CREATIVE LITTLE SCIENTISTS: Enabling Creativity through Science and Mathematics in Preschool and First Years of Primary Education

D2.2 Conceptual Framework

ADDENDUM 4 of 4:

Literature Review of Comparative Education

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The project CREATIVE LITTLE SCIENTISTS has received funding from the European Union Seventh Framework Programme (FP7/2007-2013) under grant agreement n° 289081.

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Project Information
Project no. 289081
Project acronym: CreativeLittleScientists
Start date of project: 01/10/2011
Duration: 30 months
Project title:

Creative Little Scientists: Enabling Creativity through Science and Mathematics in Preschool and First Years of Primary Education

EU Strategic Objective
Funding scheme: FP7/ CP/ Capacities
Call ID: FP7-Science-In-Society-2011-1
Topic: SiS.2011.2.2.3-1 Science and mathematics-related activities carried out in pre-school and in the first years of primary school: their link to the development of creative skills

Information about the deliverable
Dissemination level: **PUBLIC**
Due date of deliverable: March 2012
Actual submission date: 31/03/2012
Deliverable title:

D2.2 Conceptual Framework

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A. Introduction

A1. Conducting review

This review has been created for the working purpose of the CLS project to add and strengthen the understanding of comparative education. The area is rather unfamiliar among the project partners except for some research and teaching experiences in the area of comparative education. In the first phase the task leaders created the outline for the task and it was reviewed by other task leaders in WP2. The outline was described in detail in guidelines for WP2 and delivered for all partners.

The review is based on the research and policy material provided by project partners and the task leaders. The material provided by the other project partners were uploaded from the drop box and reviewed carefully by the authors. The relevant references were quoted systematically according to the structure of the outline. The subheadings were added during the writing process when the descriptions sharpened. This review does not cover the area of comparative education from all sides, but the main dimensions and features are described in terms of the purpose of the project.

All the references provided by the project partners were scrutinised. Thus in this review the rubrics of the references are not used systematically, because authors had to read all material originally to become familiar with the provided and used material. Some of the material provided did not focus on comparative education in the manner considered in the review and thus those articles are excluded. These references mainly focused on international comparisons without having international aspects of comparing educational issues.

The first draft of the review was reviewed by the project partners. All comments were collected into the review document and worked on as much as was possible in terms of human and time resources.

The conclusion of this review is structured as agreed with task leaders to provide exact and prompt material for producing the deliverable 2.2 for the WP2. The final statements are created based on the material used in the review and thus are exposed to further discussion.

A2. A historical overview of comparative education

The field of educational research called Comparative Education is considered as being born in the 1950's when the first conference of *comparative education society* was held (Swing, 2006). However, there exist earlier phases, which have dominated the definition of comparative education. Initially comparative education was linked to the question of education in different countries, with a strongly societal and cultural viewpoint. In the initial phase comparative education was concentrated on education in Asia, Africa and countries of the Middle East, and university programs focused on the education in these countries, which were characterized by poverty, the need for nation-building and a

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predominance of development assistance agencies as conduits for education policy dialogue. The definitions and boundaries and configurations of the field of comparative education have changed since its beginning and have been reshaped since, influenced by the way in which educational policy in societies developed. Thus, the trends of comparative education have reflected the changes to the economical world, as well as with the development of distinct conceptions of knowledge (Halls, 1990; Novoa and Yariv Mashal, 2003; Swing, 2006).

There appear to be specific periods during which comparative education gained legitimacy and popularity. Novoa and Yariv-Mashal (2003) describe how the 1880s is known as *"Knowing the other"* - as it reflected a curiosity to know about other countries and educational processes. The 1920s can be titled *"Understanding the other",* when different forms of knowledge production, schooling and education were compared through international cooperation. The post-colonial period witnessed a renewal of comparative approaches with the 1960s referring to *"Constructing the other"*. In this period education was considered a main source of social and economic progress and thus new educational systems were disseminated through comparative studies of different countries and regions. In 2000 comparisons are named as *"Measuring the other".* This major focus of comparative education is inspired by a need to create international tools and comparative indicators to measure the efficiency and the quality of education. These tasks are achieved by investigating the questions which are considered important at societal level, but also those questions relating to teaching and learning within school contexts. (Novoa and Yariv-Mashal, 2003.)

By the end of this decade, the field has evolved into comparative *and* international education, with a composition of researchers and practitioners who are multi-disciplinary, cross-national and international in orientation (Steiner-Khamsi and deJong-Lambert, 2006). However, the difference between the concepts of *comparative education* and *international education* has not always been clear, and thus in this review, we firstly aim to provide insight, with the aim of establishing the definition of comparative education. There generally seems to be three basic aspects which need to be considered with respect to comparative education and which are to be clarified in this review. Firstly, there is the need to define comparative education and its role in comparative research. Secondly, we need to identify the aims of comparative education, and thirdly we highlight the strengths and challenges of comparative education and comparative research. In this review the questions are first discussed in general and later it focuses particularly on the research areas of Creative Little Scientist project: science and mathematics education, creativity education and later teacher education.

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A3. Definition of comparative education and comparative research

Comparative education focuses on three main areas: 1) education in foreign countries, 2) comparative education and 3) international education. Education in foreign countries is based on the national descriptions of the country, which can implicitly attempt to influence policy or practice of another country using results from that country. Comparative education can be defined 1) through research programs that studies one country or region at a time within the context of a broader agenda using such studies to compare the results of the studies across time and space, 2) international research that builds on others' studies of the same issues, with the intent to constructing a larger comparative study on that theme, 3) comparative education studies various countries or regions using the same methods of data collection and analysis, 4) comparative education can use large international data sets already available or create international data set from national data sources, and then analyse those data comparatively. The perspectives of comparative education and international education are often interrelated, because taking an international perspective in research many times demands comparing aspects which are not specific to one's own national system (See Carnoy, 2006.). However, in sub-areas of comparative education intra-educational and intra-cultural analysis is accepted. In these studies comparison focuses on the education at the various levels, and also systematic research considers, for example, the historical, social, cultural, political forces, and compares the resultant outcomes in two or more systems, areas or even globally. This approach can also be thematic (Halls, 1990.).

A different definition for comparative education and which had already evolved from the 50's focused on two areas: thematic studies and area studies (Bereday, 1957 in Välimaa, 2010). In thematic research some contents or phenomena are compared in different places while in area studies the focus is on some particular area or country. Currently, it seems that comparative education research is a combination of these two. Thematic issues are considered and researched from several country perspectives and comparisons can range from ethnic, age, religious to gender groups (Arnove, 2007).

In last decades, reports and reviews in the field of comparative education have expanded, because of increasing number of journals. In addition, comparative education is widely institutionalised and specific courses at university level have been carried out. Similarly in terms of international networks and its conferences comparative education is going well (Cowen and Kazamias, 2009). However, mostly research has focused on the school systems of various countries and these studies have derived from comparative studies based on identifying particular indicators. There has also been growing interest towards third world countries and describing their national school systems. This discussion has given rise to a critique

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on how well the descriptions of the school system of one country are presented in the area of comparative education (also called education *abroad*). Thus one criteria of comparative education is that studies or reviews should compare at least two countries.

International assessments are designed to measure learning in multiple countries. Their aims include: (a) cross-national comparisons that target a variety of educational policy issues; (b) provision of 'league tables' that rank-order achievement scores by nation or region or other variables; and (c) within-country analyses that are then compared to how other countries operate at a sub-national level. These studies present the sub-area of comparative education called comparative pedagogy. Comparative pedagogy aims to identify processes of teaching and learning within schools and classrooms in different countries. These studies or reviews mainly focus on one particular theme.

International education has been reviewed from two sub-areas. *International pedagogy* is the study of teaching multinational, multicultural and education of linguistics minorities. This area researches also the international understanding of peace education and ecological education aiming to formulate international teaching norms. The second sub-area is called *study of the work of international education institutions.* This area overlaps with the first one, but is more concerned with policy matters, such as establishment of international qualifications and promoting international exchanges and agreements (Halls, 1990: 24.). It would appear that current initiatives in comparative education are often like cross-cultural studies in which the particular phenomenon is investigated in different contexts (see Gordon and Lahelma, 2004).

Comparative studies have moved in practice increasingly away from descriptive, historical, even philosophical function to one that is interpretive, etiological and lays claim even to be predictive. Thus the definition might then be postulated by the following tasks:

- to provide an educational morphology, i.e. a global description and classification of the various forms of education;
- to determine the relationships and interactions between different aspects or factors in education and between education and society and;
- to distinguish the fundamental conditions of education change and persistence and relate these to ultimate philosophical laws.

Lack of a precise definition of the field of comparative education has continued to block its development. Also the debate on whether comparative education can be defined as a discipline on its own has caused some difficulties in research of this field (see Halls, 1990: 26-27.). In addition, an attempt to place comparative education in the overall context of the study of education encounters difficulties of acceptability. Thus the following typology is presented:

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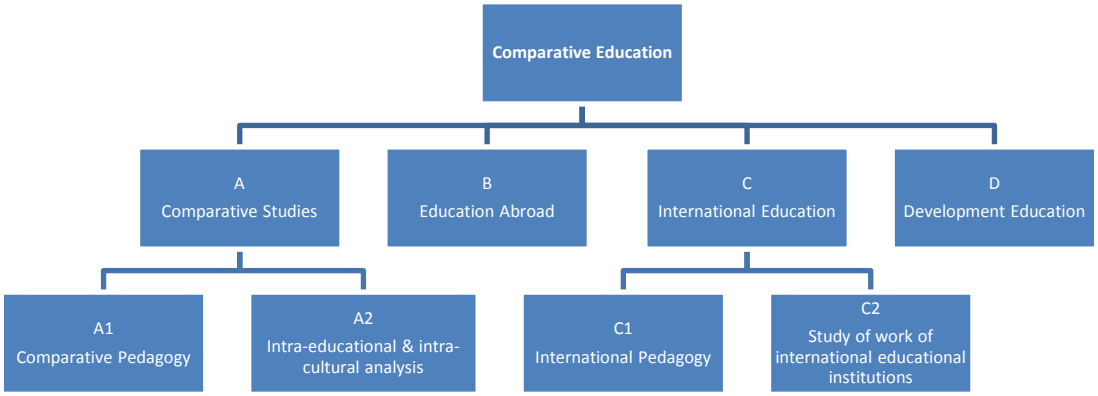

The categories of presented model are not mutually exclusive and there exist overlapping and used terms are not agreed commonly among researchers of the field (Halls, 1990: 23).

