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

D3.4 Comparative Report

www.creative-little-scientists.eu

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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D3.4 Comparative Report

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1.	27.08.12	ALL	Partners provide feedback on initial structure
2.	31.8.2012	UEF	Revised structure circulated to all partners
3.	14.2.2013	UEF	Send first draft of whole report to WP3 task leaders
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EXECUTIVE SUMMARY

The research context of the *Creative Little Scientists* project focuses on the role of creativity in science and mathematics education in early years education and first years of primary education.

This report serves as the concluding part of Work Package 3 (WP 3 - Mapping and Comparative Assessment of Existing Practice) and compiles data gathered through deliverables D3.2 (Report on Mapping and Comparing Recorded Practices) and D3.3 (Report on First Survey of School Practice) which consider existing approaches of teaching, learning and assessment as reflected in policy documents, alongside a survey of teachers views of science and mathematics and the role of creativity in these respectively.

Findings from these deliverables, alongside the National Reports compiled by each partner country, have been compared and synthesised with a view to revealing any similarities and differences between policy documents and practices of teaching, learning and assessment of science and mathematics in the early years. Consideration is also given to the characteristics of teacher education in early years mathematics and science across partner countries.

Aims of comparisons

Comparisons in the Comparative Report (D3.4) are approached in two stages and from two different perspectives. Firstly, this report compares the findings between policy and teacher surveys focusing on the issues targeted in the project. Secondly, we compare whether and how the findings from former comparison (i.e. between policy and reported teacher practice) differ among the partner countries.

Through this report, the *Creative Little Scientists* project aims to capture the similarities and differences of early years education in science and mathematics across nine European countries *to better understand* the global challenges and strengths of science and mathematics education in Europe. This report guides towards comparative pedagogy, aiming to identify processes of teaching and learning within schools and classrooms in different countries. The project aims to improve not only educational policy and practice, but also to develop the ability to generalize about education-society interaction (Arnove, 2007) both within and between the countries.

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Research questions of the report

The main research questions of the project have been provided in the Deliverable D2.2 Conceptual Framework. The report synthesises the first research question through deliverables D3.2 and D3.3:

How is the teaching, learning and assessment of Science and Maths conceptualised? What role does creativity play in these?

The synthesis is based on *aims and priorities*, *teaching, learning and assessment.* According to the policy analysis and teacher survey within the partner countries, the focus is on comparing the similarities and differences:

a) between the countries;

b) between preschool and early years education;

c) between science and mathematics education.

In addition, this report provides a viewpoint for the fourth research question of the project:

How can the findings that emerge from analysis in relation to research questions 1-3, provide information for the development of practices in the classroom and for teacher education (ITE and CPD).

The findings from this report are to be taken into account in WP4 and relevant guidelines for teacher education are to be proposed in WP5.

The following sub-questions have been used to frame the analysis in D3.2 and D3.3 and are built upon the framework of curriculum components '*vulnerable spider web'* (see van den Akker, 2007) that identify the following key questions related to student learning:

- Rationale or vision: Why are children learning?
- Aims and objectives: Toward which goals are children learning?
- Content: What are children learning?
- Location: Where are children learning?
- Learning activities: How are children learning?
- Teacher role: How is the teacher facilitating learning?
- Materials and resources: With what are children learning?
- Grouping: With whom are children learning?
- Time: When are children learning?
- Assessment: How to measure how far children's learning has progressed?

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Furthermore, the sub-questions related to approaches to teacher education were broken down into:

- Initial teacher education
- Continued Professional Development

Methodological approach

The main aim of WP3 was to map the existing approaches of early science and mathematics education and the role of creativity in these. The planning of the desk research and teacher survey commenced at the same time to achieve maximum coherence between the studies. In addition, the similar principles of Van den Akker (2007) were adopted to examine the existing approaches both in policy and in practice. In both studies the data collection, data analysis and the writing of the national reports occurred during the time of May –December 2012.

In order to compare the approaches presented in policy documents and those used by teachers in practice, the consortium released deliverables D3.2 and D3.3. The data collected and the findings from these two separate research studies are synthesised in this report.

To achieve the aims set by the consortium concerning the desk research, each partner conducted an initial analysis on national level. This analysis focused on national policy frameworks through all relevant official documents. Each partner also had to fill out a national policy questionnaire related to both primary school and preschool provision. The questionnaire items drew upon approaches that were identified in the Conceptual Framework (D2.2) and the List of Factors (D3.1), as being relevant to the role of creativity in early science and mathematics. The items also drew largely upon the questionnaire used in the teacher survey (Task 3.3) in the project.

The analysis of the teacher survey was carried out in two stages, identical to those of the desk research in order to ensure consistency between the two studies. Initially partners carried out an analysis of their country's data to produce a National Report discussing the findings and situating them within their country's educational context. In the second stage, the data gathered from all the partner countries were amalgamated and analysed as a whole. Statistical comparisons were performed to identify similarities and differences between perceived practices in partner countries; information provided in the National Reports was used to interpret these similarities and differences.

The main body of the questionnaire, used for both the policy review and teacher survey, was separated into two main sections: Approaches to

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Teaching, Learning, and Assessment, and Approaches to Teacher Development. The first section was further split according to the nine curriculum components (Rationale, Aims, etc.). Each section included a series of questions *(e.g. What purposes of assessment are included?),* followed by a number of items relating to this question.

A total of 815 teachers from 605 schools (238 preschools and 367 primary schools) across the consortium countries completed the online questionnaire.

Conducting comparisons for this report

At the outset of this task, each partner was asked to provide a summary of the main findings from their national reports. Each partner combined the findings from the policy and teacher survey into the same document, in order to establish country specific information and interpretations. The country summaries and conclusions have been adopted for comparisons in this report.

In the first phase, the comparative report of recorded practices was used to establish the main findings of the surveys. The policy questionnaire data was transferred from Excel format to SPSS software alongside relevant variables from the teacher survey in order to enable comparisons. Preschool and primary school data was considered separately.

Since both studies used similar factors (spider headings) for capturing the existing approaches of teaching, learning and assessment of early years science and mathematics education comparisons have been made using the same headings, as follows:

- aims and rationale for early years science and mathematics education;
- teaching, learning and assessment;
- contextual factors;
- teacher education.

This makes comparisons possible and valid. The List of Mapping and Comparison Factors (D3.1) was used as a tool for comparing the significant components from the findings of the original survey. The comparative report builds a synthesis of the themes mentioned above, focusing on each item under its particular theme. Comparative tables were created with items, splitting the data firstly into the countries and secondly by dividing preschool and school.

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Conclusions

Rationale and Vision

The overall picture formed by the policy review and teacher survey in regard to the rationale or vision for science learning in the early years and compulsory education shows that even though policy in the partner countries tends to focus its guidance on specific drivers for science education, teachers do not clearly focus on one specific rationale, but rather follow a more holistic approach considering all priorities as important.

In almost all the partner countries, the purposes of education are focused on enhancing children's lives now and in the future as well as their roles as citizens, with particular emphasis on environmental awareness. In terms of reported practice as revealed through the teacher survey, only one purpose of compulsory science education is singled out by teachers as less important than the others, to produce future scientists and engineers, although this is still given greater emphasis than in preschool and primary policy documents. This particular rationale has the largest variance in policy evidencing the diverse focus on the economic driver of education in early years education settings across the partner countries, in response to the view that today's knowledge economy dictates an imperative for countries to have scientists capable of competing globally.

Aims and Objectives

Comparisons between the policy review and teacher survey reveal an interesting imbalance in the framing of learning outcomes linked to science in preschool and early primary education across the partner countries. The learning aims and objectives of the science curriculum in partner countries tend to focus on cognitive factors of science learning and particularly on the development of process skills associated with scientific inquiry and of knowledge and understanding of science ideas (the latter particularly in primary school). The findings from the teacher survey on the other hand suggest that teachers perceive the teaching of science overall as contributing primarily towards affective and social aspects of teaching and learning. Teachers view their role in the early years as mainly one that places at the forefront fostering positive attitudes and dispositions for science and lifelong learning and the development of children as socially and environmentally aware and responsible citizens.

Learning outcomes connected to the cognitive dimensions of science learning, even though used quite often by teachers, are featured less

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strongly in teachers' responses in comparison to outcomes linked to the social and affective dimensions. In contrast to responses to the teacher survey, the review of policy across partner countries showed that social and affective dimensions of learning are given more limited attention compared to cognitive dimensions. More particularly, the majority of policy documentation inspected lacked emphasis on promoting positive attitudes to learning and interest in science among the intended learning aims of early years science education. The vast majority of teachers on the other hand reported including such learning outcomes very frequently in their teaching.

In the teacher survey of practice, learning outcomes linked to the social aspects of teaching and learning were reported by teachers as very frequently included in their planning for learning and teaching. Here the comparison between findings of the teacher survey and policy review reveal a significant correspondence in the strong emphasis placed in both on including learning outcomes connected to fostering children's abilities to collaborate with others in science learning.

Learning Activities

Overall the surveys of policy and teachers' views found that features of inquiry were both promoted in curricular policies among suggested learning activities, as well as frequently included by teachers in the preschool and early primary science classroom. In particular, learning activities associated with observation, questioning, communication and the use of simple tools took a dominant place among inquiry related activities.

On the other hand the survey results indicated that inquiry skills associated with planning and conducting investigations and using data to construct explanations, that are linked to the development and use of scientific concepts and procedural knowledge, were given a less prominent place in the learning activities carried out in the classroom and in curriculum guidance.

Pedagogy

Bringing together the results discussed in the Report on First Survey of School Practice (D3.3) and the Report on Mapping and Comparing Recorded Practices (D3.2) about policy and teachers' conceptualisations of the various learning contexts and approaches linked to pedagogy it can be concluded that teachers overall appreciate the role of dialogue and collaboration in their practice, but fail to see their potential for development of creativity in children. This is consistent with policy in

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partner countries which puts some emphasis on the importance of dialogue and collaboration but includes very limited reference to features of creativity that might be fostered through dialogue and collaboration and very limited guidance to support teachers in enabling creativity using classroom discussions and collaborative work.

There is an uneven treatment in both policy and reported practice of the contexts and approaches grouped under the synergy motivation and affect. The contexts of 'drama' and 'using history to teach science' are used the least frequently and are least considered as 'creativity enabling' by teachers while curricula also fail to promote these approaches or make reference to the potential for creativity of these two learning contexts. The approaches of 'building on children's prior experiences' and 'relating science to everyday life' on the other hand are amongst those reported as most frequently used by teachers and referenced in policy, though still not highlighted as similarly 'creativity enabling' by both teachers and policy guidance.

There is also an uneven treatment of the contexts and approaches grouped under the synergy play and exploration. Preschool teachers use 'open/unstructured play' and 'role/pretend play' significantly more than early primary school teachers, and a greater proportion of preschool teachers also conceptualise these as 'creativity enabling'. This is also reflected in curricula across the partner countries. Policy in the majority of partner countries promotes playful exploration in preschool considerably more than in primary education, with guidance that suggests a recognition of its value in promoting creative skills and dispositions. On the other hand teachers who responded to the survey from both preschool and primary phases were in agreement in reporting frequent use of physical exploration of materials and identifying its 'creative' potential. This agreement across phases is however not reflected in policy guidance.

In terms of the synergy problem solving and agency, official policy across partner countries emphasises almost all relevant approaches and contexts identified by the project across both phases of early years education. In the majority of partner countries, this emphasis on problem solving in policy is often also linked to suggestions about its potential to foster children's creativity, particularly in preschool. According to responses to the teacher survey, teachers use problem solving approaches quite or very frequently. A large majority of teachers across both phases of early years education considered almost all problem solving and agency contexts and approaches to be amongst the most 'creativity enabling' approaches to learning and teaching.

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Concerning the learning approaches associated with questioning and curiosity, these are either given various mentions or emphasised in preschool policy in the majority of partner countries. However in contrast to preschool, more limited emphasis is given to questioning in the primary age phase. In terms of teachers' reported practices, there is correspondence between teachers' use of practices that encourage children to ask questions and foster their imagination and teachers' perceptions of these practices as 'creativity enabling'. However, the same cannot be said for the use of questioning by teachers and their encouragement of different ways of recording and expressing ideas. Although results from the teacher survey indicated that both practices are used quite or very often by the large majority of teachers, they are not considered amongst the three most 'creativity enabling' by many of them. These findings are also reflected in policy guidance across partner countries.

Assessment

Assessment, especially formative assessment, was widely highlighted as a particular area for development in both policy and practice in both preschool and primary phases. A common theme to emerge across the two research surveys was lack of policy guidance in terms of both methods of assessment and criteria for assessing on-going progress, resulting in considerable variability in approaches adopted among partner countries. The findings from the policy and teacher surveys also reveal particular challenges in assessment related to inquiry and creativity, linked to a common tendency to focus on product rather than process in assessment requirements, allied with the pressures of statutory summative assessment processes in a number of partner countries.

The policy review highlights the need for a closer match between the aims and rationale for science education and assessment priorities and approaches. For example while assessment of science ideas is widely emphasised in policy, more limited attention is given to assessment of inquiry processes and procedural understanding and even less to social and affective dimensions of learning, although these dimensions are often highlighted in the rationale and aims set out for early science and mathematics education. Interestingly, the cognitive dimensions rated most highly among teachers were children's understanding of important science processes and inquiry competences, highlighted as given little emphasis in the survey of policy. Teachers' responses to the survey regarding their priorities for science assessment were consistent with the frequency with which they say they pursue the corresponding aims and

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objectives in their science teaching. This is in contrast with the mismatch identified between rationale, aims and assessment priorities in official policy across partner countries.

In terms of the creative attributes that were identified in partner policy, thinking skills feature most strongly, especially in the early primary age phase. The other creative attributes most commonly emphasised or mentioned include curiosity (greater emphasis in preschool), ability to work together (greater emphasis in primary) and ability to make connections with learning in other subjects. The teacher survey showed that a large majority of the sample of all teachers across the partner countries reported praising and rewarding creative dispositions in their pupils in science quite or very frequently. The dispositions most frequently rewarded were children's ability to work together, their curiosity and imagination.

Content

The findings from both the policy and teacher surveys suggest a number of differences in the presentation and nature of curriculum content for science and mathematics across partner countries.

In preschool, science is generally included within broader areas of learning such as 'Discovery of the World' (France) or 'Child and the environment' (Greece) or 'Knowledge and Understanding of the World' (UK (Wales)) with the majority of official guidance advocating integrated cross-curricular approaches to learning and teaching. In addition, overall there is limited specification of subject specific content for science in this phase of education. The emphasis is rather on the development of basic skills and positive attitudes in the context of content selected to build on children's prior experiences and interests. This is the case for the Flemish community in Belgium, France, Finland, Germany, Malta and England. In early primary school, many national curricula such as of the Flemish community in Belgium, Finland, Germany, Greece, Northern Ireland and Wales continue to specify science within broader areas of learning. In Wallonia, France, Malta and Romania on the other hand, science is presented as a separate area of learning. In both cases, the emphasis is placed on developing specific scientific concepts associated with learning objectives for the primary age phase.

A greater role for creativity was generally identified as implicit in policy, indicated for example in the common presentation of the curriculum in terms of experiences, the importance given to play and exploration, building on children's interests, and the greater attention to affective and social factors within curriculum content.

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In comparison to science, mathematics is more commonly set out as a distinct area of learning in partner policy at both phases of education. As in science, mathematical content specified in the curriculum includes both concepts and processes with increasing focus on concepts and higher order thinking skills across the primary school. Mathematical content of the curriculum receives greater attention in preschool in comparison to science, and in mathematics reference is often made to problem solving rather than inquiry or investigation. In general there is a similar focus on affective and social factors. Mathematics in some countries is also treated as a cross-curricular dimension.

Location

The teacher survey indicated that collaboration amongst peers and working in small groups are approaches employed by the majority of teachers, as recommended in policy across partner countries and phases of education. With regards to the use of outdoor learning environments there is also consistency between policy and teacher surveys. Outdoor learning is mentioned in most countries' policy guidance - more strongly for preschool. Similarly, teachers in the majority of partner countries reported making use of teaching and learning opportunities linked to outdoor environments. On the other hand, non-formal learning environments such as visits in places of interest were given limited attention in most partner countries' policy and also reported to be used rarely by most teachers across the consortium.

Materials and resources

The National Reports on policy indicate that limited guidance is offered about materials in the national policy of many partner countries. In the instances where guidance is provided, equipment associated with inquiry, such as materials to explore or equipment for measuring are most often mentioned, as well as digital technologies. Teachers' responses regarding the materials used most frequently in the classroom are consistent with the guidance offered in curricula. Interestingly the vast majority of respondents use quite or very frequently equipment and materials for hands-on exploration in the classroom, such as magnets, building blocks, sorting activity games and rulers, despite the fact that only a little over 60% (for mathematics) and a little over 50% (for science) reported that their schools are fairly or well equipped in these resources.

