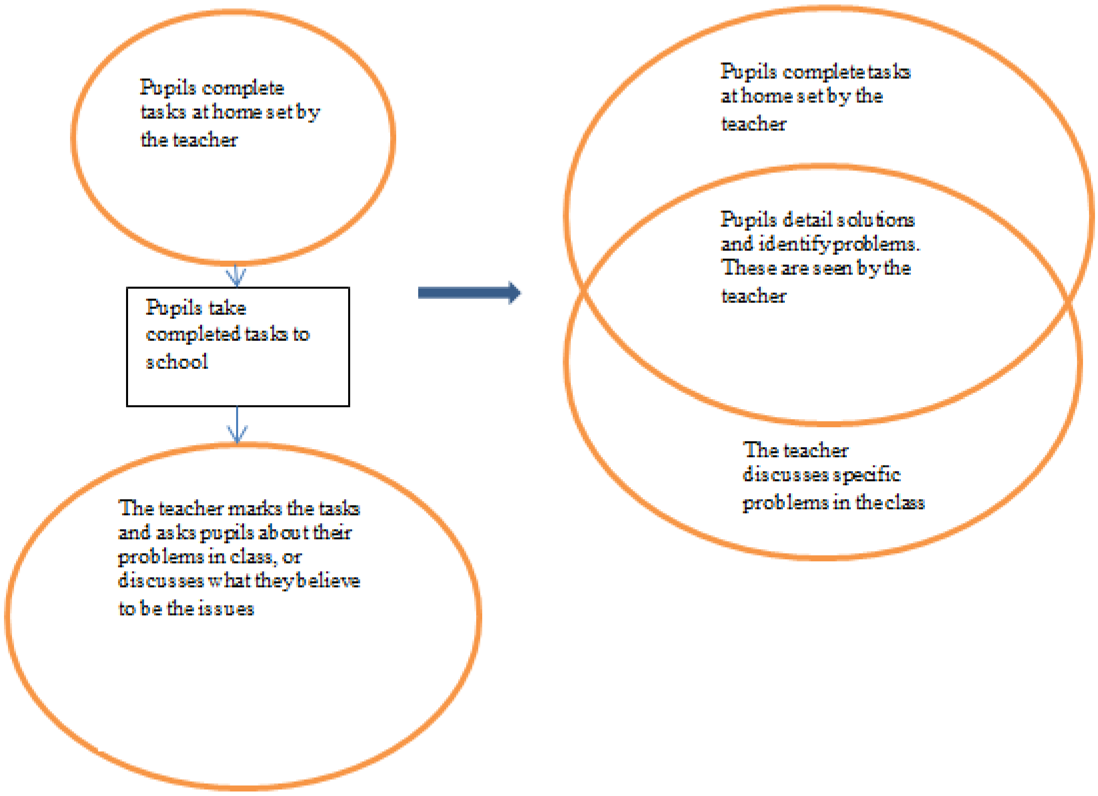


Figure 5. Moving formal and informal learning connections to formal and informal learning links

The platform eZbirka allows us to consider what might have been conceived to be separate learning practices within formal and informal learning settings as a more integrated concept of supported and reflective learning. The facilities within the platform allow a focus on essential learning concerns: practice; revision; identification of success and issues; reflection; and refocusing. It is quite possible that the ICT is providing here a more neutral medium, which will allow pupils to reflect more 'coldly' on issues and challenges; they might otherwise have difficulty in discussing such issues in a face-to-face way. If this is the case, then this platform medium is taking an important step in moving concerns of pupils from 'the need to produce right answers' to 'the use of their issues to support their learning'.

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