A4. Tasks and aims of comparative education

European integration and global competition have increased the need for comparative research. Several international associations and organizations (Eurydice; OECD; CEDEFOP; ETF) have been established to support policy makers in their decisions. The European Union finances such research projects within its member countries, in terms of these aims, in a remarkable way (Keränen, 2001; Novoa and Yariv-Mashal, 2003.).

Research, often done in international contexts and by several international organizations, can have affects on national policy developments, particularly national educational policy. Thus it is significant to understand the role of comparative education and its facets from different perspectives. This has affected both the concept of comparative education as well as that of international study. The link between comparative and international studies is creating educational policy which sometimes determines the role of research as well. Thus comparative education is seen as taking the role of measuring the "other", in which comparative education is used for evaluating the quality or effectiveness of education systems (Novoa and Yariv-Mashal, 2003.).

The role of comparative education in current and future academic debate seems very challenging; there are many questions which focus on the direction and opportunities of comparative education. Based on several research studies it seems that one of the main aims of comparative education and research should be based on localization and derive

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justifications on local experiences. In addition, comparative education has been questioned on how well it takes account the local context and whether they produce a description of the homogeneous reality (Keränen, 2001). It is important to value local specialties and thus accept the differences within a contextual perspective.

One function of comparative education is to define particular shared concepts of the target in different contexts. Individuals in different cultures may think about concepts and problems in different ways and one particular concept could have different meanings in different countries or jurisdictions, but also many societal and pedagogically significant concepts can be understood in several ways. For example, the concept *intelligence* has seen very context dependent issue and its assessment is deeply linked with the cultural and contextual factors such as values, traditional habits, usefulness of knowledge and even physical health (Sternberg, 2007). Moreover the societal orientated concept of *pre-school education* has been under wide review because of variations in the definition of the concept in different countries. The quality of pre-school education has been considered in many countries and jurisdictions for determining the concept and content of education (Niikko and Havu-Nuutinen, 2009; Ojala and Talts, 2007; Sheridan, 2009; Sylva et al., 2006). In addition, the questions of early years education has been under comparison from several viewpoints such as teacher professionalism (Hujala, et al., 2009), technology education (Rasinen, et al., 2009) and children's early numeracy (Aunio, et al., 2008) due to the large variation of the contents and methods of different countries.

Besides the tasks mentioned above, comparative education must also analyse and justify the comparisons made and the methodology used for finding them: how well the structure, culture and geographical location are taken account in the comparisons (Välimaa, 2008.). Based on this analysis, comparative education does not only advocate and evaluate different perspectives, based on different cultural traditions, but also, ultimately, is a multidirectional flow of scholarship and ideas to improve not only educational policy and practice but also to develop the ability to generalize about education-society interactions (Arnove, 2007: 11). This is one of the main aims of this project, Creative Little Scientists. Not only does it aim to provide an international perspective with a review of a number of countries (Greece, Romania, Germany, Portugal, United Kingdom, France, Finland, Belgium and Malta), but it also considers the inter-relationship between the three areas of: science, mathematics and creativity, within early years education. This project, thus, experiences many of the challenges identified within the complexity of early year's education, where there is wide variation even at the level of age ranges, with different countries extending the early years phase to different ages (e.g. 5. 6 or 7 years), and definition of the concepts under research.

One other aim of the comparative study is to help academics and students overcome linguistic and geographic obstacles. The world

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involves a myriad of cultures and languages, which while expressing richness in cultural and linguistic diversity, can also be obstacles for academics and students to understand each other and work together better. This diversity can create misunderstandings and create obstacles which can only be overcome through a level of knowledge of how different countries or regions approach similar issues. Comparative education provides insights into these differences and can act as a bridge to enhance understandings and communication across countries which can only be achieved when there is a good understanding of different systems and ways of working (Arnove, 2007).

In carrying out comparative education, it is also important to ensure that those involved have similar understandings of similar concepts. It is often the case that the same technical terms can have different understandings and values in different national contexts. It is for this reason that attempts at developing glossaries e.g. that developed on Terminology of European education and training policy by CEDEFOP (2008) and quality in education in 2011 (CEDEFOP, 2011) in order that a common reference with which to work is established.

A5. Strengths and challenges of comparative education

Crossley and Watson (2003) have highlighted several challenges in comparative education research, and which must be kept in mind when conducting and assessing comparisons. Comparative education studies are often complicated and generate many challenges. Large scale studies involving gathering of information, whilst at the same time taking into account the cultural context, is not always easy, especially when the data is not accurate. Official data sources provide data which often are general descriptions and aim to show the positive aspects of education. There is also danger that when data is derived out of its context it may not be understood properly and misleading justifications can be made (see also Sternberg, 2007).

In trying to overcome these challenges, comparative education always includes several viewpoints which are taken into account when making deep analysis. However, often in cross-national data it is not possible to take into account all variables and the sample is not always representative. This can cause problems of validity and generalization, and thus theoretical and practical interpretations may have some limitations. In addition, several methodological paradigms such as using the quantitative or qualitative methods regulate the discussion (e.g. Aunio, et al., 2008; Crossley and Watson, 2003). Crossley and Watson (2003) also highlight the educators' or researchers' misconceptions or stereotype conceptions which are often present. Educators or researchers should be aware of their preconceptions because they can affect their understanding of other cultures and results may be biased, thus it is essential to communicate with local experts and with local people. Short visits to another country do not always produce enough relevant information and there are several problems with such an approach. A

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foreigner brings to the study of another system his own cultural prejudices, which may cloud the judgments made and invalidate the conclusions drawn. Thus, the essential condition for carrying out comparative education research is that of establishing research groups where members have appropriate knowledge and skills of their own educational systems and educational research. This aspect is fulfilled in the Creative Little Scientist project as the partnership includes experts from each of the partner countries and it is the local experts who feed information in about their educational context. Even thought the responsibility for compiling transnational data into a single report is carried by one or a few partners, this is always checked by each local expert to ensure that comments and conclusions made reflect actual situations and not prejudiced stereotypes.

The aim of comparative education is to produce descriptions of how the systems of a particular country develop and compare them to many other countries. Even though the results of the comparisons are relevant and done in an accurate way, there is still the challenge of putting them into practice. Global and local aims often differ and cannot be changed easily. In addition, cultural determinants may not capitulate for the demands of other cultures. For example, including foreign elements in the curriculum may not produce the desired results because of local features. Also, understanding the status of the teacher is deeply linked with the task of educating and philosophical thinking on which education is based. There are many different traditions of organizing teacher education, and this can impact on perceptions and conceptions of teaching and learning (see Sternberg, 2007; Hujala, et al., 2009). This in itself justifies the inclusion of approaches to teacher education in the *Creative Little Scientists* project.

A significant element of comparative education is to find and use similar concepts to understand educational phenomena. In comparative education the data and original material comes from different cultures and the concepts used and their contents may differ. Also, there may be cases where people doing the comparison use the same language but due to their different cultural backgrounds may generate different meanings for the particular concept (Crossley and Watson, 2003; see also above). In terms of the project Creative Little Scientists there are several concepts which need to be considered, and for the researchers involved to become aware of their understanding of the contents of the concepts (science education, pre-school education, creative education).These concepts are defined and described precisely in separate tasks of WP2 and considers aspects such as early years, creativity, inquiry etc.

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B. Methodological approaches for comparative education

The first steps of the methodology of comparative education were already developed in the 60's. Comparison is still a relevant method, because it helps open new viewpoints for researching familiar phenomena and opens new insights for developing education. Methodologically, comparative researches are either descriptive in nature or designed to find differences between at least two countries. However, some researchers tend to focus on cause-relations rather than only descriptions while at the same time some researchers see that comparisons must be localized and produce knowledge which is strongly linked to the cultural and historical foundations of the countries. For example, large-scale surveys, like PISA, do not recognize and elaborate the role of language (natural or mathematical) nor cultural dependencies or socioscientific issues, although some background variables, such as attitudes, school traits from school administrators, are available (Andersson, et al., 2010.). Neither does it provide possibilities to analyze developmental trends or the validation of developmental hypotheses (Krapp and Prenzel, 2011). Hence, there are continuous debate about the relevance of qualitative and quantitative methods in comparative studies and interpretations.

B1. Quantitative methods in comparative studies

In recent years, a new set of quantitative studies has emerged, of which the best known are the Programme for International Student Assessment (PISA) investigations organized by OECD. These studies follow conceptualizations of school impact similar to those used by IEA, but differ in their data collection and analysis. IEA uses intact classrooms, and thus analyzes data by grade, whereas PISA gathers and analyzes data by student age. Moreover, PISA studies do not engage in multilevel analysis of schooling effects (Stromquist, 2005.).