Grouping

The surveys of policy and teaching practice indicate that grouping is an aspect of practice where advice in policy is limited and teachers are able

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to make their own decisions about groupings for particular purposes. There are a number of common themes in the policy guidance provided. In some countries a variety of approaches is advocated in policy, appropriate for particular tasks or learning needs. The benefits of collaborative working in pairs or groups are most commonly highlighted. References are also made in policy guidance to opportunities for individual work and whole class teaching.

According to the teacher survey, class groups comprise of between 20-30 children and there were only a few exceptions to this (either smaller or larger classroom sizes) in the partner countries. As indicated in policy documents, this makes the option of collaboration and group work possible in science and mathematics. Working in small groups is an approach used quite or very frequently by the large majority of all sampled teachers. A further issue explored was whether children are allocated to age or ability groups for learning. Just over half of the teachers in the total sample report to using assessment (quite or very often) to group children for science instruction purposes.

Time

In all but two of the partner countries there are no specific time requirements for either science or mathematics in preschool policy. As in preschool, set requirements concerning the time allocated for science and mathematics are absent from all official documentation in the majority of countries. Teachers' responses about the amount of time dedicated to teaching science and mathematics per week point out that overall more time is spent teaching mathematics than science. Preschool teachers in the majority of partner countries reported to teaching 1 to 2 hours of science and mathematics per week. In primary schools, there is a more varied picture for science with teachers spending 1 to 2 hours teaching per week in four of the participating countries; 3 to 4 hours in two other countries, while only Portuguese primary teachers spend over 4 hours per week teaching science. In regard to mathematics teaching, teachers in all sample countries reported to dedicating more than 4 hours per week without any exceptions.

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1 Introduction

1.1 Aims of this report

The research context of the *Creative Little Scientists* project focuses on the role of creativity in science and mathematics education in early years education and first years of primary education.

This report serves as the concluding part of Work Package 3 (WP 3 - Mapping and Comparative Assessment of Existing Practice) and compiles data gathered through deliverables D3.2 (Report on Mapping and Comparing Recorded Practices) and D3.3 (Report on First Survey of School Practice) which consider existing approaches of teaching, learning and assessment as reflected in policy documents, alongside a survey of teachers views of science and mathematics and the role of creativity in these respectively.

Findings from these deliverables, alongside the National Reports compiled by each partner country, have been compared and synthesised with a view to revealing any similarities and differences between policy documents and practices of teaching, learning and assessment of science and mathematics in the early years. Consideration is also given to the characteristics of teacher education in early years mathematics and science across partner countries.

This report concludes with a synthesis of the teaching, learning and assessment approaches in the nine partner countries (and 13 corresponding educational systems) and examines teacher education, in order to provide a platform for establishing a better understanding of current science and mathematics education in the European context. Based on this, the report can inform the empirical research in schools associated with Work Package 4 and identify the need for teacher training, associated with Work Package 5.

1.2 Comparing policy and practice

Aims of comparisons

Comparisons in the Comparative Report (D3.4) are approached in two stages and from two different perspectives. Firstly, this report compares the findings between policy and teacher surveys focusing on the issues targeted in the project. Secondly, we compare whether and how the findings from former comparison (i.e. between policy and reported teacher practice) differ among the partner countries.

Through this report, the *Creative Little Scientists* project aims to capture the similarities and differences of early years education in science and

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mathematics across nine European countries *to better understand* the global challenges and strengths of science and mathematics education in Europe. This report guides towards comparative pedagogy, aiming to identify processes of teaching and learning within schools and classrooms in different countries. The project aims to improve not only educational policy and practice, but also to develop the ability to generalize about education-society interaction (Arnove 2007) both within and between the countries.

Research in Comparative Education and its role in the* Creative Little Scientists *project

In the area of comparative education, much research has been published regarding science and mathematics education, although this rarely focuses on early years education. The Eurydice (2006) report *Science Teaching in Schools in Europe,* reflects the trend of policy and research. It also presents an overview of the main findings from research and offers an appraisal of the expertise now available on the most effective ways to encourage young people to study science across 30 countries.

Several EU and OECD countries report practices through surveys or other methods of measurement that have been conducted, aiming to support relevant policies at school, national and international levels. For example TALIS (see Scheerens 2010) is the first international survey to focus on the working conditions of teachers and the learning environment in schools; it aims to help countries to review and develop policies that foster conditions for effective schooling. In addition, the OECD report 'Starting Strong III' focuses on policy perspectives, examining the quality of ECEC and providing a practical toolbox for practice (OECD 2012).

Most of the academic research focuses on particular countries and themes without having policy perspectives, the main focus being on surveys and other empirical data. However, Rasinen et al. (2009) have made comparisons through analysing the curricula and educational systems of five countries, trying to find basic materials for a holistic and gender-equal technology education curriculum. Another aim of the study was to create new ways and alternative educational methods to make the image of technology and technological careers appear more attractive to girls. The authors examined pupils' attitudes and motivation towards technology through a questionnaire study involving 235 German and Finnish pupils. Based on the results, they suggested several principles for instruction (see Rasinen et al. 2009). The PISA results have also inspired researchers to combine some policy material and PISA measurements, aiming at indicating consequences and identifying potential research and policy

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directions in the future (see Anderson et al. 2010). In general, these studies do not systematically focus on comparing policy and practice nor do they particularly concentrate on the area of science and maths education in the early years.

Research in Comparative Education offers possibilities for developing the educational systems of different countries; the differences and contradictions between countries can be determined and developmental issues can be identified. Studies in comparative education provide crucial, wide-span perspectives for policy development more globally; the general lines of current education can be revealed and based on the data, new suggestions for policy developments can be presented. These suggestions have, however, often been derived from experience in practice. There are several comparative studies available that provide essential implications for the development of these particular areas; in early years (Ofsted 2003), in science education (Prokop et al. 2009) and about mathematics skills (Ee et al. 2006; Aunio et al. 2008) in mathematics education.

In comparative studies, as it is the whole which is most relevant, rather than certain parts or even cases, there is the danger that cultural variation could easily vanish. However, instruction and assessment are issues which are often linked to cultural context (Sternberg 2007), therefore the tools which are used in the research should take into account the cultural background. This is often challenging in comparative research, because the research tools should be similar in all countries in order to be able to compare the targeted issues. However, sometimes specific cultural dynamics or nuances are not able to be reached and some of the very significant issues cannot be taken into account.

To address some of the aforementioned issues related to undertaking comparative studies in Creative Little Scientists, core research tools were used as a basis for the research with some variation in their application. To confirm national requirements and characteristics, the research data was gathered using the national languages whilst policy analyses were made by partners already engaged in the project, using their national language and who had the competence to do this research in their country. In addition, the teacher surveys were translated into the national languages and data was gathered using the teachers' mother tongues. Reverse translations were then done by the researchers.

According to Van den Akker (2007) it is possible to distinguish three broad forms of curriculum presentations, which are interlinked in this report. *Intended Curriculum* comes through Policy documents which focus on general descriptions of the ideal curricula. *Implemented Curriculum* is

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focused through the eyes of the teacher, aiming to capture the interpretations of the curriculum in practice.

In this report, these two dimensions of the three level typology, are compared and synthesised to enable us to examine the third level, *Attained Curriculum,* in the following phase of the project (see Figure 1).

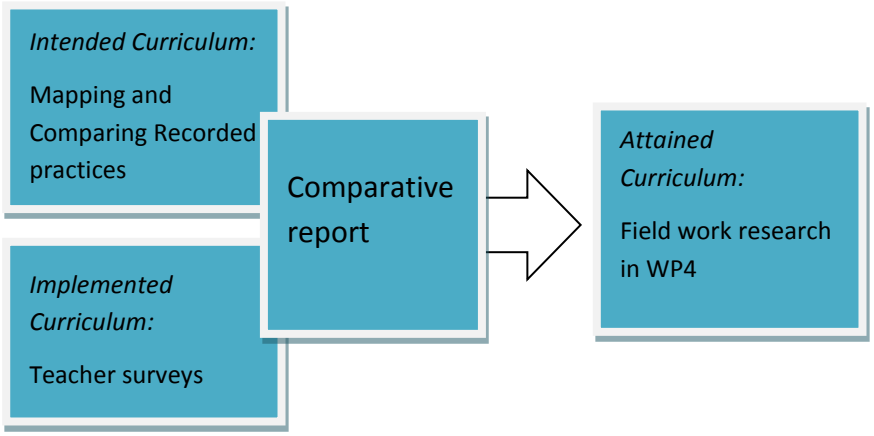

Figure 1. Role of the comparative report following Van den Akker's (2007) typology of Curriculum in the Creative Little Scientist –project.

1.3 Research questions of the report

The main research questions of the project have been provided in the Deliverable 2.2 *Conceptual Framework*. The report synthesises the first research question through deliverables D3.2 and D3.3:

How is the teaching, learning and assessment of Science and Maths conceptualised? What role does creativity play in these?

The synthesis is based on *aims and priorities*, *teaching, learning and assessment.* According to the policy analysis and teacher survey within the partner countries, the focus is on comparing the similarities and differences

a) between the countries

b) between preschool and early years education

c) between science and mathematics education

In addition, this report provides a viewpoint for the fourth research question of the project:

How can the findings that emerge from analysis in relation to research questions 1-3, provide information for the development of practices in the classroom and for teacher education (ITE and CPD).

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The findings from this report are to be taken into account in WP4 and relevant guidelines for teacher education are to be proposed in WP5.

The following sub-questions have been used to frame the analysis in D3.2 and D3.3 and are built upon the framework of curriculum components '*vulnerable spider web'* (see van den Akker, 2007) that identify the following key questions related to student learning:

- Rationale or vision: Why are children learning?
- Aims and objectives: Toward which goals are children learning?
- Content: What are children learning?
- Location: Where are children learning?
- Learning activities: How are children learning?
- Teacher role: How is the teacher facilitating learning?
- Materials and resources: With what are children learning?
- Grouping: With whom are children learning?
- Time: When are children learning?
- Assessment: How to measure how far children's learning has progressed?

Furthermore, the sub-questions related to approaches to teacher education were broken down into:

- Initial teacher education
- Continued Professional Development

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2 Summary of key findings from the policy review and teacher survey

This section provides an overview of key themes emerging from the research findings of both the policy review and teacher survey. These key findings are presented in relation to the curriculum components of van der Akker's (2007) 'vulnerable spider web' and are grouped into three areas of interest, which contain all ten of the components of the spider web. The three areas are:

- ***Aims/purpose/priorities*** (containing Rationale or vision and Aims and objectives)
- ***Teaching, learning and assessment*** (containing Learning activities, Pedagogy and Assessment)
- ***Contextual factors*** (which contain Content, Location, Materials and resources, Grouping and Time)

The brief summary of the conclusions from the two previous reports (Policy review and Teacher survey) in this particular part of the deliverable serves as an introduction to the synthesis of findings, reminding the reader of the key issues revealed in the previous stages of the research and facilitating the comparisons which are presented in the findings and conclusions sections that follow.

2.1 Aims, purpose and priorities

Policy

The policy review revealed that varied attention is given to issues of vision and rationale in partner countries. The review carried out concerning the rationale provided for early years science education in partner policies revealed two common emphases: the need to develop socially and environmentally aware citizens, and the importance of fostering skills and dispositions to support future learning. In only a small minority of countries was the need to provide a foundational education for future scientists or to develop more innovative thinkers prioritised in policy.

National policy in the 9 partner countries indicates varied emphases on cognitive, social and affective learning objectives across countries and phases. The aims, objectives, and content of the science curriculum tend to emphasise the development of process skills associated with scientific inquiry and of knowledge and understanding of science ideas (the latter particularly in primary school). More limited attention is afforded to social and affective dimensions of learning and even fewer countries highlight understandings related to the nature of science.

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In their National Reports, partners identify varying roles for creativity articulated in policy related to the purposes for science education in their countries. Their commentary indicates some explicit reference to 'creativity' or 'creative' dispositions in partner policy. However in many cases, references to creativity in partner documentation are implicit in the creative dispositions mentioned in relation to the purposes of education such as curiosity, imagination or sense of initiative.

Survey

The survey data, similarly with policy, indicate a varied vision or rationale for science in compulsory education across partner countries. The overall picture of the purpose of science education clearly shows that all purposes included in the survey are considered important for teachers across all partner countries. Children developing important attitudes and dispositions as a foundation for future learning, and becoming socially and environmentally aware and responsible citizens are the most important purposes for teaching science in compulsory education according to teachers' responses in the survey. On the other hand, the purpose which is seen as least important is to provide a foundational education for future scientists and engineers.

Teachers, according to their responses, very often plan their teaching of science in preschool and early primary education to pursue affective learning aims about science, science learning and learning in general. Learning aims linked to social outcomes are also commonly pursued, whereas science cognitive outcomes are less so but more frequently by primary teachers. Out of the inquiry-related science learning aims teachers foster quite or very frequently the development of children's capabilities to carry out scientific inquiry, such as questioning, gathering and communicating findings, and, to a lesser degree, planning and conducting simple investigations. Learning aims related to the nature of science and thus understandings about scientific inquiry, that is about how scientists develop knowledge and understanding of the surrounding world, are the least frequently pursued by teachers

2.2 Approaches to teaching, learning and assessment

Policy

The National Reports indicate a common emphasis in policy on hands on approaches and activities linked to children's everyday lives. In preschool providing a broad range of experience and making links across the curriculum is widely recommended. There is a considerable focus on play and fostering autonomous learning. Encouraging problem solving and

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children trying out their own ideas in investigations are emphasised in the majority of countries. Approaches given the least attention include the use of drama, stories, history, field trips and everyday experiences as contexts for learning. Fostering imagination or the discussion of alternative ideas also do not feature strongly in policy guidance.

In primary school greater attention is paid to the processes of scientific inquiry and scientific concepts, reflecting aims, objectives and content identified in partner policies. Overall, the range of teaching approaches listed features less strongly in policy. None of the approaches listed are emphasised in a majority of countries. Least attention is given, as in the preschool phase to drama, stories and history as contexts for learning and to fostering imagination and discussion of alternative ideas. However in contrast to preschool, more limited emphasis is given to play, questioning and fostering autonomous learning. Approaches to teaching and learning associated with inquiry are widely emphasised in policy guidance in partner countries. For example problem solving and children trying out their own ideas are mentioned. Promoting inquiry skills such as questioning, observation and communication is widely advocated. Approaches given the least attention include the use of drama, stories, history, field trips and everyday experiences as contexts for learning. There were also differences in the aspects of inquiry discussed, with most limited reference to connecting explanations to scientific knowledge and reflection on inquiry processes and learning. It is notable that in most countries limited references are made to the role of imagination or the discussion of alternative ideas – also linked with creative approaches to learning and teaching.

Policies in partner countries mostly suggest open and/or guided approaches should be adopted. Generally guided approaches predominate, except in relation to questioning. Where policy exists in this area, only a small minority of countries advocate structured approaches. No strong differences are evident in relation to the level of guidance. It is notable that policy in Finland and the UK gives the greatest emphasis to open approaches for both phases of education, although both countries also recommend guided approaches.

Policy in relation to assessment showed the widest variation across partner countries. In many cases findings reflected the limited guidance for science assessment and inconsistencies in emphasis across different elements in curriculum policy. There is very limited evidence in policy of a role for creativity either in the priorities or methods for assessment advocated across partner countries. Greatest emphasis is given to the assessment of science ideas. Understandings and competencies in relation

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to scientific inquiry are emphasised in assessment policy in a minority of countries and in only a few instances are attitudes a priority for assessment in science. In general, guidance in relation to assessment methods is limited, with little attention to multimodal forms of assessment or the involvement of children in assessment processes often associated with creative approaches to learning and teaching in the early years.

As highlighted above, assessment, especially formative assessment, was widely mentioned as a particular area for development in both policy and practice in both preschool and primary phases. The most common theme to emerge was lack of policy guidance in terms of both methods of assessment and criteria for assessing on-going progress, resulting in considerable variability in teacher judgements. There are particular challenges in assessment related to inquiry and creativity. This is linked to the tendency to focus on products rather than processes in assessments, as indicated above, allied with the pressures of statutory summative assessment processes in a number of partner countries.

Learning activities most associated with creativity in policy guidance were questioning and observing, conducting investigations in preschool and planning investigations in primary school. Those least associated in policy documents with creativity were employing simple equipment (both phases) and use of data to construct explanations (in preschool). In terms of pedagogy, policy guidance for the preschool phase highlights in particular the role for creativity in relation to play. The approaches judged to be given the least creative emphasis in policy were use of stories, history and field trips as contexts for teaching, building on children's prior experiences and fostering discussion of alternative ideas. Comments in the National Reports indicate again very limited explicit reference to creativity. They however identify a strong implicit role for creativity in relation to opportunities for play in pre-school and problem solving in primary school.

Survey

The analysis of teachers' responses to the survey reveal that the inquiry-based science activities which are used most commonly are predominantly linked to observation, as well as to fostering children's questioning and eliciting their curiosity in natural phenomena. Promoting understanding about scientific concepts and developing children's basic science procedural knowledge takes a less dominant place in the learning activities carried out in the classroom. In particular, learning approaches that involve children planning and designing their investigations are the least common of all the approaches tied to scientific inquiry. The low

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frequency of use of these activities is consistent with the findings about teachers' inquiry-related science learning priorities.

Social activities such as communicating results and explanations based on evidence are also used quite frequently in the classroom. In these, teachers tend to allow children to choose freely and independently how to justify their explanations. Teachers consistently and uniformly across the partner countries hold a great appreciation for all pedagogical contexts and approaches that promote dialogue and collaboration in science amongst children.

Although also uniformly teachers endorse strongly affective learning outcomes in their teaching of science, the way they perceive the contexts and approaches identified in the research literature as enhancing motivation and affect in children varies significantly.

There is a strong consensus amongst teachers – reflected in their reported practice - that the teaching of science should be building on children's prior experiences and help relate science to everyday life. Using drama and history to teach science are not practices very commonly used by teachers across the partner countries. Nor are they considered very 'creativity enabling' by them. Teachers tend not to foster children's autonomy in learning very frequently, nor to link this autonomy with creativity. Teachers quite or very frequently encourage children to record and express their ideas in different ways, as well as evaluate alternative ideas.

Teachers' responses reveal that almost half of them prefer to use an 'open' approach when children formulate and communicate explanations based on evidence, whereas value a 'guided' approach in respect of all other features of IBSE (i.e. setting questions, identifying and analysing evidence, making connections to scientific knowledge and reflecting on the inquiry process).

The part of the Report on First Survey of School Practice dedicated to assessment presents the responses teachers provided to the survey section dedicated to assessment and aim to address: the ways in which formative and summative assessment are used in science and mathematics teaching in early years; the involvement of children in assessment processes; the use of multimodal approaches to assessment; the role of context and authenticity of assessment tasks; and the person/people considered to be responsible for making judgments in assessing science and mathematics.

Affective assessment priorities are considered as the most important out of all priorities for assessment, based on teachers' responses. On the

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other hand, cognitive priorities, such as acquiring knowledge and understanding of science ideas and processes, including competences of and understandings about scientific inquiry, are considered as quite or very important by many fewer teachers, though still the clear majority of them. Overall, teachers report to be assessing children frequently during classroom interaction, attending to the pictures and other visual materials they produce as well as to their gestures or physical activity, and using questions in-context, authentic problem-based tasks and portfolios (collection of evidence of children's work and progress). All these point to a formative emphasis of science assessment by teachers for the particular age range examined by Creative Little Scientists. Out of all formative approaches, these of self- and peer-assessment where the locus of the assessment judgment is on children rather than on teachers are the least used. The use of assessment by teachers is similarly predominantly for formative purposes, such as to identify ways to improve science learning and regularly monitor children's progress towards a set of desirable science learning outcomes. The latter however seem to be defined by teachers themselves who only infrequently involve children in the decision process. Improving the science curriculum and grouping children for instruction are the least frequently identified purposes of assessment for the 3-8 age group of children.

In terms of creativity in teaching and learning, interesting findings can be found about the relationship between the IBSE activities teachers consider most 'creativity enabling' and the ones they use most frequently. The top two activities which teachers consider most 'creativity enabling' and the ones they use most frequently and they are the ones that involve children in the observation of natural phenomena and in asking questions about them. However, the next two in the 'creativity enabling' order, which involve children in the design (or plan) and conduct of simple investigations (or projects), are the least frequently used by teachers. Correspondingly, the activities that refer to children employing simple equipment and tools to gather data, using data to construct reasonable explanations, and communicating these explanations are considered as the least creative, but are used quite frequently. In particular, the largest discrepancy between teachers' frequency of use and perception of creativity potential regards these latter two activities, i.e. of using data to construct reasonable explanations, and of communicating these explanations. The proportion of teachers who use these activities quite or very frequently is close to three times the one of teachers who consider them as amongst the three potentially contributing to children's creativity development.

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Teachers overall appreciate the role of dialogue and collaboration in their practice, but fail to see their potential for creativity development in children. The contexts of 'drama' and 'using history to teach science' are used the least frequently and are least considered as 'creativity enabling'. The approaches of 'building on children's prior experiences' and 'relating science to everyday life' on the other hand are amongst the most frequently used, though still not considered as similarly 'creativity enabling'. Almost all problem solving and agency contexts and approaches are thought of amongst the most 'creativity enabling' by a large number of teachers, who also report to use them quite or very frequently. Concerning the areas of questioning and curiosity, there is correspondence between teachers' use of practices that encourage children to ask questions and foster their imagination and teachers' perceptions of these practices as 'creativity enabling'. Finally, the cross-disciplinary teaching of science ('integrating science with other curricular areas') is a context used frequently by both preschool and early primary school teachers, but not considered equally as 'creativity enabling' by them; many more early primary than preschool teachers consider this context as 'creativity enabling'.

2.3 Contextual factors

Policy

Science is represented in different ways within the curriculum: in some countries within a broad area of learning such as 'Knowledge of the World' or 'Study of the Environment', in others as a single subject. In general, limited advice is given in policy in terms of the physical and social environment for learning. Where advice on materials is provided, it mostly related to the provision of equipment for inquiry and use of digital technologies. There was very little emphasis on a budget for teaching or technical support for science. In terms of forms of grouping, common themes include the recommendation of a variety of approaches to suit particular tasks and learning needs and the benefits of collaborative learning. The report on policy across the nine participating countries indicates that this is an aspect of practice where advice in policy is limited and teachers are able to make their own decisions about groupings for particular purposes. Commonly found in the policy guidance provided across the countries are the benefits of collaborative working in pairs or groups.

National Reports indicate limited explicit references to creativity in policy related to curriculum content. However partners identified roles for creativity implicit in the widespread promotion of skills and experiences

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associated with inquiry and problem solving both in preschool and early primary school and in references to curiosity and other affective factors. In a number of National Reports, implicit links to creativity are identified in terms of grouping children; for example in the use of group work in fostering 'a spirit of collaboration', the role of individual work in encouraging autonomy and self reliance, as well as the emphasis on dialogue and collaboration enabling 'learners to take risks without fear of self-failure'

Survey

Group work is the preferred way of work for teachers in the early years science classroom, which on average has between 21 and 30 children. Teachers report spending 2 hours or less per week teaching science, whereas they spend more than 3 hours weekly on mathematics. According to their teachers, preschools and early primary schools are well resourced in computers and relevant library materials for science teaching, and in instructional materials, computers and equipment and materials for hands-on exploration in the classroom for mathematics teaching. Support personnel for teaching, or for technical issues, in both science and mathematics is overall the least available resource in schools. In their teaching of science and mathematics, overwhelmingly teachers use materials prepared by themselves or downloaded from the internet. On the other hand, materials prepared collaboratively by teachers in the school are the least commonly used resource by teachers after digital technologies. Teachers also frequently use equipment and materials for hands-on exploration in the classroom, but less frequently equipment and materials for hands-on exploration outside the classroom. Schools seem to be better resourced in mathematics than in science, at least in terms of instructional materials, equipment for hands-on exploration in the classroom and ICT resources.

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3 Methodology

3.1 Methodological issues regarding comparisons

Creative Little Scientists has used the methodology of Comparative Education in which the same methods of data collection and analysis have been used in making comparisons (see Carnoy 2006). This report is based on two corresponding pieces of research conducted on the *Creative Little Scientists* project. Firstly desk research of policy approaches which mainly followed qualitative, case-orientated methodology and strategy; qualitative research analysis methods and partly quantitative approaches which have been used to present descriptive statistics. Secondly, the teacher survey, in which data was gathered through a teacher questionnaire and analysed using statistical descriptions. In this report, because the existing data has been used to build up the synthesis of these two dimensions, the study contains some of the advantages and challenges of the mixed methods paradigm (Creswell & Clark 2011). While policy analysis provides more cultural views of the printed ideology of education, the teacher survey focuses on the practices conducted by individual teachers. This comparative report uses data gathered from each of these in order to develop a better picture of policy and practice in early years science and mathematics in the partner countries.

The language barrier between different countries is a core methodological issue identified when undertaking comparative studies. In the *Creative Little Scientists* project the shared language is English, although the materials and tools used in the data collection were translated into the national languages of the partner countries. Part of the methodological approach selected for both reviews was dedicated to ensure that the cultural and national characteristics of languages and expressions were not lost in translation. However, specific concepts or terms cannot always be translated to/from English.

3.2 Methodological approach

The main aim of WP3 was to map the existing approaches of early science and mathematics education and the role of creativity in these. The planning of the desk research and teacher survey commenced at the same time to achieve maximum coherence between the studies. In addition, the similar principles of Van den Akker (2007) were adopted to examine the existing approaches both in policy and in practice. In both studies the data collection, data analysis and the writing of the national reports occurred during the time of May–December 2012. The phases and timing of WP3 are presented in Figure 2.

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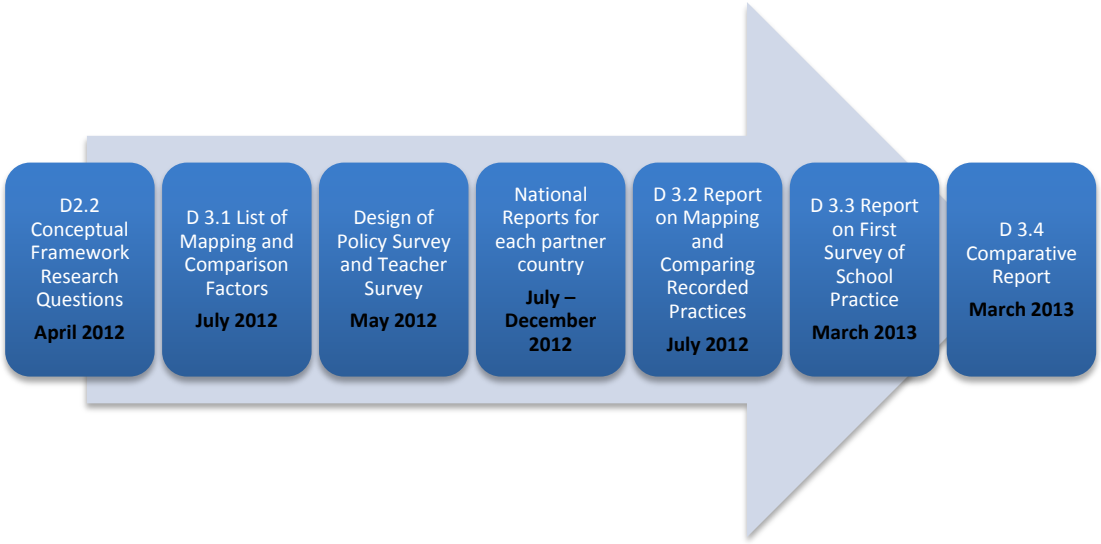

Figure 2. Processes and timing of the comparative research

3.2.1 Desk research and teacher survey as data sources

In order to compare the approaches presented in policy documents and those used by teachers in practice, the consortium released deliverables D3.2 and D3.3. The data collected and the findings from these two separate research studies are synthesised in this report.

Desk research

The first phase of WP3 was the desk research which mapped and compared the official national policy statements with regards to teaching, learning, and assessment of science and mathematics in early years. In addition, the analysis focused on teacher education in early years science and mathematics. To achieve the aims of the task, each partner conducted an initial analysis on national level. This analysis focused on the national policy frameworks through all relevant official documents. These documents varied from research reports to curriculum documents, adopted to examine Teaching, Learning and Assessment within the components of *Rationale, Aims, Content, Location, Learning activities,* Teacher role, Materials and Resources, Grouping and Time. Each partner also had to fill out a national policy questionnaire related to both primary school and preschool provision.

The questionnaire was separated into two main sections: Approaches to Teaching, Learning, and Assessment, and Approaches to Teacher Development. The first section was further split according to the nine curriculum components (Rationale, Aims, etc.). Each section included a series of questions *(e.g. What purposes of assessment are included?),*

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followed by a number of items relating to this question. These items drew upon approaches that were identified in the *Conceptual Framework* (D2.2) and the *List of Factors* (D3.1), as being relevant to the role of creativity in early science and mathematics. The items also drew largely upon the questionnaire used in the teacher survey (Task 3.3) in the project. The teacher survey, also conducted in this phase of the project, aimed to identify teachers' conceptions of teaching, learning and assessment of science and mathematics in the early years. By aligning the two surveys, the aim was to facilitate subsequent comparisons of conceptions promoted in policy with those held by teachers for whom policy is largely intended.

The purpose of the desk research was to make comparisons between policies in the partner countries through using the contextual expertise of the researchers. The questionnaires served to allow justifications and explanations to be made which then formed the basis for the published deliverable 3.2 on mapping and comparing recorded practices in partner countries, in which the findings of these analyses were summarised.

Teacher Survey

The analysis of the teacher survey was carried out in two stages, identical to those followed during the desk research in order to ensure consistency between the two studies. Initially partners carried out an analysis of their country's data to produce a National Report discussing the findings and situating them within their country's educational context. The results of this first layer of analysis can be found as addenda to the Report of First Survey of School Practice. In the second stage, the data gathered from all the partner countries were amalgamated and analysed as a whole. Statistical comparisons were performed to identify similarities and differences between perceived practices in partner countries; information provided in the National Reports was used to interpret these similarities and differences. The findings of this second layer of analysis were presented in the main body of the Report of First Survey of School Practice.

The final version of the questionnaire, which resulted after including the feedback from piloting, and its translated versions (Greek, Dutch, Romanian, German, French, Finnish, Portuguese and Welsh) were made into online surveys using SurveyMonkey, an online survey software and questionnaire tool. A total of 13 separate questionnaires were uploaded to SurveyMonkey and separate web links were sent to all partners to start disseminating the survey and gather participants.

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The questionnaire that resulted from this development process includes a short introduction and 44 questions divided into 7 sections. These sections are:

- Background Information – About your School
- Background Information – About You
- Your Knowledge, and Skills and Confidence in Teaching Science and Mathematics
- Your Views about and Approaches in Teaching Science
- Your Views about and Approaches in Assessing Science Learning
- School Science and Mathematics Resources and Your Use of Them
- Thanking You and Further Communication

As previously mentioned, all items included were chosen to specifically address all curriculum components associated with the 'vulnerable spider web' and important themes of the conceptual framework. These questions were then pre-coded according to the list of factors (D3.1) linking questionnaire items to specific factors. Previous research on teachers' beliefs about creativity, early years science and mathematics education, as well as creativity in science and mathematics education, were used for the development of the questionnaire and to increase its validity. The questionnaire was piloted following feedback from the partners.

A total of 815 teachers from 605 schools (238 preschools and 367 primary schools) across the consortium countries completed the online questionnaire. Despite exceeding the minimum number of sampled schools, specified as 500 in the project's Description of Work (DoW), it is important to recognise a series of biases in the sample. First of all, although it was recognised from the outset (i.e. in the DoW) that the national samples are not going to be 'representative' in a formal statistical sense of either the number of schools or teacher population in the partner countries, some countries' or regions' samples are clearly under-represented in the total sample, in particular Germany's, France's, Wallonia's, Wales' and Scotland's, whereas other countries' samples are overrepresented, namely Finland's, Greece's and Romania's. In the case of Romania in particular, surveyed schools and teachers make up 27% and 30% of the total school and teacher samples respectively, outweighing the country's anticipated contribution to the sample.

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3.2.2 Conducting comparisons for this report

In the first phase, each partner was asked to provide a summary of the main findings from their national reports. Each partner combined the findings from the policy and teacher survey into the same document, in order to establish country specific information and interpretations. The country summaries and conclusions have been adopted for comparisons in this report.

Phases of data analysis

In the first phase, the comparative report of recorded practices was used to establish the main findings of the surveys. The policy questionnaire data was transferred from Excel format to SPSS software alongside relevant variables from the teacher survey in order to enable comparisons. Preschool and primary school data was considered separately.

Since both studies used similar factors (spider headings) for capturing the existing approaches of teaching, learning and assessment of early years science and mathematics education comparisons have been made using the same headings, as follows:

- aims and rationale for early years science and mathematics education;
- teaching, learning and assessment;
- contextual factors;
- teacher education.

This makes comparisons possible and valid. The *List of Mapping and Comparison Factors* (D3.1) was used as a tool for comparing the significant components from the findings of the original survey. The comparative report builds a synthesis of the themes mentioned above, focusing on each item under its particular theme. Comparative tables were created with items, splitting the data firstly into the countries and secondly by dividing preschool and school.