The International Association for the Evaluation of Educational Achievement (IEA) is a non-governmental, non-profit organization founded in 1958 that has evolved from a collective of national research institutions to a professional organization. IEA provides international benchmarks that identify strengths and weaknesses in educational systems; provides information on key factors that influence teaching and learning; and that direct educational reforms; develops educational systems' capacity to engage in national strategies for monitoring and improving performance; as well as contributes to research in educational evaluation, developing world-wide network of researchers in this critical area. In its early years, IEA studies were perceived as value-free, empirical, and therefore "scientific," but they were also based on a cross-national comparison, a radical departure from the traditional emphasis on single case studies and historiography used in comparative education up to that time.

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Large-scale, cross-national studies are expensive and tend to be limited in number and the quantitative studies provide limited explanation for variation in individual achievement (Stromquist, 2005). However, international large-scale comparative studies of education help educators view their own systems of education more objectively because factors potentially related to educational achievement have to be defined in a standardized way when using quantitative measurements.

For narrower comparisons questionnaires are common tools for capturing knowledge, conceptions, attitudes and perceptions. Survey studies are used widely in several educational fields, but very often there are challenges of socially desirable responses or translation problems.

B2. Qualitative approaches and case studies

Case studies have often been considered relevant in terms of comparative education research. Case studies are also likely to continue to be the most commonly used approach to study education-society relations. Case studies provide a rich and multidimensional way to theorize comparisons, but at the same time do not limit the possibility of new viewpoints. However, it is to be kept in mind that, in case studies the sample of data is never representative in terms of national education and results of studies cannot be generalized in an accurate way (see Aunio, et al., 2008).

Many of the international comparisons of education provide key data about the issues which can be collected through databases or through school administrators. However, there is lack of instruments or methodological approaches which provide reliable and valid information on several aspects of teaching and learning situations. The reviews provided are associated with the effectiveness of classroom activities such as classroom managements, learning climate and interactions. The instruments are often created for the need of one particular country and thus those need national standardization.

One example of more recent research in comparative education is one which led to the development of a standard observation instrument for comparative research. This was developed by school inspectors, and examined the quality of the mathematics classroom for 9 year olds, comparing four countries United Kingdom, the Netherlands, Germany and Belgium (van de Grift, 2007). The teaching strategies adopted by teachers were put into an operational format in an observation instrument under six quality characteristics, which together comprised of 24 indicators. For every item in this scale, several examples of 'good practice' were formulated. These helped the observer to focus attention on the same aspects. Inspectors had to rate as (1) predominantly weak; (2) more weaknesses than strengths; (3) more strengths than weaknesses; and (4) predominantly strong. This instrument was brief and straightforward and could be completed easily by an inspector during a lesson period of approximately 40 minutes. With over 800 lessons

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observed and evaluated for quality and effectiveness, using this instrument showed how it is possible to measure and compares the common activities of teaching across different cultural and linguistic contexts in valid way (van de Grift, 2007.).

Demerath (2006) suggests five modes through which qualitative researchers in education can respond to this challenge in and through their work. These modes of responses derive from a synthesis of contemporary developments in qualitative methodology in international context, and thus includes several aspects which are relevant in terms of comparative research:

- the Critical Response: Inquiry into the socio-intellectual frameworks and institutional networks driving these policy developments;
- the Instructive Response: Educating peers and policy-makers about key precepts of cultural practice and qualitative methodology;
- the Elucidative Response: Achieving greater transparency in research design, development of inferences and theory, and quality criteria;
- the Pragmatic Response: Mixed or hybrid methodologies;
- the Public Response: Public interest and public access education research.

In summary, in comparative education challenges have been identified in terms of policy-demands and research orientation: data collection methods and research designs are often different for different purposes and thus the debate of qualitative and quantitative approaches should be discussed deeply. According to Sayer (2006), it has become clear, from individual projects, that both qualitative and quantitative shared research is valuable for the project and can in turn be engendered in the process of development work.

B3. Validity aspects of comparative education research

Increased comparative research has not always produced methodologically or theoretically high-quality results, because for example choosing nationalities or geographical countries as a unit of research is not always accurate, for example because of cross-national global educational programs, projects and their effectiveness. All educational questions are not only nation or country based, but more discussed and prepared in international contexts. Sometimes it might be more relevant to make comparison in particular countries than between them. At the same time the challenge of comparative education research remains in the analysis of similarities and differences of research units how the analysis can be conducted using accurate philosophical, theoretical and methodological decisions. The ongoing challenge is to find the theory and respective method which support each other but at same

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time is able to reveal rich and deep information of the context while still supporting the development of theory (see Välimaa, 2011).

As Vavrus and Bartlett (2006) highlight, students and scholars of comparative and international education need to pay greater attention to epistemological issues related to *what* can be known about the world and *how* it can be known through comparative research before attending to the rules and procedures—the methods—used to gain such knowledge.

C. The areas of comparative education in European countries - as well as those beyond

The focus in this review is on young children's learning in the areas of science and mathematics education, the role of creativity in their education, how an inquiry approach is addressed in these particular fields of education and teacher education for the early years. The project Creative Little Scientists belongs to the area of early childhood and primary education. In many countries the early years phase (from 3 to 8 year olds) includes a variability of ages, which form part of compulsory education, and also in the possible existence of a transition from one school culture (often kindergarten/pre-school to primary) to another (OECD, 2006). However, there were already several studies on early childhood education which have especially focused on early years and have described and considered it in several policy reports. The search for a more unified approach to early years has also generated different policy options. For example, the readiness for school approach has been adopted in many French and English speaking countries while social psychology is inherent for Scandinavian and central European countries (OECD, 2006.).

Comparative education has been under consideration quite largely in the area of early childhood education in recent years. Especially IEA (the International Association for the Evaluation of Educational Achievement) has produced several study projects focusing on pre-primary education, science and mathematics (see Leimu, 2004), but these are often quite narrow in terms of developing education or understanding particular educational processes in depth. On the other hand, many more examples of studies in comparative education in the early years were carried out by academics, but there are quite limited number of specific thematic comparative research projects in early years (see Aunio, et al., 2008; Prokop, et al., 2009).The projects attempt to investigate science and mathematics education and the role of creativity in those learning processes. The project Creative Little Scientists aims to compare the current picture in different countries and develop new methods encouraging inquiry and creativity based learning approaches.

International organizations like UNESCO, OECD and the EU are interested in and follow developments in education in general, but they also have a particular interest in science, mathematics and technology education.

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This is, of course, in part due to these subject areas having key roles in modern society, where a science and technology driven economy requires a supply of scientists and engineers for industry driven by research and innovation. There is also interest in these subject areas for cultural and democratic reasons. The Trends in International Mathematics and Science Study (TIMSS) and Programme for International Student Assessment (PISA) evaluations are the two main tools used to measure and compare achievement in mathematics and science across many countries in the World. The values of such measures made are mainly justified by the importance that science and mathematics enjoy in a knowledge based and competitive, technologically oriented global economy. Reports and recommendations from these international organizations have undoubtedly large political importance and are used also when drawing up national policies.

International organisations which have followed developments related to science and technology include the Organisation for Economic Co-operation and Development (OECD) (which also runs the PISA exercise) and the Eurydice network co-ordinated and managed by the EU Education, Audiovisual and Culture Executive Agency in Brussels. The aim of OECD is to promote policies aimed at improving the economic and social well-being of people around the world. It provides a forum in which governments can work together to share experiences and seek solutions to common problems. Science and mathematics education are among the many subject areas on which they have focused. The Eurydice Network, on the other hand provides information on and analyses of European education systems and policies. As from 2011 it consists of 37 national units based in all 33 countries participating in the EU's Lifelong Learning programme (EU Member States, EFTA countries, Croatia and Turkey). They have periodically carried out studies related to science and mathematics education as well as creativity and early childhood education (European Commission, 2006; 2011a; 2011b).

The interest in mathematics and science achievement across different countries, however, tends to be with respect to older students within primary level education and secondary level. There is little measure of science and mathematics comparative research with younger children, specifically those in the early years. The processes used in the TIMSS and PISA comparisons will be described in general, even if these studies relate mainly to students older than those targeted in the Creative Little Scientist -project. The TIMSS and PISA evaluations provide a relevant foundation for the project, because the studies are often used to determine the mathematics and science curriculum more generally, not just for the ages that are tested. The assumption is that we need to lay the foundations in primary in order to achieve the success later.

C1. Comparative education and science education

As already indicated, one finds studies related to science education achievement by TIMMS and PISA as well as the OECD and Eurydice

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network. Whereas TIMMS and PISA focus on student achievement in science as well as mathematics and their relation to educational factors, studies by OECD and the Eurydice network have focused on policies and practices across different countries.

C1.1. TIMMS measures

The Trends in International Mathematics and Science Study (TIMSS) assesses fourth (9-10 years old) and eight graders' (14-15 years old) success in mathematics and science education and collects background information from students, their teachers and schools. Fourth graders are usually 9 years old, that is, just beyond the early years, and thus to a degree, assesses the quality of learning in the previous years. TIMSS data have been collected in 1995, 1999, 2003, and 2007. Another round of evaluation was executed in 2011 in more than 60 countries.

TIMSS 2003 and 2009 were framed by two organizing dimensions or aspects, a content domain and a cognitive domain. There were five content domains in mathematics (number, algebra, measurement, geometry, and data) and five in science (life science, chemistry, physics, earth science, and environmental science). The cognitive domains, four in mathematics (knowing facts and procedures, using concepts, solving routine problems, and reasoning) and three in science (factual knowledge, conceptual understanding, and reasoning and analysis) defined the sets of behaviours expected of students as they engage with the mathematics and science content (See Martin and Mullis, 2004.). Comparing the results of TIMSS 2007 in mathematics and science at age 10, it seems that in content domains pupils are quite similar to one another, while Hong Kong, Singapore and Massachusetts pupils are much stronger in the cognitive domain of knowing in comparison with applying and reasoning. In the case of science, in tasks relating to the knowing domain pupils in Singapore and Massachusetts scored significantly higher than other countries (England, Alberta, United States, Australia and New Zealand) but In applying and reasoning Singapore, Hong Kong and Massachusetts were significantly higher than for example England and Alberta and Australia (Department for Education, 2011.). Thus, cognitive domains especially need further development in school science and mathematics learning and thus are significant in terms of Creative Little Scientist -project.