Originally surveys for policy and reported practice coded the variables using a different scaling system. To make comparisons relevant to showing the core differences, the scaling of surveys was recoded. The policy questionnaire originally had a 4 point Likert scale: Not mentioned, Single Mention, Various Mentions and Emphasised. This scale was summarised from two points: Not Emphasised (combined Not Mentioned, Single Mention) and Emphasised (combined Various Mentions and

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Emphasised). In the tables in this report, the numerical data is transferred into qualitative description.

In the teacher survey, the scales were also mainly on a 4 point Likert scale: Never, Rarely, Quite Often, Very Often. These were combined into two categories, Never and Rarely and Quite Often and Very Often, to show the occurrence of this particular item among the teachers. In some cases the importance was measured: Not Important, Little Important, Important or Very Important. These were also combined into two categories: Not Important and Little Important and Important and Very Important

Although the distillation of survey content might lead to the disappearance of some information, recoding was needed for valid comparison. Hence the core issues were able to be determined and the most significant differences recognised. In addition, the country comparison would not have been practical by keeping the original scales.

Whilst radar charts were created for each item only the most significant ones were taken into consideration to make the comparisons in the identified areas; comparison between the countries, differences between preschool and school and differences between science and mathematics. Some inconsistencies can be determined especially when focusing on mathematics education and the issues discussed concerning teacher education. The teacher survey could not reach all the different dimensions discussed in the policy analysis. These areas are considered in this report within the bounds of the information available.

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4 Findings

The findings section of this report section provides a summary of commonalities and differences related to each section; it is a comparison of the findings from policy analysis and teacher survey and at same time, is an attempt to summarise issues and tensions most relevant to the potential for creativity, reflecting on the role of inquiry based approaches. The findings are considered using characteristics common to both surveys.

The findings will also be discussed in relation to the different characteristics of the national educational systems and their provision across the consortium. The conclusions drawn from this will, in particular, inform the development of practices and teacher education.

4.1 Aims/purpose/priorities

In this section, focusing on the findings of the two reports, one for policy and one for practice the two main areas of priorities will be compared. Both the sub-questions; rationale or vision; aims and objectives; are discussed under separate headings.

4.1.1 Rationale or vision: Why children are learning?

The *Creative Little Scientists* Conceptual Framework (D2.2) identified five different drivers with regards to the vision of science and mathematics education. These drivers have been captured in the following statements:

1. science economic imperative;
    - To provide a foundational education for future scientists and engineers
2. creativity economic imperative;
    - To develop more innovative thinkers
3. scientific literacy and numeracy for society and individual (including the development of the child as a citizen through science);
    - To develop socially and environmentally aware and responsible citizens
    - To develop positive attitudes to science
4. technological imperative;
    - To enrich the understanding and interaction with phenomena in nature and technology
5. science and mathematics education as a context for the development of general skills and dispositions for learning.
    - To develop important attitudes and dispositions as a foundation for future learning

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4.1.1.1 Key themes from the policy review and teacher survey

Policy documents in partner countries revealed varied responses with regards to the rationale for learning science in preschool and primary education. The main emphasis is on fostering socially and environmentally aware citizens and on skills and dispositions for supporting future learning in both preschool and primary school across the partner countries. On the other hand, little emphasis has been put on science as an economic imperative for producing future scientists or innovative thinkers.

In comparison, the teacher survey revealed that preschool and early primary education teachers consider all the purposes listed above as important, but give varied significance to them, with specific common themes emerging between the partner country samples. Echoing the results from the policy review, consistently across all partner countries, the rationales are considered as most important for learning science in compulsory education are: as a context for the development of general skills and dispositions for learning; and for children to become socially and environmentally aware and responsible citizens. The view of science learning as an economic imperative, is the view least favoured by the teachers, same as in the policy analysis.

4.1.1.2 Differences between Preschool and Early Primary School

The review of policy across the partner countries indicates no substantial differences in the rationale for science education between preschool and early primary school in the majority of countries. Where differences are mentioned, they are related to a more general and holistic approach to the rationale for preschool education, more limited attention to subject-specific detail and a slightly greater role for creativity. Similarly, there is some difference in emphasis on providing a foundational education for future scientists and engineers, with greater attention in the early primary phase.

In comparison, the results of the teacher survey do not reveal any significant differences between preschool and primary teachers' conceptualisations of the purposes of science learning in compulsory education.

4.1.1.3 Comparisons between the policy and teacher surveys at partner country level

Science education for the development of socially and environmentally aware and responsible citizens

In general the comparison of the different partners' surveys results reveals that the largest consensus between education policy makers and

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teachers at country level is for the view that the purpose of science learning in both the early years and compulsory education should be the achievement of scientific literacy and numeracy for society and the individual, and in particular the development of socially, environmentally aware and responsible citizens (Table 1). This alignment between recorded (policy review) and reported (teacher survey) practice is consistent with the belief that looking at the world from a scientific perspective enriches the understanding and interaction with phenomena in nature and technology, and thus empowers students (and therefore future adults) to take part in societal discussions and decision-making processes, and gives them an additional element from which to form interests and attitudes (Gago et al., 2004). An exception to this policy focus on this particular vision for science education are the policy documents for preschool education in England where there is only a single mention to developing socially, environmentally aware and responsible citizens in the entire curriculum.

To develop socially and environmentally aware and responsible citizens	**Preschool**		**Primary**	
	Policy survey	**Teacher survey**	**Policy survey**	**Teacher survey**
Belgium (Flanders)				
Finland				
France				
Germany				
Greece				
Malta				
Portugal				
Romania				
UK: England				

■ Not rated ■ Not emphasised/Not Important ■ Emphasised/Important

Table 1. Emphasis on *'science education for the development of socially and environmentally aware and responsible citizens'*: results from policy review and teacher survey, per partner country.[1]

[1] Partner countries with small survey samples of fewer than 20 teachers in any of the two educational phases (preschool and primary) are not displayed in tables and figures, as the comparison of their responses with findings from the policy review would not be valid.

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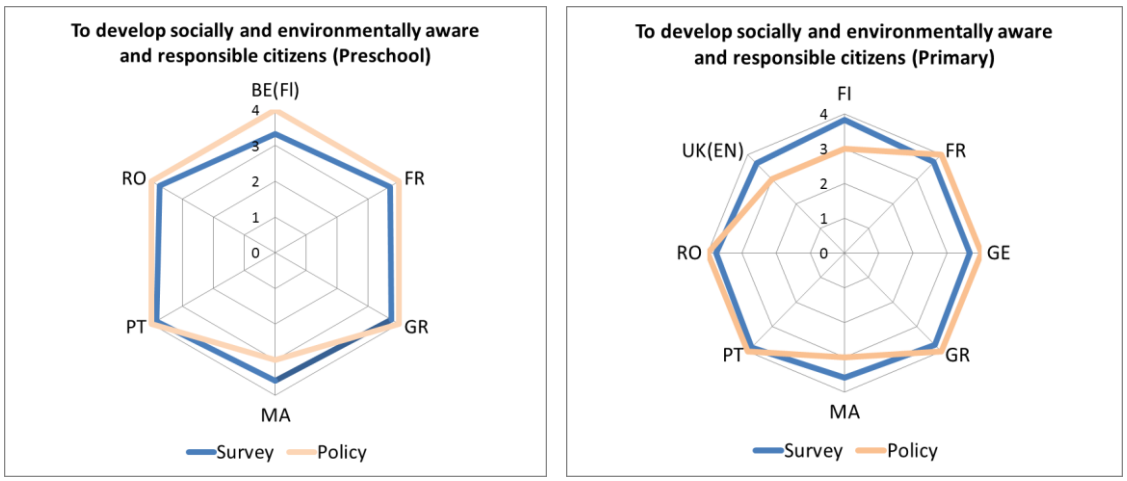

Policy
0: Not rated **1**: Not mentioned **2**: Single mention **3**: Various mentions **4**: Emphasised
Survey
1: Not important…..to…..**4**: Very important

Figure 3. *'To develop socially and environmentally aware and responsible citizens'*: results from policy review and teachers responses (means), per partner country.

Figure 3 shows the comparative data in each country for preschool and primary school. Overall it shows how this purpose of science education is embraced slightly more emphatically in preschool than school policy, but uniformly by both preschool and primary teachers.

Science education as a foundation for the development of important attitudes and dispositions for future learning

In addition, both the policy review and the teacher survey revealed a strong emphasis on science learning for children's development of important attitudes and dispositions for future learning. This common high focus of both reported and recorded practice recognises the importance of affective factors in early years education and is consistent with the view that science and mathematics provide a context for their development. According to the Conceptual Framework (D2.2), this is possible through the promotion of curiosity, motivation and confidence to engage in inquiry and debate, willingness to change ideas, flexibility and respect for evidence.

As evident in Table 2 below, exceptions to this alignment of policy and reported practice on the importance of fostering positive attitudes for future learning through science appear in the cases of: primary education in Greece, Finland, France and England, and preschool education in France and Portugal. In all these countries, the corresponding policy documents appear to under emphasise this rationale for science education, whereas teachers overwhelmingly rate it as very important (see Figure 4).

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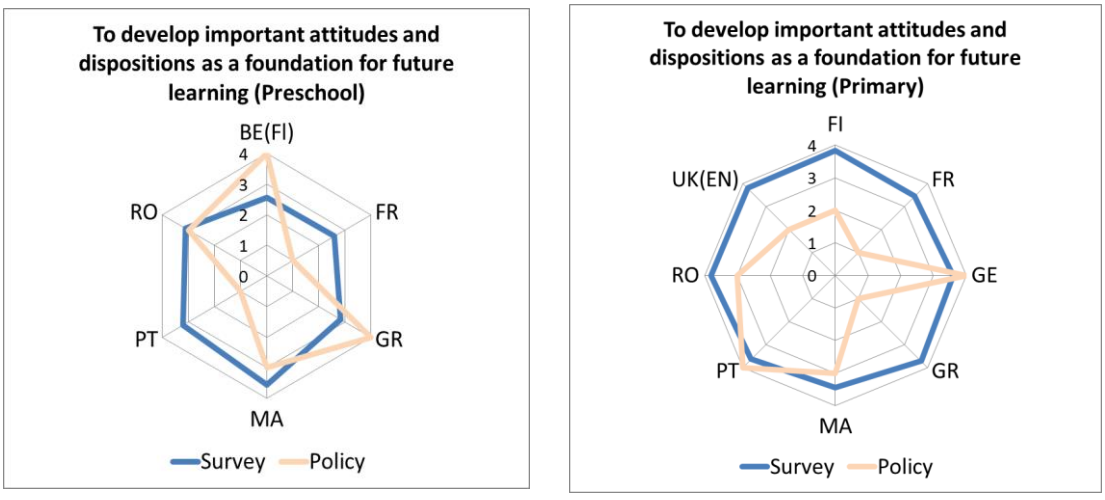
Interesting exceptions to this pattern are the cases of Greece and Flanders, where preschool education policy appears to emphasise this rationale more strongly than the relevant teachers conceptualise its importance.

To develop important attitudes and dispositions as a foundation for future learning	Preschool		Primary	
	Policy survey	Teacher survey	Policy survey	Teacher survey
Belgium (Flanders)				
Germany				
Malta				
Romania				
Greece				
Finland				
UK (England)				
Portugal				
France				

■ Not rated ■ Not emphasised/Not Important ■ Emphasised/Important

Table 2. Emphasis on '*science education as a foundation for the development of important attitudes and dispositions for future learning*': results from policy review and teacher survey, per partner country.



Policy
0: Not rated **1**: Not mentioned **2**: Single mention **3**: Various mentions **4**: Emphasised
Survey
1: Not important…..to…..**4**: Very important

Figure 4. '*To develop important attitudes and dispositions as a foundation for future learning*': results from policy review and teachers' responses (means), per partner country.

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Science education as foundational education for future scientists and engineers

The largest dissonance between recorded and reported practice at national level is on the view of compulsory science education as serving the economic imperative of providing a foundational education for future scientists and engineers. Few countries' policy documents emphasise the supply of future scientists and engineers as a rationale for science education, while teachers, in general, consider this rationale as important for compulsory science education (Table 3). This dissonance appears more pronounced at preschool level and in particular in Greece, Malta, and Portugal (and less so in Romania) (Figure 5). At primary school level there is still a significant difference of emphasis between policy and reported practice in Greece, Malta, England, Finland, Romania (and less so in Germany). The relevant policy documents in all these countries do not include emphasis on the development of a scientific workforce, whereas their teachers perceive this purpose as very important.

Policy makers and teachers appear to agree in favour of this rationale for science education only in France (at preschool and school levels) and Flanders (at preschool level), with policy documents advocating it even more strongly than teachers.

To provide a foundational education for future scientists and engineers	Preschool		Primary	
	Policy survey	Teacher survey	Policy survey	Teacher survey
France				
UK (England)				
Belgium (Flanders)				
Portugal				
Romania				
Germany				
Greece				
Malta				
Finland				

Not rated Not emphasised/Not Important Emphasised/Important

Table 3. Emphasis on '*science education as foundational education for future scientists and engineers*': results from policy review and teacher survey, per partner country.

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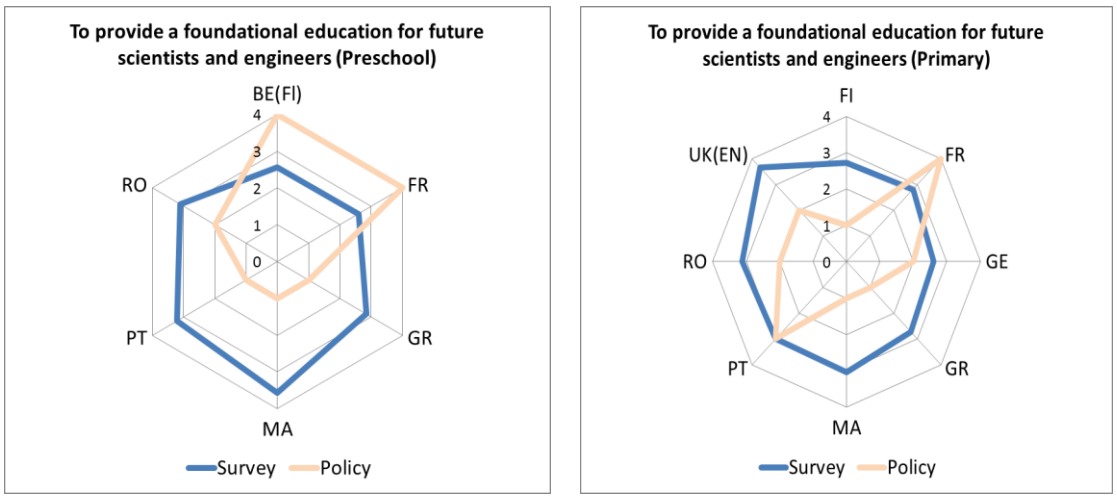

Policy
0: Not rated **1**: Not mentioned **2**: Single mention **3**: Various mentions **4**: Emphasised
Survey
1: Not important…..to…..**4**: Very important

Figure 5. *'To provide a foundational education for future scientists and engineers'*: results from policy review and teachers' responses (means), per partner country.

The overall picture formed by the policy review and teacher survey in regard to the rationale or vision for science learning in the early years and compulsory education shows that even though policy in the partner countries tends to focus its guidance on specific drivers for science education, teachers do not clearly focus on specific rationales, but rather follow a more holistic approach considering all priorities as important.

Commentary included by partners in their National Reports provides information on the focus for the rationale and vision presented in their policy documents. In almost all the partner countries, the role of education is focusing on enhancing children's lives as well as their roles as citizens, with an added emphasis on environmental awareness. The development of skills and dispositions for future learning takes on a more prominent role in Belgium, Germany, Malta and Romania, while attention to the economic benefits of developing children's basic skills and dispositions is given in France, but also in Flanders. In terms of reported practice as revealed through the teacher survey, only one purpose of compulsory science education is considered by teachers as less important, though still more important than in preschool and primary policy documents; to produce future scientists and engineers. This particular rationale has the largest variance in policy evidencing the diverse focus on the economic driver of education in early years education settings across the partner countries, in response to the view that today's knowledge

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economy dictates an imperative for countries to have scientists capable of competing globally (European Commission, 2006).

The rationale, according to van der Akker (2007) is placed in the middle of the spider web and is referring to the central mission of the curriculum. The rationale is the major orientation point and the nine other components should be linked to the rationale, as well as being consistent with each other. It is thus important for this particular dimension of the curriculum to be aligned for policy and teaching practice in order to provide a steady basis for the rest of the dimensions.

4.1.2 Aims and Objectives

Learning aims and objectives in the framework of *Creative Little Scientists* are considered in relation to cognitive, social and affective dimensions. The factors within these three dimensions have been defined in D3.1 *List of Mapping and Comparison Factors* and they are briefly presented below.

Cognitive dimensions focus on four factors and include the following statements:

1. knowledge/understanding of science content (ideas and processes)
    - To know and understand the important scientific ideas (facts, concepts, laws and theories).
    - To know and understand important scientific processes.
2. understanding about scientific inquiry (nature of science)
    - To understand that scientists describe investigations in ways that enables others to repeat the investigations.
    - To understand that scientific investigations involve asking and answering a question and comparing the answer with what scientists already know about the world.
    - To understand that scientists develop explanations using observations (evidence) and what they already know about the world (scientific knowledge).
3. science process skills
    - To be able to employ simple equipment and tools, such as magnifiers, thermometers, and rulers, to gather data and extend to the senses.
    - To be able to plan and conduct a simple investigation.
4. capabilities to carry out scientific inquiry

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- To be able to ask a question about objects, organisms, and events in the environment.
- To be able to communicate investigations and explanations.

Social dimensions of science learning are expressed by two statements:

- To be able to collaborate with other children
- To be able to communicate investigations and explanations.

Affective dimensions of science learning are represented by the following three statements:

- To have positive attitudes to science learning.
- To be interested in science.
- To have positive attitudes to learning.

4.1.2.1 Key themes from the policy review and teacher survey

The aims and objectives of the science curriculum in partner countries emphasise the development of process skills associated with scientific inquiry and of knowledge and understanding of science ideas (the latter particularly in primary school). More limited attention is afforded to social and affective dimensions of learning and few countries highlight understandings related to the nature of science. A role for creativity is most strongly indicated in the focus on questioning and investigating and the importance given to curiosity. In most countries a very limited role for creativity is identified in relation to the development of science ideas.

In comparison, teachers say that they very often plan their teaching of science in preschool and early primary education to pursue affective learning aims about science, science learning and learning in general. Learning aims linked to social outcomes are also commonly pursued, whereas science cognitive outcomes are less so and more frequently by primary teachers. Out of the inquiry-related science learning aims teachers foster quite or very frequently the development of children's capabilities to carry out scientific inquiry, such as to ask questions, gather and communicate findings, though to a lesser degree children's abilities to plan and conduct simple investigations. Learning aims related to the nature of science and thus understandings about scientific inquiry, that is about how scientists develop knowledge and understanding of the surrounding world, are the least frequently pursued by teachers.

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4.1.2.2 Differences between Preschool and Early Primary School

The review of policy in the partner countries reveals a number of significant similarities between preschool and early primary school in terms of learning aims and objectives. The main differences noted in policy guidance are in the greater emphasis in primary school on subject specific concepts and a wider range of process skills associated with the different phases of scientific inquiry. Often aims and objectives for preschool are expressed in more experiential terms with an emphasis on the development of skills and dispositions associated with inquiry, for example questioning, observing and curiosity are mentioned in many partner policies. In primary school aims and objectives often make much greater reference to specific subject content and include a wider range of inquiry skills such as planning, reasoning and evaluation skills associated with the generation and evaluation of data; whereas obtaining data tends to be the prime focus in preschool policy.

The findings from the teacher survey complement those that have arisen from the policy review. Significant differences were found (independent-samples t-test, $p<0.01$) between preschool and primary teachers in relation to nine out of the thirteen learning outcomes fostered by them, indicating that teachers in early primary education (compared to preschool teachers) more frequently set science learning objectives concerned with cognitive and nature of science aspects but also with some inquiry-related and affective ones. On the other hand, no significant differences were found between preschool and primary teachers' responses in how frequently they promote children's collaboration, their positive attitudes to learning and abilities to ask questions as well as using simple equipment and tools.

4.1.2.3 Comparisons of policy and teacher surveys between the partner countries

All countries specify aims and objectives for early years education. The policy review indicates varied emphases on cognitive, social and affective factors across partner countries. The teacher survey reveals more of an emphasis on the social and affective factors when planning lessons than is stipulated in policy guidance. As previously mentioned, teachers overall aim to foster more frequently children's positive attitudes and collaboration than cognitive aspects of science learning, including some related to scientific inquiry (e.g. to be able to plan and conduct a simple investigation).

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Aims and objectives linked to affective outcomes of science learning

Comparisons between the findings of the policy review and teacher survey in terms of affective learning outcomes of science education reveal an incongruity between the widespread practice reported by teachers across all partner countries of pursuing such outcomes very frequently and the official guidance in most of these countries.

For example the dissonance between policy guidance and reported teaching practice in relation to the emphasis given on fostering children's interest in science is particularly evident in a number of countries, such as France (preschool), Portugal and England (primary), and Romania and Greece (both phases) (see Table 4). In all these countries, the corresponding policy documents appear not to mention or underemphasise this affective learning outcome of science education, whereas teachers overwhelmingly report to include it regularly in their planning and teaching (Figure 6).

To be interested in science	Preschool		Primary	
	Policy survey	Teacher survey	Policy survey	Teacher survey
Belgium (Flanders)				
Finland				
Germany				
Malta				
France				
Greece				
Portugal				
Romania				
UK (England)				

■ Not rated ■ Not emphasised/Never/Rarely ■ Emphasised/Quite often/Very often

Table 4. Comparison of aims and objectives across the partner countries *"To be interested in science"*

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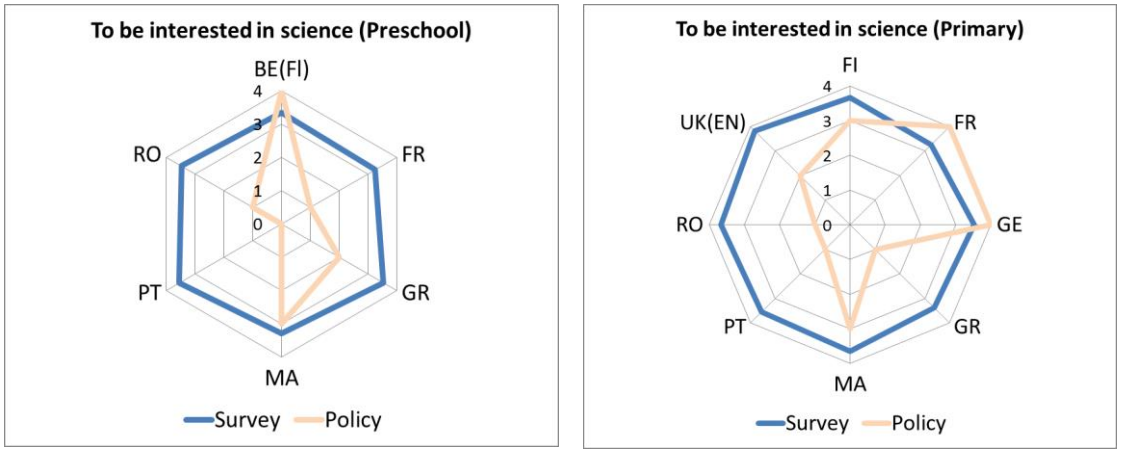

Policy
0: Not rated **1**: Not mentioned **2**: Single mention **3**: Various mentions **4**: Emphasised
Survey
1: Never **2:** Rarely **3:** Quite often **4:** Very often
Figure 6. "To be interested in science": results from policy review and teachers responses (means), per partner country.

Aims and objectives linked to cognitive outcomes of science learning

The cognitive outcomes of science learning in the framework of *Creative Little Scientists,* encompass learning objectives that are linked to understanding of science content, promoting the development of process skills and developing both understandings about scientific inquiry and capabilities to carry out scientific inquiry. Framing all these under the cognitive dimension in terms of learning objectives reflects the high focus placed by the project on the importance not just of pupils' engagement with scientific concepts but of the need to develop their understanding of the nature of science and scientific processes.

Understanding of science ideas (facts, concepts, laws and theories) is given considerable emphasis in both preschool and early primary phases of policy guidance in the majority of partner countries, as well as by the majority of teachers in the teacher survey. This alignment between policy and teaching practice features stronger in primary education than in preschool. The only exception to this is Malta where policy seems to undervalue the inclusion of learning objectives that promote understandings of science ideas within the curriculum for both preschool and primary education, while teachers have reported to frequently setting such learning outcomes as part of their teaching practice.

Having said this, data from preschool education in France and the Flemish community in Belgium paint a different picture. In these settings, even though official policy promotes learning aims linked to knowing and

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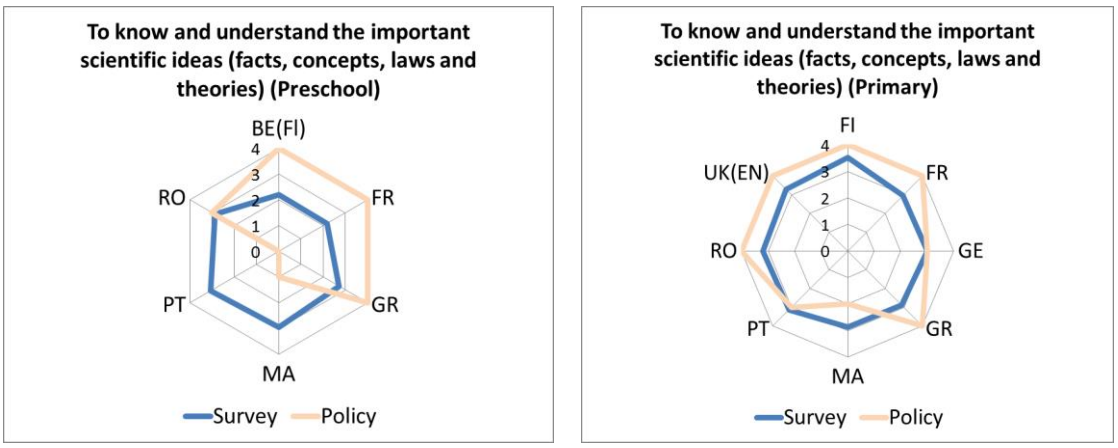
understanding of scientific ideas, teachers do not say they include such aims frequently in their teaching (Table 5, Figure 7).

To know and understand the important scientific ideas (facts, concepts, laws and theories)	Preschool		Primary	
	Policy survey	Teacher survey	Policy survey	Teacher survey
Finland				
UK (England)				
Greece				
Romania				
Portugal				
Germany				
France				
Belgium (Flanders)				
Malta				

■ Not rated ■ Not emphasised/Never/Rarely ■ Emphasised/Quite often/Very often

Table 5. Comparison of aims and objectives across the partner countries *"To know and understand the important scientific ideas (facts, concepts, laws and theories)"*



Policy
0: Not rated **1**: Not mentioned **2**: Single mention **3**: Various mentions **4**: Emphasised

Survey
1: Never **2:** Rarely **3:** Quite often **4:** Very often

Figure 7. *"To know and understand the important scientific ideas"*: results from policy review and teachers responses (means), per partner country.

On the other hand, even though teachers report that they frequently include learning objectives promoting knowledge and understanding of scientific processes, policy guidance in the majority of countries, especially in preschool does not include learning objectives linked to the understanding of scientific processes (Table 6).

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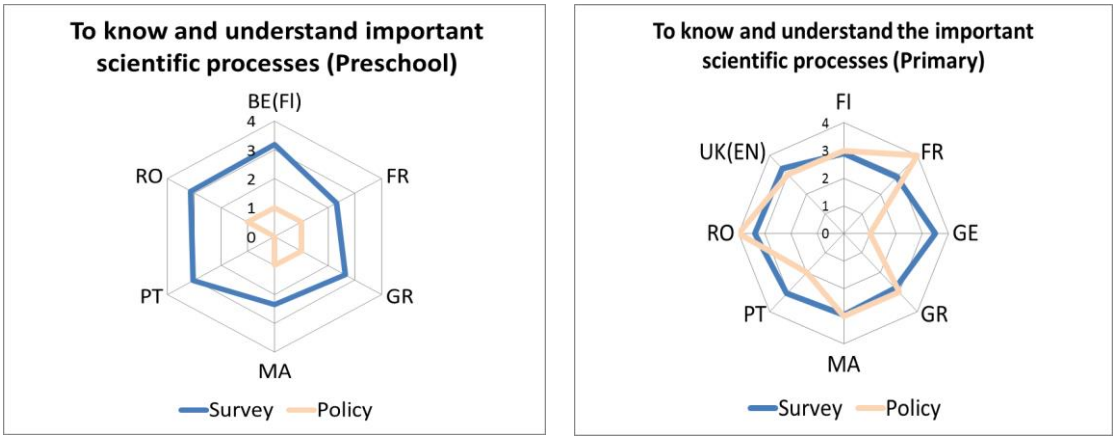
To know and understand the important scientific processes.	Preschool		Primary	
	Policy survey	Teacher survey	Policy survey	Teacher survey
Finland				
UK (England)				
Belgium (Flanders)				
Romania				
Greece				
Portugal				
Germany				
France				
Malta				

■ Not rated ■ Not emphasised/Never/Rarely ■ Emphasised/Quite often/Very often

Table 6. Comparison of aims and objectives across the partner countries *"To know and understand the important scientific processes"*

The dissonance between policy guidance and teaching practice is particularly evident in Romania, Greece and Flanders in preschool, and Germany in primary education. In these countries and settings the vast majority of teachers report to include learning outcomes aimed at children understanding important scientific processes frequently or very frequently in their teaching, whereas the relevant policy guidance does not provide even a single mention to such aims (Figure 8).



Policy
0: Not rated **1**: Not mentioned **2**: Single mention **3**: Various mentions **4**: Emphasised

Survey
1: Never **2:** Rarely **3:** Quite often **4:** Very often

Figure 8. *"To know and understand important scientific processes"*: results from policy review and teachers' responses (means), per partner country.

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Capabilities to carry out scientific inquiry

There is more varied attention to the capabilities necessary to carry out scientific inquiry skills associated with inquiry. Questioning and communication are given greatest priority in both phases. Setting learning aims linked to promoting children's questioning is equally valued in policy and reported practice in the majority of countries. Only in preschool education in Finland and Romania, as well as in both phases in Greece, policy guidance does not feature learning aims linked to children asking questions (Table 7).

To be able to ask a question about objects, organisms, and events in the environment	Preschool		Primary	
	Policy survey	Teacher survey	Policy survey	Teacher survey
Belgium Flanders				
Finland				
Germany				
UK: England				
France				
Malta				
Portugal				
Greece				
Romania				

■ Not rated ■ Not emphasised/Never/Rarely ■ Emphasised/Quite often/Very often

Table 7. Comparison of aims and objectives across the partner countries *"To be able to ask a question about objects, organisms, and events in the environment"*

As evident by Figure 9 the alignment between policy and reported practice is very strong in all partner countries with the exception of Greece and Romania (only in preschool).

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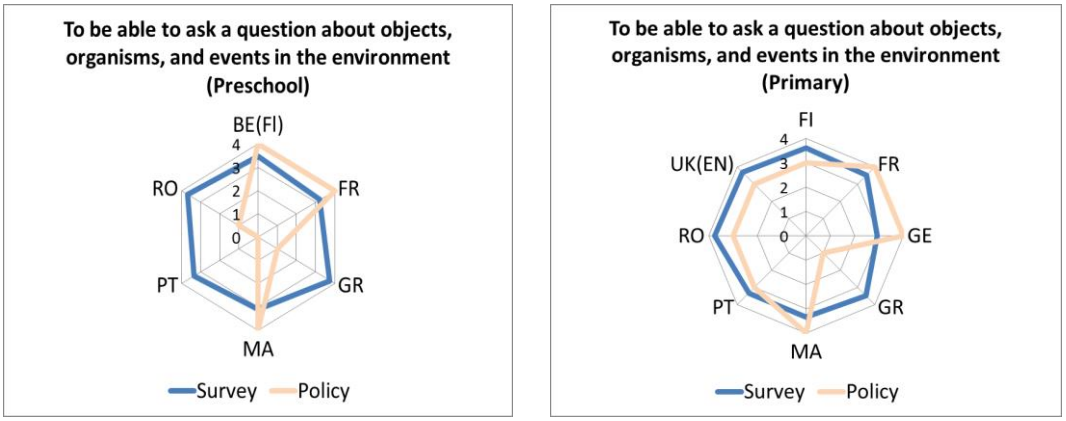

Policy
0: Not rated **1**: Not mentioned **2**: Single mention **3**: Various mentions **4**: Emphasised
Survey
1: Never **2:** Rarely **3:** Quite often **4:** Very often

Figure 9. *"To be able to ask a question about objects, organisms, and events in the environment"*: results from policy review and teachers' responses (means), per partner country.

Understanding about scientific inquiry (Nature of Science)

Learning outcomes related to the nature of science and thus understandings about scientific inquiry, that is about how scientists develop knowledge and understanding of the surrounding world, are overall the least frequently pursued by teachers of early years and early primary education, and are also included rarely in official policy. Having said this, there is still a significant incongruity between the reported practice and recorded policy in relation to these learning outcomes.

The two questionnaire items linked to understandings about the nature of science point to similar findings and conclusions. Focusing on one of the two items, "To understand that scientists develop explanations using observations (evidence) and what they already know about the world (scientific knowledge)", we find that in the majority of partner countries, teachers frequently set learning outcomes linked to how scientists develop explanations, whereas their curricula tend not to mention such outcomes in their guidance (Table 8).