In 2007, 36 countries participated at grade four and 48 participated at grade eight. The TIMSS 2007 assessment contained 353 items at the fourth grade, including 179 in mathematics and 174 in science. At the eighth grade there were 429 items, 215 in mathematics and 214 items in science. At both grades, the TIMSS 2007 assessment involved assembling the items into 14 booklets, with each student administered a single booklet (Martin et al., 2008). Looking at trends across all of the participating countries, more countries showed improvement in average achievement between their first cycle of participation and TIMSS 2007. At the fourth grade, 11 countries had higher average achievement in 2007

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than in their first TIMSS assessment, 5 had lower average achievement, and 7 showed no significant change. Average science achievement for girls was higher than for boys on average across the TIMSS 2007 countries (Martin et al., 2008).The high performing jurisdictions were Singapore and Massachusetts and Hong Kong which were the three countries in top.

TIMMS 2011 with fourth graders was designed to carry out one comprehensive international assessment of the core curriculum areas—mathematics, science, and reading. Mathematics, science, and reading achievement data on the same cohort of primary-school children, accompanied by information from parents, schools, and teachers, were thought to help countries to:

- determine global educational standing in subjects essential for further learning – reading, mathematics, and science;
- profile relative strengths and weaknesses in reading, mathematics, and science achievement in an international context;
- extend PIRLS and TIMSS trend lines to measure progress over time;
- inform national and local policy about schools' curricula and instruction;
- collect in-depth information about school environments and resources and instruction; and
- examine concerns about equity in learning opportunities(TIMMS and PIRLS International Study Centre, 2011).

TIMSS 2011 results are not available yet.

C1.2. PISA Measures

PISA is an international study which began in the year 2000. Unlike TIMMS which measures also performance at lower levels of education, PISA aims to evaluate education systems worldwide by testing the skills and knowledge of 15-year-old students in participating countries/economies. Since the year 2000 over 70 countries and economies have participated in PISA. The assessment focuses on young people's abilities to apply science and mathematical skills to real life problems and situations. Pisa is not assessing the contents of curricula, but searching the abilities which are needed in society, discipline related literacy skills such as analyzing reasoning and communicating but also solving problems in a variety of contexts (Andersson et al., 2010.). Thus Pisa is firstly aiming to inform policy-decisions, even if it has caused several debates and research interest among educators and probably for one's part increased the interest in comparative education.

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C1.3. Comparative research of structures and policies in science education

OECD and Eurydice have also conducted a number of comparative studies and reviews related to science education and science learning. The PISA exercise captures more than just student achievement, and through a number of questionnaires compiled by participants, parents, schools and other educators, the results in achievement can be viewed in terms of various factors which impact on learning and achievement in science. One study on 'learning time' (OECD, 2011a) draws on data from the 2006 cycle of the Programme of International Student Assessment (PISA), and describes differences across and within countries in how much time students spend studying different subjects, how much time they spend in different types of learning activities, how they allocate their learning time and how they perform academically. It yields interesting trends as the relationship between the average of learning time in regular school lessons is positively, but weakly, related to country average performance, while learning time in out-of-school-time lessons and individual study is negatively related to performance. Such trends help countries when shaping their educational policies related to science education (OECD, 2011a). Pisa 2009 focused on science content domains at age 15. Finland was the highest-performing jurisdiction across all domains followed by Hong Kong and Canada.

OECD also publishes regular reports of statistics and trends focusing on science and innovation within which science education issues such as the number of graduates in science and technology (OECD, 2011b). Other regular publications focus as well on education trends, also among older ages but also including specific sections on science (OECD, 2011c). OECD has, in 2005, also carried another comparative study on teacher recruitment, amongst which science subject teachers were identified as difficult to find when recruiting teachers across many countries (OECD, 2005).

The Eurydice network has also focused on science education, repeating similar study design in 2006 and 2011. The studies (European Commission, 2006; 2011a) focus on policies and practice in science education across different countries. Both primary and secondary level education is included. The early years are not targeted specifically but indirectly due to the later years included as part of the primary compulsory education. The study includes an analysis of difference aspects: existence of national strategies in science education; how it is taught within the primary and secondary cycles; the degree of context-based teaching and hands-on activities; types of assessment used; support for low achievers; investment in teacher skills; as well as initial teacher-training. The most recent Eurydice study (European Commission 2011a) has shown that few European countries have developed a broad strategic framework to raise the profile of science in education and wider society. School partnerships with science-related organisations were

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common across Europe but were very diverse with respect to the areas they cover, how they are organised and the partners involved. However, all partnerships were found to share one or more of the following aims: to promote scientific culture, knowledge and research among students; to improve students' understanding of what science is used for; to strengthen the teaching of science at school and, to increase recruitment to MST (mathematics, science and technology) fields. With respect of what science is learnt, in all European countries, science education begins as one general integrated subject throughout the entire period of primary education. In many countries the same approach is continued for one or two years into lower secondary education with science teaching later split into the separate subjects of biology, chemistry and physics. Only a few countries have implemented specific programmes and projects to further develop gifted and talented pupils and students in the field of science while there is no specific support policy for low achievers in science subjects. Countries which have a strategic framework for the promotion of science education normally include the improvement of science teacher education as one of their objectives. A pilot field survey conducted by part of the study with initial teacher education programmes found that the most important competence addressed in teacher education is the knowledge and ability to teach the official mathematics/science curriculum.

C1.4. Other comparative projects, reports and research in science education by academics

Science achievement, understanding of concepts and children's conceptions are widely studied in literature on science education. Some studies carried out cross-country analysis of the TIMMS and Pisa Results. For example Kaya and Rice (2010) compared the PISA 2003 results for five countries: USA, Singapore, Japan, Australia and Scotland. The results showed that selected student background characteristics were consistently related to elementary science achievement in countries involved at the student level, higher levels of home resources and self-confidence as well as higher levels of class meant home resources yielded higher science achievement. On the other hand, the emphasis on science inquiry was positively related to science achievement in Singapore but negatively related in the USA and Australia (Kaya and Rice, 2010.).

England has published curriculum comparison analysis based on the results of TIMSS, PISA and PIRLS selecting five comparator jurisdictions (Department for Education, 2011.). For the comparison of curriculums of science education the chosen jurisdictions were Alberta, Canada; Hong Kong; Massachusetts, USA; Singapore; and Victoria, Australia. The aim of the analysis was to find similarities and differences between the curricula which could be used for developmental work of the National Curriculum in England. Based on the comparison in science education, the structure and approach of science education cover the same ground in the key domains of biology, chemistry and physics. Earth and space science is

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also included in all curricula, but in Alberta and Massachusetts it is as a separate discipline. All curricula emphasized scientific processes and scientific enquiry both at primary and secondary level. The most significant variations occurred across the reviewed documents in the levels of detail provided. The analysis also showed that there are significant differences in how science curricula are expressed, with most focus on learning outcomes (ibid.).

Several other research reports focused on how a particular scientific phenomena or concept is considered and understood among young learners. However, even if it has been shown in many studies that children's science learning process is culturally distributed, there have been limited researches which compare children's ideas across countries and cultures. The majority of the published studies have been carried out mostly with samples from single countries. In addition, there is lack of comparative perspectives among young learners. Some examples of comparative studies identified have focused on the children's conceptions of animal breathing in Turkey and Slovakia (Prokop et al., 2009), young children's conceptions of human body in several countries (Reiss et al., 2002), children's conceptions of animals and conceptions of landscape in Finland and Russia (Eloranta and Yli-Panula, 2005) and living and non-living things distinctions (Atran, 1994). According to these studies it seems that young children's conceptions of scientific phenomena are context dependent and cultural and geographical determinants such as living environments, media and language impact on the learning outcomes. Thus there seems to be interest among researchers comparing educational pedagogies. These comparative studies focused on the science education highlighting the meaning of cultural characteristics or educational tools used in each country. The pedagogies, methods of instruction but also the societal recourses and environments vary and produce different kind of results (see Prokop et al., 2009; Lindemann- Matthies et al., 2011).

The international comparative study entitled Relevancy of Science Education (ROSE) focuses on the attitudes and interest of secondary level students in the area of science and technology, which takes into account both subject areas of science in a large number of contexts (Sjøberg and Schreider, 2010). ROSE is a cooperative research project with international participation of 40 countries. The purpose of ROSE is to gather and analyze information from the learners about several factors that have a bearing on their attitudes to science and technology and their motivation to learn these phenomena. Concrete examples relates to a variety of science and technology out-of-school experiences, interests in learning different topics in different contexts, prior experiences with and views on school science, views and attitudes to science and scientists in society, future hopes, priorities and aspirations as well at young peoples' feeling of empowerment with regards to environmental challenges, etc. (ibid.) The ROSE tools have been applied across a significant number of countries and the results create many possible interesting comparisons

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between the young generation and the adults across countries in the world. The overall picture is that attitudes to science and technology among adults and young people are mainly positive, but in the richest countries (Northern Europe, Japan) young people are more ambivalent and skeptical than the adults. On the other hand, youths from developing countries still view science as a potential area to help them in their careers as well as their country. There is growing gender difference, with girls, in particular in the richest countries, being more negative (or skeptical, ambivalent) than boys (Sjøberg and Schreiner, 2010.). Similar findings have been found from comparative studies in other fields of science education, for example bioenergy (Halder, et al., 2011). In addition, the results reveal also that school science in many countries fails. Although the results vary across the countries and among the genders the main results can be summarized in the following way: School Science is less interesting than other subject; science has not opened pupils' eyes for new and exciting jobs and has not increased their career chances. Science has not increased their appreciation for nature; it has not taught the pupils how to take care of their health. In addition, science education has not increased pupils' curiosity, nor has it shown them the importance of science and technology for our way of living (Sjøberg and Schreiner, 2010.).