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To understand that scientists develop explanations using observations (evidence) and what they already know about the world (scientific knowledge).	Preschool		Primary	
	Policy survey	Teacher survey	Policy survey	Teacher survey
Germany				
UK (England)				
France				
Greece				
Malta				
Portugal				
Romania				
Finland				
Belgium (Flanders)				

■ Not rated ■ Not emphasised/Never/Rarely ■ Emphasised/Quite often/Very often

Table 8. Comparison of aims and objectives across the partner countries *"To understand that scientists develop explanations using observations (evidence) and what they already know about the world (scientific knowledge)"*

A more in-depth look at the data collected from both the policy and teacher questionnaires reveals further similarities amongst the partner countries (Figure 10). Policy documents, for both phases of education in Romania, Portugal, Malta and Greece, and for primary education in France, do not include a single mention to children learning about how scientists develop explanations, while teachers in these countries claim to foster this learning outcome quite frequently. In France's preschool education on the other hand, teachers are the ones who seem to undervalue this learning outcome in their practice in disagreement to the guidance provided to them.

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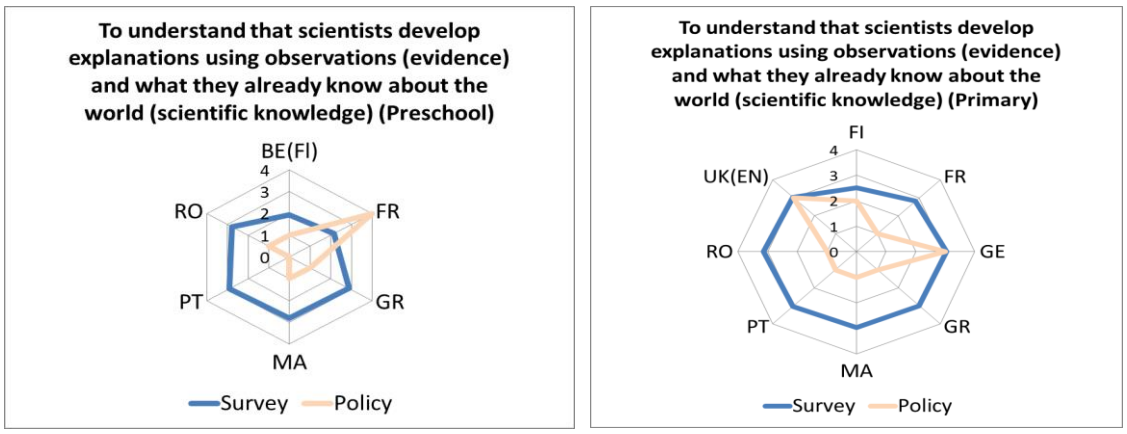

Policy
0: Not rated **1**: Not mentioned **2**: Single mention **3**: Various mentions **4**: Emphasised
Survey
1: Never **2:** Rarely **3:** Quite often **4:** Very often

Figure 10. *"To understand that scientists develop explanations using observations (evidence) and what they already know about the world (scientific knowledge)"*: results from policy review and teachers responses (means), per partner country.

Interesting exceptions to this discord between policy and reported practice are the cases of English and German primary education and Flemish preschool education in Belgium. In these three cases policy and teachers' responses seem to converge either in valuing the inclusion of these learning outcomes linked to the nature of science and scientists' work (in the cases of England and Germany), or in downplaying its importance (in Flanders).

Aims and objectives linked to social outcomes of science learning

The social outcomes of science learning according to the *Creative Little Scientists* Conceptual Framework (D2.2) and the List of Mapping and Comparison Factors (D3.1) are studied by looking at children's abilities to collaborate with other children as well as to communicate their investigations and explanations.

Both policy and teacher surveys revealed a strong emphasis on children being able to collaborate with other children in science learning. In the majority of partner countries, results from both questionnaires clearly show that there is high focus on fostering collaboration in teachers' everyday practice as well as in curricula (Table 9). There are only two exceptions to this common focus, one in preschool (Romania) and one in primary education (France). In both countries, even though teachers reported to include very frequently learning outcomes to promote children's collaboration, policy guidance either provided a single reference to it (Romania) or failed entirely to mention it (France) (Figure 11).

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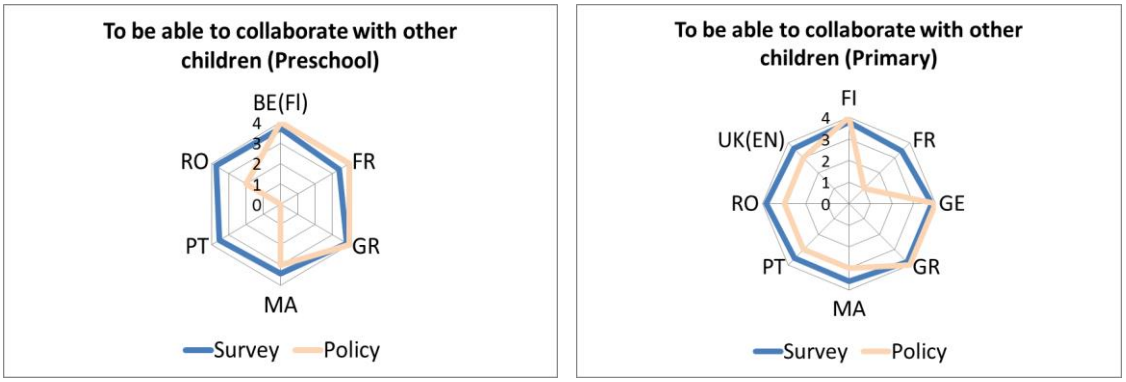
To be able to collaborate with other children	Preschool		Primary	
	Policy survey	Teacher survey	Policy survey	Teacher survey
Belgium (Flanders)				
Finland				
Germany				
Greece				
Malta				
Romania				
UK (England)				
France				
Portugal				

■ Not rated ■ Not emphasised/Never/Rarely ■ Emphasised/Quite often/Very often

Table 9. Comparison of aims and objectives across the partner countries *"To be able to collaborate with other children"*



Policy
0: Not rated **1**: Not mentioned **2**: Single mention **3**: Various mentions **4**: Emphasised
Survey
1: Never **2:** Rarely **3:** Quite often **4:** Very often

Figure 11. "To be able to collaborate with other children": results from policy review and teachers responses (means), per partner country.

With regard to the social learning outcome which refers to children's abilities to communicate their explanations and investigations, the results paint a very similar overall picture (Table 10). This learning outcome is valued in curriculum guidance, as well as in teachers' practice across most of the partner countries. Exceptions to this are the cases of Romania, Malta and Greece in preschool and Portugal in primary, where significant divergence between policy and practice is observed, with policy lagging behind practice. In the case of Malta the disagreement is reversed and teachers seem to undervalue in their practice learning linked to children communicating their investigations and explanations when policy guidance makes several references to these outcomes (Figure 12).

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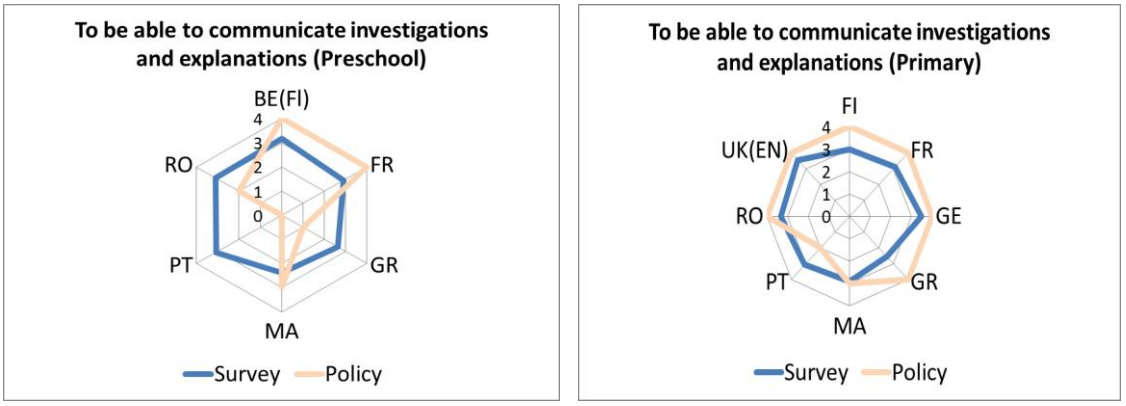
To be able to communicate investigations and explanations	Preschool		Primary	
	Policy survey	Teacher survey	Policy survey	Teacher survey
Belgium Flanders				
Finland				
UK: England				
Germany				
France				
Romania				
Greece				
Malta				
Portugal				

■ Not rated ■ Not emphasised/Never/Rarely ■ Emphasised/Quite often/Very often

Table 10. Comparison of aims and objectives across the partner countries "To be able to communicate investigations and explanations"



Policy
0: Not rated **1**: Not mentioned **2**: Single mention **3**: Various mentions **4**: Emphasised

Survey
1: Never **2:** Rarely **3:** Quite often **4:** Very often

Figure 12. "To be able to communicate investigations and explanations": results from policy review and teachers responses (means), per partner country.

4.1.2.4 Overall findings

Comparisons between the policy review and teacher survey reveal an interesting imbalance in the framing of learning outcomes linked to science in preschool and early primary education across the partner countries. The learning aims and objectives of the science curriculum in partner countries tend to focus on cognitive factors of science learning and particularly on the development of process skills associated with scientific inquiry and of knowledge and understanding of science ideas (the latter particularly in primary school). Such learning outcomes take on a dominant place in the curricula of Finland, France, Greece, Romania and England. The findings from the teacher survey on the other hand suggest

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that teachers perceive the teaching of science overall as contributing primarily towards affective and social aspects of teaching and learning. Teachers view their role in the early years as mainly one that places developing children's attitudes and dispositions in the forefront so that they grow to become socially and environmentally aware and responsible lifelong learning citizens.

Social and affective dimensions of learning are given more limited attention in policy documents compared to cognitive dimensions. The promotion of children's positive attitudes to learning and interest of science, in particular, is scarcely mentioned amongst the intended aims of science education in the early years in the majority of them. Exceptions to this are the Flemish community in Belgium, Germany and Malta where raising interest in science is seen as one of the main learning outcomes of early years science education.

Learning outcomes linked to the social aspects of teaching and learning are very frequently pursued by teachers, according to them. Policy appears similarly to promote these outcomes and in particular puts a strong emphasis on children being able to collaborate with other children when learning science.

Finally, learning outcomes related to how science works and scientists develop knowledge are under-pursued in both policy and reported practice. As indicated in the *Report on Mapping and Comparing Recorded Practices* (D3.2) policy documents for both phases of education across the consortium make limited reference to knowledge and understanding of the nature of science. Similarly, learning outcomes related to the nature of science and thus understandings about scientific inquiry, that is about how scientists develop knowledge and understanding of the surrounding world, are the least frequently pursued by teachers overall.

4.2 Comparisons of approaches to teaching, learning and assessment

4.2.1 Learning activities: How are children learning?

Children's learning in science has been described in *Creative Little Scientists* in the frame of inquiry activities. The latter have been further considered as supporting cognitive and social learning objectives, following the 'foundation for lifelong learning' approach (See D.2.2), in which the cognitive development of children is evaluated in terms of their readiness for school –approach and on their social development. Learning activities have been considered through the following comparison factors (D3.1):

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1. **Cognitive dimension**

questioning

- Asking questions about objects, organisms, and events in the environment.

designing or planning investigations

- Designing or planning simple investigations or projects.

gathering evidence

- Observing natural phenomena such as the weather or a plant growing and describing what they see.
- Conducting simple investigations or projects
- Employing simple equipment and tools to gather data and extending them to the senses

making connections and explaining evidence

- Using data to construct reasonable explanations.

2. **Social dimension**

- Using data to construct reasonable explanations.
- Communicating the results of their investigations and explanations.

4.2.1.1 Key themes from the policy review and teacher survey

In general, decisions about learning activities are made by teachers in the light of the rationale, learning objectives and curriculum content specified for areas of learning in the partner countries. Some form of guidance is provided about appropriate activities in all nine participating countries. Questioning is commonly mentioned, particularly in relation to preschool.

Commentary provided by partners in their National Reports for the teacher survey point to a common emphasis on hands on approaches and activities linked to children's everyday lives in science classrooms. The learning activities which are reportedly used most commonly by the respondents are predominantly linked to children being allowed opportunities to gather evidence, ask questions and elicit their curiosity in natural phenomena. The National Reports from the review of policy, very similarly to the teacher survey results, indicate a common emphasis in policy on hands on approaches and activities linked to children's everyday lives. Observation and communication feature strongly in learning activities recommended for both phases. Questioning is also commonly mentioned, particularly in relation to preschool. In the majority of countries conducting investigations or projects and using simple equipment are also included in guidance provided. There is more variation in relation to planning investigations and using data to construct reasonable explanations. These activities feature more strongly in early primary school policy.

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4.2.1.2 Differences between Preschool and Early Primary School

As indicated in earlier sections most findings coming from both the policy review and teacher survey comment on a more experiential approach in preschool and place a greater emphasis on scientific concepts and procedures in learning activities recommended for the early primary age phase.

In preschool policy guidance providing a broad range of experience and making links across the curriculum is widely recommended, while greater attention is paid to the processes of scientific inquiry and scientific concepts, reflecting aims, objectives and content identified in primary school. Encouraging children asking questions is commonly mentioned, particularly in relation to preschool, but less so in primary. There is more variation in relation to planning investigations and using data to construct reasonable explanations, with these activities featuring more strongly in early primary school policy. In comparison, the teacher survey indicates significant differences between preschool and primary teachers' responses only in relation to the use of learning activities structured to promote the observational skills of children. These learning activities are found to be used significantly less in early primary settings compared to preschool.

4.2.1.3 Comparisons of policy and teacher surveys between the partner countries

The comparison of the different partners' surveys results reveals that the largest consensus between education policy makers and teachers at country level is for learning activities that promote gathering evidence about natural phenomena through observation (Table 11).

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Observe natural phenomena such as the weather or a plant growing and describe what they see	Preschool		Primary	
	Policy survey	Teacher survey	Policy survey	Teacher survey
Belgium (Flanders)				
Finland				
France				
Germany				
Greece				
Malta				
Portugal				
Romania				
UK: England				

Not rated Not emphasised/Never/Rarely Emphasised/Quite often/Very often

Table 11. Emphasis on learning activities in which children 'Observe natural phenomena such as the weather or a plant growing and describe what they see': results from policy review and teacher survey, per partner country.

Policy guidance and teaching practice are not only aligned in terms of developing children's skills to gather evidence, but more importantly in the high focus they both place on learning activities linked to observation. Curricula across a number of partner countries emphasise the importance of observation in both phases, a finding in line with teachers' responses to the survey, where such learning activities are used frequently in science across all partner countries. There are only a few exceptions to this common focus of policy and reported practice, the German curriculum for preschool and the Portuguese curriculum for primary education (Figure 13). The former mentions learning activities that promote observation skills only once, while being entirely absent from the latter. In regard to the vast majority of remaining partner countries the policy review overwhelmingly points out that children gathering data by observing natural phenomena is one of the dominant learning activities promoted. Only in Portuguese preschool and Maltese primary school policy documents such learning activities, even though mentioned a number of times, cannot be considered as emphasised in official guidance provided to teachers.

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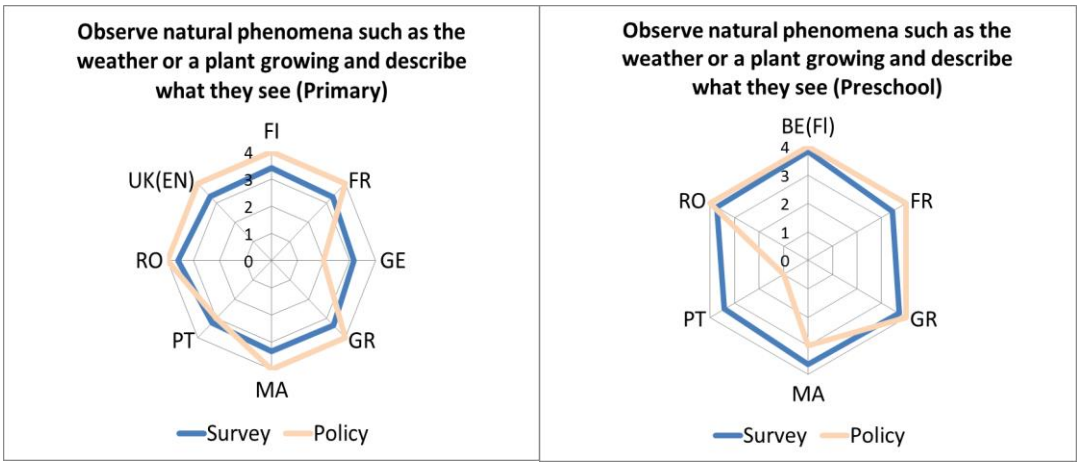

Policy
0: Not rated **1**: Not mentioned **2**: Single mention **3**: Various mentions **4**: Emphasised
Survey
1: Never **2:** Rarely **3:** Quite often **4:** Very often

Figure 13. "Observe natural phenomena such as the weather or a plant growing and describe what they see": results from policy review and teachers responses (means), per partner country.

Another inquiry-related learning activity that takes an important place in both policy and practice across the partner countries is children using equipment to gather evidence. Similar to learning activities linked to observation, children using simple tools to gather data is a point of focus of the majority of curricula, as well as being frequently used by teachers in their science teaching across the partner countries in both phases.

Employ simple equipment and tools to gather data and extend to the senses	Preschool		Primary	
	Policy survey	Teacher survey	Policy survey	Teacher survey
Belgium (Flanders)				
Finland				
France				
Germany				
Greece				
Malta				
Portugal				
Romania				
UK: England				

Not rated Not emphasised/Never/Rarely Emphasised/Quite often/Very often

Table 12. Emphasis on learning activities in which children *'Employ simple equipment and tools to gather data and extend to the senses'*: results from policy review and teacher survey, per partner country.

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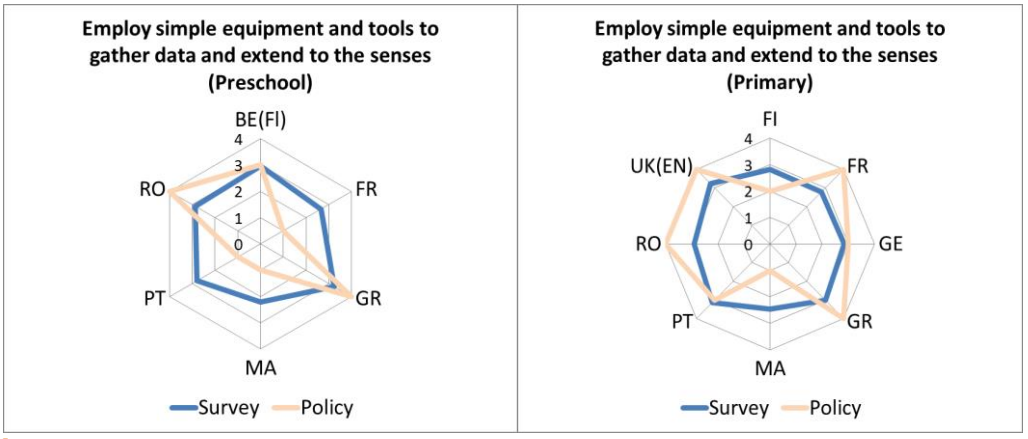
The only case, where both policy and reported practice for preschool and primary education seem to consistently undervalue the inclusion of such learning activities is Malta (Table 12). In Maltese policy, using simple equipment to gather evidence is only mentioned once in each of the preschool and primary curricula and rarely or never included in lessons for more than half of the teachers in both preschool and primary education. The largest dissonance between policy and practice in regard to children using simple tools to gather evidence was found in French and Portuguese preschools and Finnish primary schools (Figure 14). In both cases, classroom practice valued the inclusion of learning activities linked to children using equipment significantly more compared to the guidance provided in the curriculum. The same, although to a lesser degree, was observed in preschool education in France.



Policy
0: Not rated **1**: Not mentioned **2**: Single mention **3**: Various mentions **4**: Emphasised
Survey
1: Never **2:** Rarely **3:** Quite often **4:** Very often

Figure 14. "Employ simple equipment and tools to gather data and extend to the senses": results from policy review and teachers responses (means), per partner country.

Both policy and teacher surveys revealed a strong emphasis on fostering children's questioning through appropriate learning activities. This common high focus of both reported and recorded practice recognises the importance of children being allowed to pose questions as an outlet of their innate curiosity. Findings from both policy review and teacher survey indicate that the learning activities aimed at fostering children's questioning are featured very frequently by teachers across all partner countries for both phases, but take a less dominant place in policy guidance (Table 13).

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Ask questions about objects, organisms, and events in the environment	Preschool		Primary	
	Policy survey	Teacher survey	Policy survey	Teacher survey
Belgium (Flanders)				
Finland				
France				
Germany				
Greece				
Malta				
Portugal				
Romania				
UK: England				

Not rated Not emphasised/Never/Rarely Emphasised/Quite often/Very often

Table 13. Emphasis on learning activities in which children *'Ask questions about objects, organisms, and events in the environment'*: results from policy review and teacher survey, per partner country.

Exceptions to this alignment between policy and practice are the cases of Greece for both phases, Portugal and Romania in preschool and France in primary education. In all of the above mentioned countries, teachers reported that they invite children's questions frequently through appropriate learning activities which are either absent or only mentioned once in the relevant guidance provided in curricula and other official policy documents. The largest dissonance between policy and practice was found in Portuguese and Romanian preschool education where teachers include learning activities that foster children asking questions about natural phenomena, even though official policy fails to mention such activities in the guidance provided (Figure 15).

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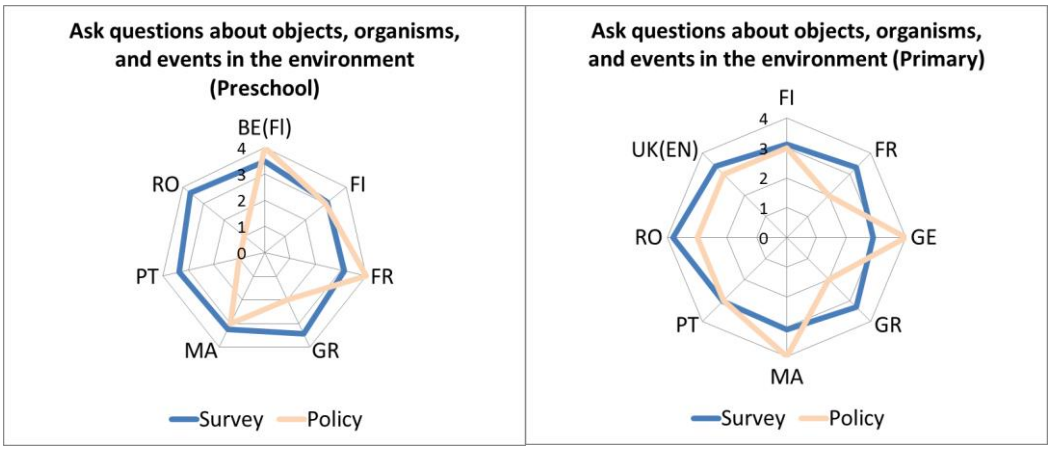

Policy
0: Not rated **1**: Not mentioned **2**: Single mention **3**: Various mentions **4**: Emphasised
Survey
1: Never **2:** Rarely **3:** Quite often **4:** Very often

Figure 15. "Ask questions about objects, organisms, and events in the environment": results from policy review and teachers responses (means), per partner country.

Learning activities that give time and space to children for communicating the results of their investigations are found to be promoted in policy documents and frequently included in lessons by teachers in both preschool and primary education, similarly to activities that are aimed at promoting children's questions. Interestingly, teachers have overwhelmingly reported to frequently allowing children to communicate their explanations quite often in their science lessons, regardless of the guidance provided by official policy (Table 14).

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Communicate the results of their investigations and explanations	Preschool		Primary	
	Policy survey	Teacher survey	Policy survey	Teacher survey
Belgium (Flanders)				
Finland				
France				
Germany				
Greece				
Malta				
Portugal				
Romania				
UK: England				

■ Not rated ■ Not emphasised/Never/Rarely ■ Emphasised/Quite often/Very often

Table 16. Emphasis on learning activities in which children *'Communicate the results of their investigations and explanations'*: results from policy review and teacher survey, per partner country.

The sole exception to the reported high frequency of use regarding learning activities that focus on communication of children's investigations results is preschool education in Malta where teachers have reported that they tend to rarely allow children to communicate their explanations in science lessons (Figure 16). Teachers' infrequent inclusion of learning activities that promote communication is made more interesting by the fact that the curriculum in Maltese preschools provides various mentions of the benefits of such learning activities.

The partner countries in which policy guidance seems to undervalue the inclusion of learning activities which promote children's communication of explanations and investigations are Portugal (both phases), Greece (preschool) and France (Primary). Interestingly, even though policy in Greek primary and French preschool education emphasizes such learning activities, no significant differences were found between preschool and primary teachers' responses.

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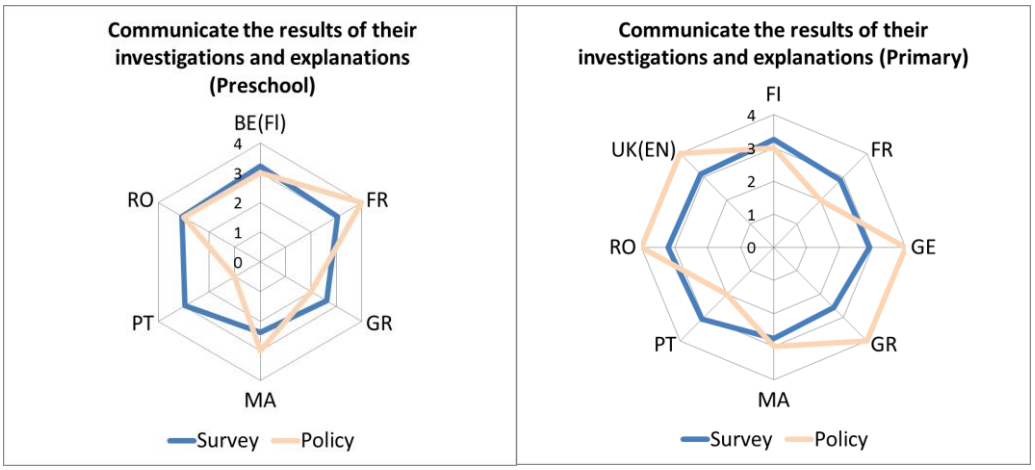

Policy
0: Not rated **1**: Not mentioned **2**: Single mention **3**: Various mentions **4**: Emphasised
Survey
1: Never **2:** Rarely **3:** Quite often **4:** Very often

Figure 16. "Communicate the results of their investigations and explanations": results from policy review and teachers responses (means), per partner country.

Teaching approach to science inquiry

Both reviews for policy and teaching practice have a questionnaire item dedicated to the preferred approach for teaching the features of inquiry-based learning. A table describing three possible variations (Open/Guided/Structured) for each of seven features of science inquiry in the classroom revealed that policy in partner countries mostly suggests open and/or guided approaches should be adopted (Tables 17 and 18). Generally guided approaches predominate, except in relation to questioning where open approaches are more commonly promoted. Where policy exists in this area, only a small minority of countries advocate structured approaches.

In comparison, the teacher survey responses reveal a similar situation in practice (Tables 17 and 18). Teachers tend to value a 'guided' approach in respect of all features of IBSE with the exception of children formulating and communicating explanations based on evidence. These two features of inquiry seem to be fostered in practice through an open approach.

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Preschool	a. QUESTION: Children investigate scientifically oriented question	b. EVIDENCE: Children give priority to evidence	c. ANALYSE: Children analyse evidence	d. EXPLAIN: Children formulate explanations based on evidence	e. CONNECT: Children connect explanations to scientific knowledge	f. COMMUNICATE: Children communicate and justify explanation	g. REFLECT: Children reflect on the inquiry process and their learning
Belgium (Flanders)							
France							
Greece							
Malta							
Portugal							
Romania							

Open Guided Structured

Table 17. Teaching approach to science inquiry in preschool education: results from teacher survey, per partner country.

Primary Education	a. QUESTION: Children investigate scientifically oriented question	b. EVIDENCE: Children give priority to evidence	c. ANALYSE: Children analyse evidence	d. EXPLAIN: Children formulate explanations based on evidence	e. CONNECT: Children connect explanations to scientific knowledge	f. COMMUNICATE: Children communicate and justify explanation	g. REFLECT: Children reflect on the inquiry process and their learning
Finland							
France							
Germany							
Greece							
Malta							
Portugal							
Romania							
UK: England							

Open Guided Structured

Table 18. Teaching approach to science inquiry in primary education: results from teacher survey, per partner country.

It is notable that policy in Finland and the UK gives the greatest emphasis to open approaches for both phases of education, although both countries also recommend guided approaches. According to the teacher survey, it's teachers in Malta who favour a 'structured' approach across all inquiry activities more than in any other partner country. An 'open' approach to identifying inquiry questions and evidence is favoured by proportionally more teachers in the UK (England), as is the preferred approach to formulating explanations of Finnish teachers and to communicating explanations by more German.

Learning activities associated with creativity

The activities most associated with creativity (either emphasised or mentioned) in curriculum guidance were questioning and observing in both phases, conducting investigations in preschool and planning investigations in primary school (Table 19). Those least associated in policy documents with creativity were employing simple equipment (both phases) and use of data to construct explanations (in preschool).

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Commentary in National Reports commonly referred to the creative potential in the active learning approaches recommended in policy.

TOP THREE PRESCHOOL IBSE ACTIVITIES		N	TOP THREE EARLY PRIMARY IBSE ACTIVITIES		N
1	Observe natural phenomena such as the weather or a plant growing and describe what they see.	207	1	Observe natural phenomena such as the weather or a plant growing and describe what they see.	244
2	Ask questions about objects, organisms, and events in the environment.	168	2	Ask questions about objects, organisms, and events in the environment.	231
3	Design or plan simple investigations or projects.	140	3	Conduct simple investigations or projects.	220
4	Conduct simple investigations or projects.	139	4	Design or plan simple investigations or projects.	213
5	Employ simple equipment and tools to gather data and extend to the senses.	106	5	Communicate the results of their investigations and explanations.	126
6	Communicate the results of their investigations and explanations.	84	6	Employ simple equipment and tools to gather data and extend to the senses.	119
7	Use data to construct reasonable explanations.	50	7	Use data to construct reasonable explanations.	103

Table 19. Top 3 'creativity enabling' IBSE activities, according to preschool and early primary school teachers.

In comparison, the top two learning activities considered by teachers as creativity-enabling in both cases are the ones that involve children in the observation of natural phenomena and in asking questions about them. However, the next two in the 'creativity enabling' order, which involve children in the design (or plan) and conduct of simple investigations (or projects), are the least frequently used by teachers. Correspondingly, the activities that refer to children employing simple equipment and tools to gather data, using data to construct reasonable explanations, and communicating these explanations are considered as the least creative, but are used quite frequently. In particular, the largest discrepancy between teachers' frequency of use and perception of creativity potential regards these latter two activities, i.e. of using data to construct reasonable explanations, and of communicating these explanations.

4.2.1.4 Overall findings

The comparison of the two separate reviews, one for policy and one for reported practice, reveals interesting findings on the significance that features of inquiry-based science education play in terms of learning activities in early years science education. Overall, features of inquiry have been found to be both promoted in curricula among suggested learning activities, as well as frequently included by teachers in the preschool and early primary science classroom. In particular, learning activities that promote observation, questioning, communication and the

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use of simple tools take on a more dominant place among inquiry related activities.

On the other hand, promoting understandings about scientific concepts and developing children's basic procedural knowledge takes a less dominant place in the learning activities carried out in the classroom and curriculum guidance. In particular, learning activities that involve children planning and designing their investigations are the least common of all the learning activities tied to scientific inquiry, despite the fact that they are thought of by many teachers as amongst the three most likely to contribute to children's creativity. The low frequency of use of these activities is consistent with the findings about teachers' inquiry-related science learning priorities. Even though no major differences were found in the use of learning activities which promote children's observational and questioning skills, the same cannot be said for activities that involve children designing (or planning) and conducting simple investigations or projects. Finnish and Maltese teachers occupy the lower end of the spectrum in the use of these activities, while English teachers the upper end. Greek and German teachers seem to involve children more in the conduct of investigations but less in their planning.

4.2.2 Pedagogy/ Teacher role: How is the teacher facilitating learning?

The section of both questionnaires for policy and teaching practice dedicated to pedagogy aims to gather data in order to explore the pedagogical synergies between inquiry-based science education (IBSE) approaches and creative approaches (CA), identified in the *Conceptual Framework* (D2.2). These synergies are:

- ***Play and exploration***, recognising that playful experimentation / exploration is inherent in all young children's activity - such exploration is at the core of IBSE and CA in the early years.
- ***Motivation and affect***, highlighting the role of aesthetic experience in promoting children's affective and emotional responses to science and mathematics activities.
- ***Dialogue and collaboration***, accepting that dialogic engagement is inherent in everyday creativity in the classroom, plays a crucial role in learning in science and mathematics and is a critical feature of IBSE and CA, enabling children to externalise, share and develop their thinking.
- ***Reflection and reasoning***, emphasising the importance of metacognitive processes, reflective awareness and deliberate

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control of cognitive activities, which may be still developing in young children but which is incorporated into early years practice, scientific and mathematical learning and IBSE.