Another type of comparative study related to science education, even if with older age students, is IRIS (Interests and Recruitment in Science), a collaborative EU funded research project addressing the challenge that few young people (women in particular) choose education and a career in science, technology, engineering and mathematics. The target population in this project are university students and the main aims include identifying: the priorities, values and experiences on which young people base their educational choice; the success factors for efforts aimed at recruiting more (female) students to science, technology and mathematics education; and in what proportions, and why, do students opt out of STEM education (Fidler and Dillon, 2011).

In summary, this section has provided a short review of the different types of comparative education carried out in science education. There are international studies which focus on student achievement such as PISA and TIMMS focusing primary and secondary level outcomes. International organisations have also carried out a number of comparative studies looking at policies and practice in science education across a different number of countries, often relating these findings to those for achievement. A number of academics have also been involved in comparative studies, focusing on particular aspects of science education. There was, however, limited focus on science education in the early years. The lowest ages included have tended to be primary education, within which the later stages of early year's education are included. Therefore, there seems to be lack of studies which focus on the educational processes of science learning. International studies often

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remain at the level in which pupils' knowledge or other achievements are scored, but not focusing on how science is approached in classrooms.

C2. Comparative education and mathematics education

As has already been highlighted, science and mathematics education achievement have both been under comparison together since 1960 from the beginning of comparative education itself. The known mathematics achievement comparisons are the named TIMSS and PISA studies in which survey questionnaires have been used to achieve a large body of information. While the PISA provides measures of achievement at age 9-10 years, both the PISA and TIMMS studies focus on compulsory school pupils at secondary level, mainly 15 years old, but taking account 9 years old. Since the measures in mathematics take place concurrently with those in science, information on how these two measures are implemented will not be repeated as they are more or less the same as those for science.

C2.1. Comparative studies in mathematics education by international organisations

Both the OECD and the Eurydice Network have focused on mathematics education when carrying out comparative studies. Using the PISA results, OECD (2010a) has carried out a comparative study on mathematics and teaching and learning strategies across the different participating countries. This highlighted the need for in-depth, context-specific analyses to fully understand each strategy's role in enhancing student performance. Student background emerged as one main determining factor for achievement in mathematics. In a study specifically on early years (OECD, 2006), one finds references to mathematics with respect to policy and curricular analysis across the different countries studied. The focus in this report, however, is more on general provision than on mathematics education in particular.

The Eurydice network has also recently published a study specifically on mathematics education. The study (European Commission, 2011a) focused on curricular approaches, teaching approaches and methods, assessment, supporting low achievers, improving student motivation, teachers' professional development as well as initial teacher training. As in the case of the study on science, trends in compulsory mathematics education including both primary and secondary level have been reviewed. There is, however, no specific focus on the early years and the later years are only indirectly included as a result of the overlap with primary education.

C2.2. Comparative studies in mathematics education by academics

Research studies in mathematics education have been interested and involved in comparative studies in their subject area. For example, ERME, the European Society for Research in Mathematics Education recognize

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the need for transnational studies and have a working group specifically focusing on comparative education. This groups work is surrounding mathematics teaching and learning in the classroom, learners' and teachers' experiences and identities, and policy issues in different cultures and/or countries. This resulted in a number of papers presented at its conferences and which focused also on comparative studies of understanding mathematics in one of their conferences (ERME, 2007). They also have a group focusing on early year's mathematics.

Studies by academics from different countries collaborating together also exist. An issue which has attracted the use of comparative studies, and which relates to a degree to mathematics education in the early years, is that of starting school age of children. An analysis of the top-performing countries in the TIMSS study demonstrated that children who performed best had a school starting age of six, even if this was not considered as evidence of a causal link between later starting and better achievement, because many factors could contribute to the higher achievement demonstrated in these countries (Sharp, 2002).

Comparison in curricula has also been investigated in mathematics education (as well as in science) at the pre-school level as part of comparative studies in early year's education provision. Bertram and Pascal (2002) provide a review of the early years curricular in 20 different countries.

Other studies identified focused on, for example, the quality of teaching in mathematics classrooms with 9 year-old children in four European countries (van der Grift, 2007). According to this study there were no significant differences in quality of teaching such as classroom management, stimulating learning climate, clear instruction, adaptation of teaching, teaching strategies and pupils involvement in mathematics identified between Netherlands, Lower Saxony and Flanders (Belgium). The highest variance between the countries emerged in clear instruction and adaptation of teaching. However, the teachers from England observed had better results than the teachers in all three countries. The researchers explain this difference in terms of special characteristics of the English sample (van der Grift, 2007), not focusing for example on the learning facilities.

The teaching of mathematics has also been the subject of a study carried out by the Netherlands Inspectorate of Education (2009) which focuses on the teaching of primary mathematics in five European countries: Flanders (Belgium), Lower Saxony (Germany), the Slovak Republic, Scotland and the Netherlands. One of the results focused on the time devoted to arithmetic in the different countries, with Flanders, the Netherlands and Scotland, devoting about 5 hours to arithmetic weekly while in Lower Saxony and the Slovak Republic the weekly time for arithmetic was less than 4 hours per week.

Comparative studies with countries beyond Europe, particularly with Asian countries which tend to do well in the TIMMS and PISA measures,

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have been carried out. Ee et al. (2006) focused on the performance of children aged 4–7 years in 3 cities: Singapore, Beijing and Helsinki using the Early Numeracy Test (ENT). A fairly large proportion of the young children had difficulty with seriation tasks, mental counting of large numbers (up to 20) without pointing, backward counting, and counting in steps. Although small, this study showed how readiness skills are easier than formal counting skills to develop among young children, revealing how to best engage young children in meaningful and interesting activities using concrete materials, exciting games, and role plays that use mathematics in daily situations.

Another identified study provided a cross-cultural comparison of preschoolers mathematical skills, showing that mathematical performance differs between Asian and non-Asian children. According to previous studies Chinese and Singapore children outperform their Western peers, such as Finnish and English, in several areas of mathematical skills. These finding are also supported in research using PISA data (Andersson, et al., 2010). However, there are no such gaps between Dutch, English, Flemish and Slovenian children or between Finnish and English in early numeracy. These differences are also seen as the result of societal aspects where mathematical skills tend to be valued more in Asian countries and the learning of it is appreciated more in Asia than Europe. In addition, the language and parents' interest are seen as significant indicators of early numeracy skills (e.g. Aunio et al., 2008).

Similar findings have very much been shown through comparison in how young children's mother tongue influence their mathematical skills. Asian students generally attain higher mathematics achievement than Western students and there are several arguments that all of these early superiorities seem related to the regularity of number words in East Asian languages (Ho and Fuson, 1998). Chinese, Japanese, and Korean (and some other languages) are regular for numbers between 10 and 100 in the same way that English is regular for the hundreds and the thousands: 5,900 is said as "five *thousand* nine *hundred*" in English and East Asian languages, but 59 also is said as "five *ten* nine" in the latter. In contrast, English uses a decade structure (e.g. twenty, thirty, forty, fifty), which obfuscates the meanings of these numbers as two-ten, three-ten, four-ten, and five-ten. In the English number words, learning the teens and using them in addition and subtraction are particularly difficult because of the irregularities (eleven, twelve). Ho and Fuson (1998) conducted a comparative study of 5 year old children in which a total of 20 children in the high-counting-sequences groups (high-CS groups) and 16 in the low-counting-sequences groups (low-CS groups) from China and England were selected for testing on counting sequence and hidden-object addition tasks. All of the Chinese and English children did the 2 + 1 trial correctly without overt counting. Both Chinese and English children were able to add small numbers without great difficulty, no matter whether their counting sequences are high or low. The task of counting sequence, children in the Chinese high-CS group did significantly better than those

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in the English high-CS group. In addition, they gave quick and accurate responses with no or little overt counting to most 10 + y trials. This suggests that the regular Chinese number-word pattern facilitates their calculation and memory of the addition facts for 10 + y sums, even when they do not have full embedded-ten cardinal understanding (Ho and Fuson, 1998).

Influence of cultural factors such as language related differences in number words and schooling and age were investigated among kindergarten, first-, second-, and third-grade children from mainland China and the United States. Psychometric paper-pencil test and information processing tasks were used, capturing the children's component skills (Geary, et al., 1996). The percentage of errors did not differ significantly across groups for either finger counting or verbal counting, but the Chinese children committed significantly fewer retrieval errors than their American peers. In addition, the results of this study support the view that the structure of Asian language and English language number words influences the development of early numerical and arithmetical competencies: 10 structures of Asian language number words facilitates the learning of the 10 based decomposition procedure in Asian children. The challenges of the study focused on the assessment of schooling effect. The quality of instruction, amount of homework and parental support varied in such a level that efforts for mathematical skills of those variables cannot be exactly measured (Geary, et al., 1996.).

In summary, as in the case of science education, comparative research in mathematics education has focused on various aspects, ranging from student achievement (PISA and TIMMS) to policies, practices and other aspects related to quality mathematics education provision. Like science education, early year's education was rarely the focus. Some studies at early year's stage were identified in the case of comparative studies by academics. There was also interest to compare early year's education in mathematics between the Western and Asian world in which cultural and language differences have shown a significant role in mathematical competence.

C3. Comparative education and creativity

Comparative studies on creativity of children have been of interest to academics for many years. Torrance (1969) had already indicated the existence of many comparative studies in the area of creativity. More recently, there have been an increasing number of policy statements and educational projects that have highlighted the role of creativity in school curricula or in educational settings. In May 2007, the European Commission produced a Communication on a European agenda for culture in a globalizing world (European Commission, 2007). The response to this led to the recommendation to encourage art education and active participation in cultural activities to develop creativity and innovation. A Work Plan for Culture 2008-10 (Council of the European

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Union, 2008) was drawn up and the commission also designated 2009 as the *Year of Creativity and Innovation*.

The project *Creative Little Scientists* focuses on the role of creativity in the early years, particularly in science and mathematics education. In addition, creativity is seen as reflecting cultural values and socio-cultural contexts and thus has also become a possible area of focus of comparative education studies. This is mainly because people's implicit theories of creativity reveal their cultural differences and similarities (see Hong and Kang, 2009).

C3.1. Comparative education and creativity education by international organisations

Creativity in itself has attracted limited attention of international organisations such as Eurydice and OECD to carry out comparative studies focused specifically on it. In studies which have been carried out, creativity has not been the main focus of the study, but more as part of Art and Culture education. In fact, two main studies were identified, one by Eurydice, and one by the Joint Research centre. The study by Eurydice focused on Arts and Cultural Education at School in Europe (European Commission, 2009a). The study contains comparative information on the provision of arts and cultural education within the curricula of 30 European countries. In reviewing curricula, creativity was among the least often referred to of the objectives of arts and culture curricula. The development of individual expression and the development of creativity were two other very widespread aims. The development of creativity was found to be in a number of cases sufficiently distinct to be regarded as a separate type of artistic aim and different from individual expression. In a number of countries there were also elements of the overall curriculum which were related to creativity as well as arts and cultural education.

The role of creativity and innovation in school curricula in the EU 27 Member States was the focus of another study, this time carried out by the Institute for Prospective Technological Studies (IPTS) (one of the 7 research institutes of the European Commission's Joint Research Centre (JRC)) in collaboration with the Directorate General Education and Culture, Directorate A, Unit A1. It aimed to provide a better understanding of how innovation and creativity are framed in the national and/or regional objectives and applied in educational practice at primary and secondary level. In total, 37 countries and/or regions were studied and around 1,200 curricula documents were identified and analysed using the search terms Creativity and Innovation. The findings indicated that Creativity was referred to in school curricula in all countries and was already part of the educational political discourse in most European countries (Heilmann and Korte, 2010). Two major approaches to creativity seemed to appear. In one perspective, creativity was defined as a creative task or activity, usually linked to specific subjects such as Art, Music, Languages, and Technologies and the focus was on doing things

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creatively. The other perspective considered creativity more broadly and treated it as a skill, like 'creative thinking' or 'creative problem solving' which should be encouraged and developed across all subjects. The use of the word creativity was found in almost all school curricula but more frequently in the Arts. On the other hand, the term 'innovation' was much less frequent. When differentiating according to school type, relative occurrences for both primary and secondary schools were at rather similar levels for all subject groups, with secondary schools slightly above primary schools in most subject groups. As can be noted, there was no particular reference to early years education in these two studies, with the lowest level included being the primary years which, as in the case of studies on science and mathematics, include the older levels of early childhood education which are included as part of compulsory education.

C3.2. Comparative education and creativity education by education academics

Creativity has been the focus of various comparative studies carried out by academics, some of which focus specifically also on creativity in the early years. Comparative studies have varied from consideration of creativity in policies, curricula as well as pedagogical aspects at the different levels of education.

The inclusions of creativity in educational policy documents have become part of concrete actions. In a curricula survey of 16 countries in Europe, America and East Asia creativity and art was embedded in their education systems (Shaheen, 2010.). According to Shaheen's review, the curricula of several countries refer to creativity for establishing aims which focus on skills; conditions; or abilities to develop creativity. In the US, education aims focus on applying strategies for creative thinking and similarly Hong Kong refers to higher order thinking skills. The Singapore curriculum expects pupils to become creative and imaginative while in China it has become one of the priority aims of education. According to Shaheen's (2010) review in Ireland, Scotland and in Turkey the role of creativity in educational policy statements are under work and not so clearly stated. However, in several countries the role of creativity in education has come under serious consideration and its value is seen as an education and societal feature. Bertram and Pascal (2002) reviewed a number of curricula in the early years in 20 different countries. It was only in four countries (Italy, Japan, Korea, and Sweden) that the centrality of creativity in children's learning and thinking was identified as one of the aims of early childhood education.

Hong and Kang (2009) conducted research in which possible differences in conception of creativity of teachers from South Korea and US were investigated. In South Korea creativity in science education has become a significant part of their learning goals, different to the US where the promotion of creativity is connected to the nature of school science. The survey data consisted of 44 secondary science teachers having 14.7

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years average teaching experience. The research questions asked for the teachers' conceptions of creativity, their pedagogical ideas and contextual factors perceived as constraints on teaching creativity. The teachers from both countries showed similar trends in their conceptions of creativity. The teachers' conceptions of creativity were rather limited and they mostly (86%) used novelty as the major characteristic of creativity. Secondly almost half of the teachers referred to problem solving. Also their pedagogical ideas were homogenous in both countries. Using inquiry activities was often mentioned by participants from both countries. Differences found in using pedagogical methods were that teachers from South Korea wanted to emphasize methods supporting thinking skills and co-operation while US teachers considered environmental or emotional support as more important. A higher proportion of South Korean teachers' considered ethicality in judging creativity and highlighting collaborative aspects in learning as a contribution to Asian culture as against to the emotional aspects and emphasis of individuality which are part of Western culture (Hong and Kang, 2009).

Fostering creativity in different school subjects has often been linked to the initial premises of learning some particular school subjects. For example Cooper and Dilek (2007) used the method of 'doing' for the learning of history. As in science education, in history education, doing history is seen as a key element. In addition, historical imagination, language and collaborative learning are emphasized. Cooper and Dilek (2007) conducted two learning projects in Turkey and England. The study was conducted as a qualitative study using video recordings of history lessons of eleven years old 6th graders. In the Turkish lesson, pupils work in groups to interpret information in texts, maps and pictures, in order to reconstruct events surrounding the Battle of Ankara in poetry, art, drama and music. In the English lesson, pupils found out about Ancient Egypt's ways of daily life, also working in groups. The study showed how pupils gradually become independent of adult support and start spontaneously using special vocabulary introduced by the teacher in new contexts. The pupils' also used causal vocabulary. Although the pupils were not advanced level in their learning skills, they still explored the past, interrogated sources to construct interpretations which included presenting the information from different perspectives and developed arguments, using specialized vocabulary (ibid).

Wang (2011) compared differences in creative thinking between student teachers in Taiwan and the United States, and attempted to understand the factors that may cause differences. The most distinctive difference between the two groups identified was the ability of elaboration. The findings implied that creative thinking has more to do with beliefs than practices. The encouragement of self-expression in education in the United States can explain why Americans scored higher on elaboration than their Japanese or Taiwanese counterparts.

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C4. Comparative education and teacher education

Comparative education in teacher education has had quite a chequered history and mixed fortunes at teacher education institutes and universities in various parts of the world (O'Sullivan, et al., 2008). The literature on comparative education in teacher education has been poor. The role of the comparative education is polarized: there are either studies concerning comparative education as a part of teacher education or there are studies in which teacher education is compared between the countries (see for example Tatto and Senk, 2011). Comparative research in teacher education has been the focus of both international organisations as well as of educational academics.

C4.1. Comparative Research on teacher education (initial and continuous) by international institutions

Teacher education has been considered in comparative studies, either as part of the focus on specific subject areas: the recent Eurydice studies on science and mathematics (European Commission, 2011a, 2011b) are two cases in point. However, teacher education and teacher competences have also been in themselves the main focus in other comparative studies. OECD (2005) has one particular study focusing on recruiting, developing and retaining teachers across different countries. The European Commission has also expressed an interest in teacher training. At the beginning of this subchapter we present some early childhood education studies published by European organizations. These studies do not explicitly focus on teacher training, but disseminate the information which provides aspects for developing teacher education and teachers' work in early childhood education. At the end of this subchapter the Eurydice studies focusing on mathematics and science education are provided.

Both the Eurydice Network and OECD have given less attention of early years education, with only a few studies carried our since the year 2000. A recent study in the area by the Eurydice network tackle early childhood education and care with respect to tackling social and cultural inequalities (European Commission, 2009b). The study looks at 30 different countries and examines the available cross-national data and national policies on early childhood education and care (ECEC). There are several possible at risk groups identified, whose distribution varies across the European countries: single parent households with small children (about 9%); non-national children (3 % of under 6 in Europe); and households with a child under the age of 6 lives on the poverty threshold (17 %). In most countries, women's engagement in the labour force is clearly linked to the age of their children. Many European women with a child under the age of 3 withdraw from the labour market. Women with children aged 3 to 6 years have lower than average economic activity rates, but most European women are prepared to take up gainful employment when the youngest child turns 6. This withdrawal from the workplace could be partly explained by the lack of available provision for young children. Two

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main organisational models for ECEC services were identified: the first model involves provision for young children which is provided in unitary settings, organised in a single phase for all children of pre-school age; and the second model, which is the most widespread in Europe, ECEC services are structured according to the age of the children (normally for children aged 0 to 3 years and for children aged 3 to 6 years). The opening hours of ECEC services have two broad approaches: subsidized ECEC more or less fully compatible with the working hours of parents or be available only on a part-time basis. In the majority of European countries ECEC settings generally provide extensive opening hours that take account of the needs of working parents, including some flexible arrangements (evenings, nights and/or weekends). In the majority of countries, intervention is targeted at groups on the basis of defined social, economic or cultural criteria. Support involves: Special language training programmes; Appointment of extra staff in mainstream settings; and Provision of separate settings/sections for specific groups. Staff caring for the ages 0-3 tend to be less qualified than those caring for the older ages.

OECD has carried out two comparative studies; both called Starting Strong and published in 2001 and 2006 (OECD 2001, 2006). The 2001 OECD study provides a comparative analysis of major policy developments and issues in 12 OECD countries - Australia, Belgium, the Czech Republic, Denmark, Finland, Italy, the Netherlands, Norway, Portugal, Sweden, the United Kingdom and the United States - highlighting innovative approaches and proposing policy options that can be adapted to different national contexts. The study puts forward eight key elements for equitable access to quality early childhood education and care: a systemic and integrated approach to policy development and implementation; a strong and equal partnership with the education system; a universal approach to access, with particular attention to children in need of special support; substantial public investment in services and the infrastructure; a participatory approach to quality improvement and assurance; appropriate training and working conditions for staff in all forms of provision; systematic attention to monitoring and data collection; and a stable framework and long-term agenda for research and evaluation. One priority identified was the need to improve the recruitment, training and remuneration of early childhood professionals, particularly for staff responsible for the development and education of children under three years.

The second OECD study (OECD, 2006) was a follow-up of the first and included the same countries and an additional eight countries: Austria, Canada, France, Germany, Hungary, Ireland, Korea and Mexico. This second study focused on the same eight aspects included in the first study with a greater focus on the governance of ECEC systems; the impact of financing approaches on quality; and contrasting pedagogical approaches. The study highlighted how support for the view that early childhood education and care should be seen as *a public good* is growing,

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and has received a strong impetus from the research of education economists.

The search for a more unified approach has generated different policy options. France and the English speaking world have adopted a "readiness for school" approach, which although defined broadly focuses in practice on cognitive development in the early years, and the acquisition of a range of knowledge, skills and dispositions. In countries inheriting a social pedagogy tradition (Nordic and Central European countries), the kindergarten years are seen as a broad preparation for life and the foundation stage of lifelong learning. The evidence obtained suggested that direct public funding of services brings more effective governmental steering of early childhood services, advantages of scale, better national quality, more effective training for educators and a higher degree of equity in access compared with parent subsidy models. In all countries, considerable gender and diversity imbalances exist within the teacher profession. The report also noted that levels of in-service training varied greatly across countries and between the education and child care sectors. It can be noted that these studies have focused more on the provision of the service and less on the curricular aspects, the learning experiences provided to children in pre-school and how these enhance their cognitive and skill development in preparation for more formal education at a later stage in their education. While there is acknowledgement for the need of quality educational experiences, these are not dealt with in detail from a pedagogical perspective.

Eurydice in 2006 published a report on a study on science teaching where it focused at one point on teacher training as well as the competences of teacher trainers. It compared the content of qualification standards, guidelines concerning initial teacher education programmes and criteria for the accreditation of higher education institutions and programmes in 30 different countries. It also identified the types of competence and expertise that prospective science teachers are expected to develop during their initial training, whether they relate to actual teaching practice or area of direct relevance to the science subject taught. A second focus dealt with the qualifications and professional experience of the teacher trainers who supervise those intending to become qualified science teachers during their initial professional training. It considers the trainers in initial teacher education institutions and also the teachers who, from within their school, supervise prospective teachers during their school placement. The study reveals differences in the amount of content and educational background of the teacher-trainers across the countries studied.

The second set of studies on Mathematics and science published in 2011 focus on policies and practices. The reference to teacher training focuses mainly on support to existing teachers as part of continuous professional development. It was early in the Millennium that Eurydice dedicated a large in-depth study on the teaching profession in Europe. Key aspects

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were examined in four separate subject-based reports. The first was devoted to a comparison of models of initial education and the transitional measures introduced to facilitate access to the profession (European Commission, 2002a). The issue of supply and demand was examined in the second report (European Commission, 2002b), while the third dealt with teachers' working conditions and pay (European Commission, 2003). The fourth and last report focused on keeping teaching attractive for the 21st century (European Commission, 2004).

One also finds comparative studies supported by the European Commission's funding programmes. One particular comparative study focuses on teacher education and inclusion (European Agency for Development in Special Needs Education, 2010) with as many as 18 countries. Teacher education was reviewed to study how teachers across different countries were trained in this area.

OECD has studied teacher education across countries from different perspectives and in different teaching areas. One study (OECD, 2010a) focused on the need to better articulate the links between initial and in-service teacher education and the necessity of addressing current gaps such as on how to attract and retain more diverse student teachers. This study discusses issues raised by student teachers, teachers, and teacher educators who participated in an online consultation relating to the issue of educating teachers for diverse classrooms. Another area of teacher education being studies by OECD relates to the use of Information and Communication Technologies (ICT) in initial teacher training in nine OECD countries (Ananiadou and Rizza, 2010). The preliminary results show that although student teachers and teacher trainers have generally good access to equipment and an adequate level of technical skills, they lack competencies in the pedagogical use of ICT.

OECD (2010b) has also carried out a study on lower secondary teachers' professional development based on the Teaching and Learning International Survey (TALIS). This study provided insight into how much the amount and profile of teachers' professional development vary within and among participating countries. The level and intensity of participation in professional development was found to vary considerably among countries. Teachers with lower qualification levels showed relatively higher levels of non-participation in professional development. There was also a difference between western European countries and other countries with respect to the types of professional development undertaken by teachers. Among OECD's latest contributions one finds how it has gathered the outcomes of its various comparative studies and prepared a background Report for the International Summit on the Teaching Profession (OECD, 2011d). This background report includes references to both initial and professional development of teachers in the provision of quality education.

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C4.2. Comparative research on teacher education by education academics

O'Sullivan et al. (2010) have recently published the study in which comparative education courses were implemented in Ireland and South Africa. In their research comparative education is presented in both roles. According to this study all student teachers indicated that comparative education should be included as a compulsory subject in the teacher education programme. The issues of comparative education assisted them in looking for work abroad, in their teaching strategies; as well as in developing their professional development (ibid).

O'Sullivan et al. (2010) stated that three main findings emerged from the study, all of which have implications for the future of comparative education in teacher education. The first is the valuable role of comparative education in professional development of student teachers. Comparative Education provided a good way for preparing students to teach in multicultural classrooms, as well as in helping them with their teaching strategies and in broadening their minds in the field of education and in general. The second is the role of contextual factors in determining the significance of different aspects of comparative education in teacher education. During this study, it was noted that the African students were older and already had some teaching experience and this may have influenced the value which they gave to the course that they followed. This is one reason for which the value of comparative education to the Irish students was significantly different from the value given by the South African students. These differences can be related to contextual differences between South Africa and Ireland. Thirdly, the centrality of clients was critical to the effectiveness of comparative education in teacher education. The Irish students expressed greater satisfaction with their comparative education course than South African students as the Irish students had a say in the structure of their course, while the South African students did not.

Another study recently conducted on teacher education is by Wilson (2005) who found that there were at the time only seven British institutions, equivalent to 6%, who offer comparative education on initial teacher training programmes, and that with the exception of one of the B.Ed. programmes, these courses were optional. Watson (2001) explains that the reason for which comparative education is not considered necessary to include within initial teacher training is that there is little appreciation to how much it can add to the development of student teachers' teaching skills and strategies, which currently forms the main focus of all courses in the UK.

A study on comparative Mathematics teacher education was carried out by Tatto and Senk (2011). This study, known as Teacher Education and Development Study in Mathematic (TEDS-M) involved the participation of 17 different countries. The aim of the project was to identify what intended and implemented policies support the development of

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prospective primary and lower secondary teachers' knowledge of mathematics as well as related teaching knowledge; what learning opportunities are available to prospective mathematics teachers that allow them to attain such knowledge; and what level and depth of mathematics and related teaching knowledge attained by teachers enable them to teach the kind of demanding mathematics curricula. The collaborative work by researchers in many countries has resulted in the development of a common language and definitions that work cross-nationally to reflect the structure and organization of different teacher education systems. The TEDS-M research team showed that it is possible to design sampling plans for teacher education that are sensitive to local conditions. This study has offered a model for data collection that provides valid, reliable, and cross-national data about the content and pedagogical knowledge of graduates from the various kinds of teacher preparation programs included in the study.

One multinational research study aimed to assess the importance given to biodiversity education in the pre-service education of primary school teachers in four European countries, and to investigate the competence and motivation of both pre-service and novice teachers to implement biodiversity education in school. Biodiversity in this study is not considered as only a scientific term but also a normative conservation concept linked to the idea of biological variation and the ecological, economic, ethical, spiritual, and cultural values related to it. One teacher education institution in each of four different countries in Cyprus, England, Switzerland, and Germany was selected as a case study due to the institution's strong involvement in biodiversity education (Lindemann-Matthies, et al., 2011.). According to the study there are differences between the countries, how teachers describe teachers education as a source of their knowledge of biodiversity. Print and electronic media as well as secondary school education were major information sources for the British participants, but hardly relevant for the others.

The Swiss participants who had received the least preparation in all aspects studied (including the investigation of the natural environment) were similar or even more confident than all others in most outdoor activities investigated. This could be due to the different teaching approaches of the teacher education institutions in different countries (Lindemann-Matthies, et al., 2011.). Based on the research the teacher education in different countries produce different kind of confidence of biodiversity but the results of the Lindemann-Matthies et al. (2011) study indicate that actual experience of outdoor teaching during teacher education and also the use of inquiry as a teaching approach contribute to pre-service teachers' intrinsic motivation to engage their future students in hands-on outdoor activities.

Mathematics teacher education is also influenced by the system of governance (e.g., whether the state is weak or strong); whether the level of country administrative control is centralized or decentralized; whether

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programs are held accountable for their performance; and whether the country's philosophy regarding diversity in mathematics knowledge is valued over homogeneity, both within classrooms and among those preparing to become teachers. Thus, in order to understand determinants of MCK, more sophisticated modelling must be undertaken.

One important message to teacher educators and policy makers is that attention needs to be paid to the emphasis, kind, and depth of the opportunities to learn provided to future teachers. For instance, future primary teachers in high achieving countries are generally provided with more opportunities to learn both tertiary-level (specifically geometry, continuity, and functions) and school-level (specifically functions, calculus probability and statistics, and structure) mathematics than primary teachers in other countries. This pattern appears to extend to future secondary teachers as well (Tatto and Seik, 2011.).

In England, the Office for Standards in Education (Ofsted) (2003) has provided an international comparative study of three countries concerning the education of six year olds in England, Denmark and Finland. The report compares and contrasts the educational experiences of six year olds and the provision that is made for them in a small sample of settings in these countries in order to contribute to the national debate about early education in England. Although the samples of schools in the three countries are small – twelve in England, seven in Denmark and eight in Finland – they provide enough illustrative material for insights to be gained into the educational values of the three countries and the ways in which these influence their approaches to the education of six-year-old children. In this study the teacher education and teachers' work was considered through the following questions: What are the similarities and differences in the expectations of parents, teachers and national and local governments in the three countries by the time children reach the age of six? How are teachers involved in curriculum development and how does this influence their professional autonomy and job satisfaction? What differences are there in the way teachers assess and record children's progress, and how do they use this information? What are the roles of teaching assistants in the three countries and how do they make a difference to children's learning and teachers' workload?

According to Ofsted's study (2003) many of the teachers in the English schools were less secure than their Finnish or Danish counterparts about the nature and purpose of the curriculum of six year olds. Several of them felt they were caught between the expectations of the Foundation Stage on the one hand and the impact of the National Curriculum testing system in Year 2 on the other. The teachers in Finland and Denmark, confident in their role to prepare children for compulsory schooling, had no such difficulties. Assessment for learning in the classrooms of all three countries was too often limited by teachers' concern that day-to-day feedback to pupils should, at all costs, be positive.

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The most effective teachers were those who maintained an encouraging ambience, but used classroom dialogue to engage constructively with pupils' thinking and ideas. All of the teachers in the three countries had responsibility for their own class of children. Teaching assistants worked alongside teachers in all the English classrooms and similar assistance was also provided in the Danish and Finnish classrooms. One important distinction was determined: In both England and Finland there was a clear professional difference in terms of qualifications (and, usually, responsibilities) between the qualified teachers on the one hand and the unqualified – although trained – teaching assistant on the other. In Denmark, however, both parties were trained as pre-school class teachers. Their training takes place in specialist institutions of higher education and lasts three and a half years. The Finnish teachers had usually undertaken the kindergarten education (Bachelor degree) lasting three years (Ofsted, 2003.).

In summary, comparative studies on teacher education, both initial and as part of professional development, appear to have attracted the interest of both international organisations as well as that of academics. This reflects the view that teachers play an important role in the learning process and that investing in the training of teachers will affect the quality of teaching within schools.

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D. Conclusion and implications for Creative Little Scientist project

In this chapter we shortly conclude the main findings of the review and provide some relevant implications for the project use in the future. Aiming to be clear and to establish short arguments we have shortly described the core findings and then listed the main implications and suggestions for the project to take account of.

D1. Conceptual and contextual ground in area of comparative education

This review has first discussed comparative education, its history and development, as well as the various forms in which it has evolved. The exercise has also served to raise issues common to comparative education and which are also relevant to this project: Creative Little Scientists which is itself a comparative research project involving a transnational study of science and mathematics and the promotion of creativity in the early years of education. Insights into the meaning and methodologies used in comparative education particularly with respect to studies involving different countries were gained. It was noted that comparative education can be envisaged as an interdisciplinary area of study that encourages scholars to engage in a comparative analysis that is both cross-national and contextual.

The growing body of literature from different regions of the world continues to expand the existing theoretical and conceptual framework of comparative and international education, eventually transforming the boundaries of the field. Thus the role of comparative education and comparative research is not only producing the different perspectives of different countries and increase the awareness, but it is also a way to learn from each other and to build global understanding of educational issues, from viewpoints of policy, practice and research. Politicians at the European level have recognised that education and of today's knowledge society and economy. The EU's strategy emphasises countries working together and learning from each other. Comparative education provides a contextual base for the project from the following viewpoints:

- Cross-national information about the studies carried out in Europe and outside.
- Theoretical concepts and foundations for defining research paradigm and contextualizing the research in terms of other comparative studies in Europe and other countries. The project covers the features of thematic studies and cross cultural studies (working key terms).
- The meaning of comparative studies for the research, policy and practice under consideration. There exist the needs to understand the foundations of policy in its wider context historical, cultural political etc.

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- Limitations of official data sources or policy documents – danger of emphasis on positive aspects of focusing only on particular viewpoints out of contexts.
- Prove the important role of concept definition and meaning of glossaries when conducting comparative research.

D2. Existing research gaps and suggestions for research foci

While there have been a number of comparative studies in science and mathematics, whether focusing on student achievement, education provision, promotion of creativity or teacher education, the focus has been mainly on primary and secondary level of education. Comparative research on early year's provision has been very limited. The major studies identified have focused on early year's education in a holistic way focusing on the policy and quality issues, and to a lesser degree on specific subject areas. In many cases where the early years were included in studies, this was mainly the result of a focus on primary education, the first two to three years of which fall within the later stages of early years education, and not because the early years was the focus of the study.

In the area of science and mathematics education several research reports have been published comparing pupils' achievements in science and mathematics in several countries. However, these studies also focus on later years of schooling and there exist lack of studies which focus on early year's comparison and the comparisons of the educational processes of science and mathematics learning. In addition, according to the previous studies, it seems that on one hand challenges of science and mathematics learning are linked to the questions of motivation among girls and boys. In science we need to encourage girls to do science and increase their interest of doing science and encourage their intrinsic motivation towards the subject.

Creativity is seen as significant in education systems across Europe and there are several statements which prove the importance of creativity education among the policy makers in Europe. Usually in European curricula creativity education is linked to specific subjects such as Art, Music, Languages, and Technologies and the focus was on doing things creatively. The other perspective consider the concept of creativity more broadly and treat it as a skill, like 'creative thinking' or 'creative problem solving' which should be encouraged and developed across all subjects. In addition, the learning methods developing the skills of creativity are seen relevant for supporting the pupils' thinking and learning skills in several countries. Thus there seems to be a place to adjust how creativity is defined across the countries involved in the project and ensure the definitions are shared in future research of the project.

Comparative teacher education has also attracted attention in the 2000s. Comparative education in teacher education has emerged as an area of

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study in teacher training in recent years, with many countries currently seeking to include international perspectives and global education in their curricula, including teacher education curricula. In recent years, there have been also calls for the inclusion of global perspectives in teacher education curricula (Holden and Hicks, 2007; Willard-Holt, 2001). However, there are still some challenges for the inclusion of comparative education in initial teacher education, mainly due to limited usable data about teacher education programs in research studies, such as lack of a precise number of students in the program, the hours allocated to each area of study, the qualifications within the faculty, a good follow-up system for graduates, and the costs of running the program, among others. This calls for better teacher education program databases including a framework to truly be able to develop useful accountability systems (see also Tatto and Senk, 2011.).

The research needs of comparative education under issues of the project focus on the following aspects:

- Focus on early years and transition to primary level.
- Focus on the research into the learning and educational processes in classrooms to be able to compare a) the teaching and learning, b) learning climate and c) pedagogical strategies in science and mathematics education.
- Capture the role and significance of creativity in science and mathematics education in partner countries and underline the need for definition of the concept in the project.
- Clarify the role of the differences in teacher education among the partner countries and its meaning for the science and mathematics education in early year's education.
- Provide the alternative approaches of educational processes of creativity and science education in partner countries and developing reflective methods, envisage alternatives to develop the education in other countries.

D3. Patterns of methodological approaches - Implications for *Creative Little Scientists* project

The review has highlighted a number of aspects which help direct the methodology to be adopted in this project. Of particular importance, one finds the need to share meanings of the terminology used, as understandings may be different across different countries. The context within which the research is carried out also needs to be described and understood and any research findings can only be interpreted within their own context, even in comparing one country to another (see sub-chapter 4.1). Comparative studies also have value for countries to learn from one another. The comparative exercise thus goes beyond measuring who is the best, but identifies best practices which can serve as reference to other countries wanting to improve their own education systems.

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A number of comparative studies highlight the need for the researchers to invest in discussing meanings and methodology before implementation in the different country contexts. Methods to be adopted are to be various and different in order to capture different perspectives of the same issue. Researchers involved in comparative research should thus seek actively to engage in an ongoing dialogue by providing an intellectual space to explore alternative theories, methodologies and local experiences that would capture the nuances of global and local contexts through both qualitative and quantitative comparative research (see also Silova, 2009). This also demands a good level of expertise in methodological issues by partners of the project.

Comparative studies on mathematical skills suggest that the children's culture begin to affect children's mathematical skills very early in life, and that cultural differences are already in place. Thus in comparative studies which focus on young learners, establishing a cultural framework through which the comparisons are reflected seems to be significant.

From the methodological viewpoint the review of comparative education suggest the project to take account the following issues:

- The balance of quantitative and qualitative data collection methods; how the project achieves the representative data?
- To find or create the measurements through which the data collection is carried out in valid way. This means focusing on the a) possibilities to compare the national findings globally but also b) to give space for national and local specialties.
- To clearly define how comparisons will be made in the project.
- Limitations of official data sources or policy documents – danger of emphasis on positive aspects.
- To solve the risks of translations from English to national languages and back-translations.
- To capture needs of the policy and at same time to conduct high-quality scientific research. This means the reconciliation of local differences and globally valid scientific methods of comparative education.

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