- **Questioning and curiosity**, which is central to IBSE and CA, recognising across the three domains (science, mathematics, creativity) that creative teachers often employ open ended questions, and promote speculation by modelling their own curiosity.
- ***Problem solving and agency***, recognising that through scaffolding the learning environment children can be provided with shared, meaningful, physical experiences and opportunities to develop their own questions as well as ideas about scientifically relevant concepts.
- ***Teacher scaffolding and involvement***, which emphasises the importance of teachers mediating the learning to meet the child's needs, rather than feel pressured to meet a given curriculum.

4.2.2.1 Key themes from the policy review and teacher survey

The National Reports indicate a common emphasis in policy on hands on approaches and activities linked to children's everyday lives. In preschool providing a broad range of experience and making links across the curriculum is widely recommended. There is a considerable focus on play and fostering autonomous learning. Encouraging problem solving and children trying out their own ideas in investigations are emphasised in the majority of countries. Approaches given the least attention include the use of drama, stories, history, field trips and everyday experiences as contexts for learning. Fostering imagination or the discussion of alternative ideas also do not feature strongly in policy guidance.

In primary school greater attention is paid to the processes of scientific inquiry and scientific concepts, reflecting aims, objectives and content identified in partner policy. Overall, the range of teaching approaches listed features less strongly in policy. None of the approaches listed are emphasised in a majority of countries. Least attention is given, as in the preschool phase to drama, stories and history as contexts for learning and to fostering imagination and discussion of alternative ideas. However in contrast to preschool, more limited emphasis is also given to play, questioning and fostering autonomous learning. Approaches to teaching and learning associated with inquiry are widely emphasised in policy guidance in partner countries. For example problem solving and children trying out their own ideas are mentioned. Promoting inquiry skills such as questioning, observation and communication is widely advocated.

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Approaches given the least attention include the use of drama, stories, history, field trips and everyday experiences as contexts for learning. There were also differences in the aspects of inquiry discussed, with most limited reference being to connecting explanations to scientific knowledge and reflection on inquiry processes and learning. It is notable that in most countries limited references are made to the role of imagination or the discussion of alternative ideas – also linked with creative approaches to learning and teaching.

There is a large consensus amongst teachers – reflected in their reported practice - that the teaching of science should be building on children's prior experiences and help relate science to everyday life. Teachers consistently and uniformly across the partner countries hold a great appreciation for all pedagogical contexts and approaches that promote dialogue and collaboration in science amongst children, failing however to see the potential of these approaches for creativity development in children. Learning contexts such as drama and using history to teach science are not practices very commonly used by teachers across the partner countries. Nor are they considered very 'creativity enabling' by them. Similarly, teachers tend not to foster children's autonomy in learning very frequently, nor to link this autonomy with creativity. Although also uniformly teachers endorse strongly affective learning outcomes in their teaching of science, the way they perceive the contexts and approaches identified in the research literature as enhancing motivation and affect in children varies significantly. The large majority of all teachers promotes frequently the physical exploration of materials by children and considers this as a creative practice. Finally, all problem solving science contexts and approaches are thought of as amongst the most 'creativity enabling' by a large number of teachers, who also report to use them quite or very frequently.

4.2.2.2 Differences between Preschool and Early Primary School

Responses to the policy questionnaire and partner commentary in their National Reports suggest much greater emphasis on play, the use of questioning and the importance of autonomous learning in preschool. Similarly, the teacher survey revealed that preschool staff tend to make more use of both open/unstructured play and role play in science lessons compared to their primary counterparts. In comparison to early primary school, ratings of items in both reviews suggest more widespread promotion of a range of approaches to learning and teaching. According to the teachers' responses, drama, using storytelling to teach science, focusing on physical exploration of materials and taking advantage of opportunities offered by outdoor learning activities are the approaches

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that are used more frequently in preschool than early primary. On the other hand, fostering classroom discussion and evaluation of alternative ideas, as well as relating science to everyday life were found to take on a more dominant place in primary education according to the teacher survey, a finding that was not found in policy guidance across the partner countries.

4.2.2.3 Comparisons between the policy and teacher surveys at partner country level

Play and exploration, the first of the seven synergies identified, is represented by five learning/teaching contexts and approaches: open/unstructured play; role/pretend play; a physical exploration of materials; use of outdoor learning activities; and use of digital technologies. Apart from the use of outdoor learning in science, a context for which no significant differences were found between the responses to two surveys, the remaining contexts and approaches under the synergy play and exploration, revealed interesting findings.

Open/Unstructured play	Preschool		Primary	
	Policy survey	Teacher survey	Policy survey	Teacher survey
Belgium (Flanders)				
Finland				
France				
Germany				
Greece				
Malta				
Portugal				
Romania				
UK: England				

■ Not rated ■ Not emphasised/Never/Rarely ■ Emphasised/Quite often/Very often

Table 20. Emphasis on *'open/unstructured play*: results from policy review and teacher survey, per partner country.

Play in both forms, open or pretend, is clearly valued more in preschool than primary education by both teachers and official policy (Table 20). Even though teachers seem to include playful activities in both phases, admittedly less so in primary, the findings from majority of partner countries show that classroom practice tends to follow the direction promoted in policy. In countries where playful activities are not mentioned, teachers tend to use them less in lessons compared to countries where policy emphasises their inclusion. In England and Finland

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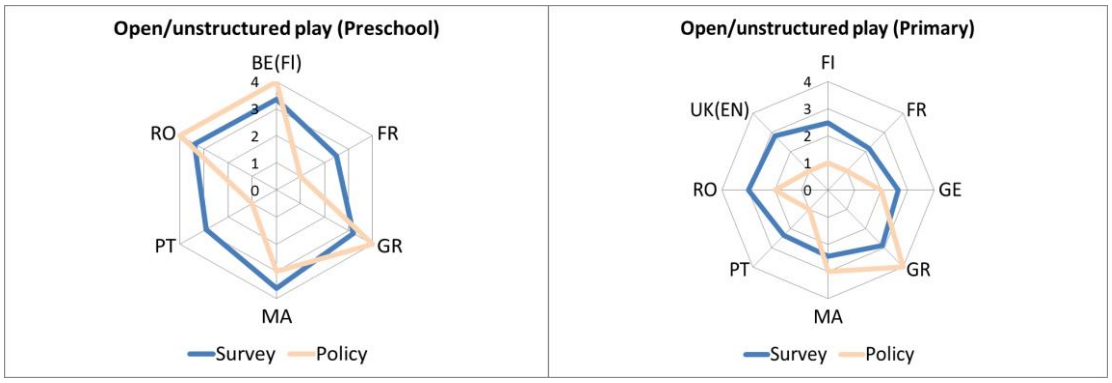
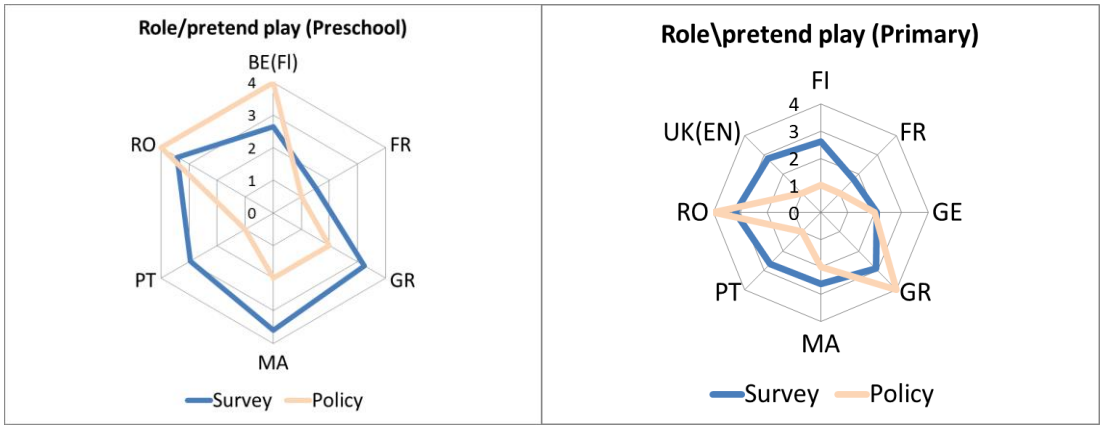
(in primary education), Portugal (in both phases) and France (in preschool for open play) teachers have reported using play frequently even though it is not mentioned in the curriculum (Figures 17 and 18) going against the overall trend. There is no evidence of the opposite happening in any of the partner countries, as no sample of teachers seem to go against the guidance of the curriculum by not including playful activities in their lessons even though they are promoted in the curriculum.



Policy
0: Not rated **1**: Not mentioned **2**: Single mention **3**: Various mentions **4**: Emphasised
Survey
1: Never **2:** Rarely **3:** Quite often **4:** Very often

Figure 17. "Open/unstructured play": results from policy review and teachers responses (means), per partner country.



Policy
0: Not rated **1**: Not mentioned **2**: Single mention **3**: Various mentions **4**: Emphasised
Survey
1: Never **2:** Rarely **3:** Quite often **4:** Very often

Figure 18. "Role/pretend play": results from policy review and teachers responses (means), per partner country.

The comparison of the different partners' surveys results reveals that the largest consensus between education policy makers and teachers at country level in regard to learning approaches used by teachers is to

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promote the physical exploration of materials for both preschool and primary education (Table 21).

Physical exploration of materials	Preschool		Primary	
	Policy survey	Teacher survey	Policy survey	Teacher survey
Belgium (Flanders)				
Finland				
France				
Germany				
Greece				
Malta				
Portugal				
Romania				
UK: England				

■ Not rated ■ Not emphasised/Never/Rarely ■ Emphasised/Quite often/Very often

Table 21. Emphasis on '*Physical exploration of materials*': results from policy review and teacher survey, per partner country.

This alignment between the policy review and teacher survey is consistent with the findings presented in the learning activities section of this report. Similar to the important place of allowing children to employ simple equipment to extend the senses in the learning activities that are being used in science lessons, physical exploration of materials is a learning approach that is heavily promoted in policy and very frequently included by teachers in their practice. An exception to this policy focus on this particular learning approach are the policy documents for preschool and primary education in Malta where only a single mention to promoting the physical exploration of materials by children is included for each phase.

Figure 19 shows the comparative data in each country for preschool and primary school.

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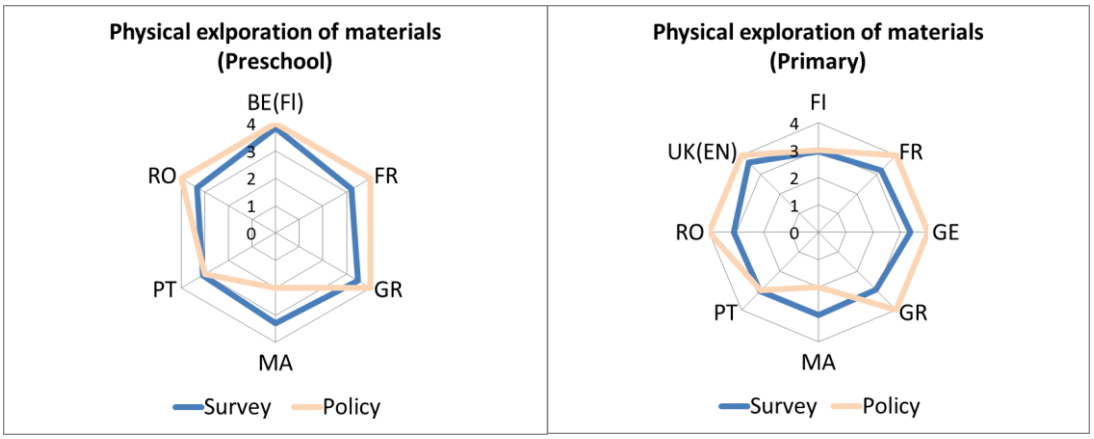

Policy
0: Not rated **1**: Not mentioned **2**: Single mention **3**: Various mentions **4**: Emphasised
Survey
1: Never **2:** Rarely **3:** Quite often **4:** Very often

Figure 19. "Physical exploration of materials": results from policy review and teachers responses (means), per partner country.

Teaching/learning contexts and approaches linked to motivation and affect are: use of drama, stories, history, informal learning settings and cross-disciplinary contexts to teach science, by relating it to everyday life and incorporating children's prior experiences.

The differences between partner countries in relation to the use of contexts and approaches linked with motivation and affect present a particular interest. The results of the teacher survey show that most of the relevant contexts (drama, teaching science with history, teaching in informal settings) are undervalued in curricula and get the lowest use by teachers, whilst the relevant approaches (build on children's prior knowledge, relate science to everyday life) the highest use.

Table 22 presents the findings from both reviews for drama, an underused learning context, and teachers building on children's prior knowledge, an important learning approach, both linked to the synergy of motivation and affect.

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	Drama				Building on children's prior knowledge			
	Preschool		Primary		Preschool		Primary	
	Policy survey	Teacher survey	Policy survey	Teacher survey	Policy survey	Teacher survey	Policy survey	Teacher survey
Belgium (Flanders)								
Finland								
France								
Germany								
Greece								
Malta								
Portugal								
Romania								
UK: England								

Not rated Not emphasised/Never/Rarely Emphasised/Quite often/Very often

Table 22. Emphasis on *'Drama, Building on children's prior knowledge'*: results from policy review and teacher survey, per partner country.

Figure 20 shows the comparative data in each country for preschool and primary school. Overall it shows how learning approaches linked to building on children's prior knowledge are embraced slightly more emphatically in primary than preschool education policy, but are used as frequently by both preschool and primary teachers during their science lessons. There are very few instances where policy and practice as reported by teachers did not focus on promoting learning approaches linked to a constructivist approach. These are the cases of preschools in France and Greece, where even though policy undervalues the importance of building on children's prior knowledge, not mentioned in French policy and only mentioned once in Greece, teachers seem to frequently utilise similar learning approaches during their teaching practice.

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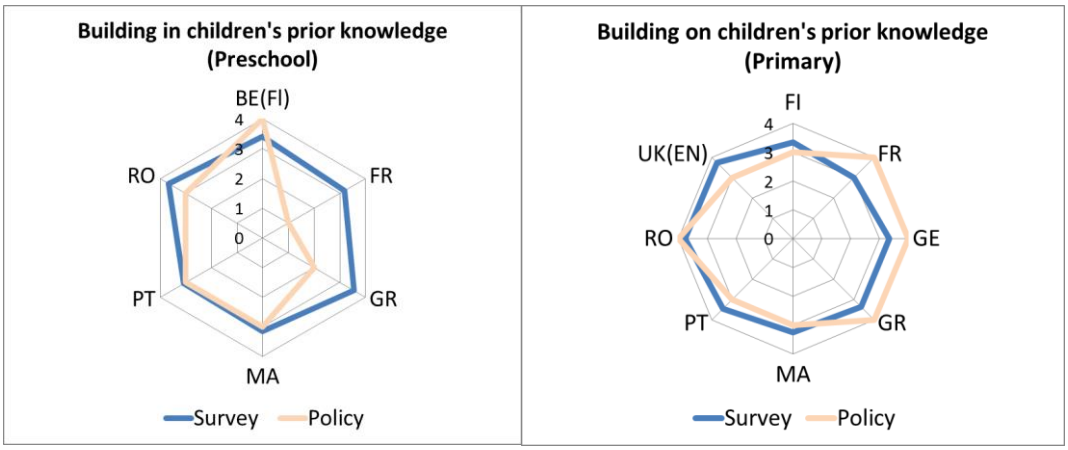

Policy

0: Not rated **1**: Not mentioned **2**: Single mention **3**: Various mentions **4**: Emphasised

Survey

1: Never **2:** Rarely **3:** Quite often **4:** Very often

Figure 20. "Building on children's prior knowledge": results from policy review and teachers responses (means), per partner country.

The situation is very different for learning contexts, such as drama, when comparing curriculum guidance and reported practice. The place of drama in early years science education is not clear from the findings of both reviews. In general, policy guidance seems to undervalue the inclusion of drama in science in both phases, teachers on the other hand have reported using drama as a context in science lessons in a number or partner countries in preschool and aligning themselves with policy in primary education. There are very few examples of countries where policy and practice seem to agree on the use of drama in science. These are mostly cases of primary education in countries that both policy and practice undervalue drama as a useful context for science in early years settings, such as France (in preschool), Finland, Germany, Malta, Portugal, Romania and England (in primary). The opposite was only observed in Romanian preschools and Greek primary schools, where policy makes various mentions to the use of drama in science and teachers frequently plan learning activities that include the use of drama.

This is consistent with the findings from both reviews in the majority of partner countries, although at a lesser degree. In general, curricula do not tend to focus on drama as a useful learning context in early years science, while teachers seem to include this particular context in their science lessons frequently.

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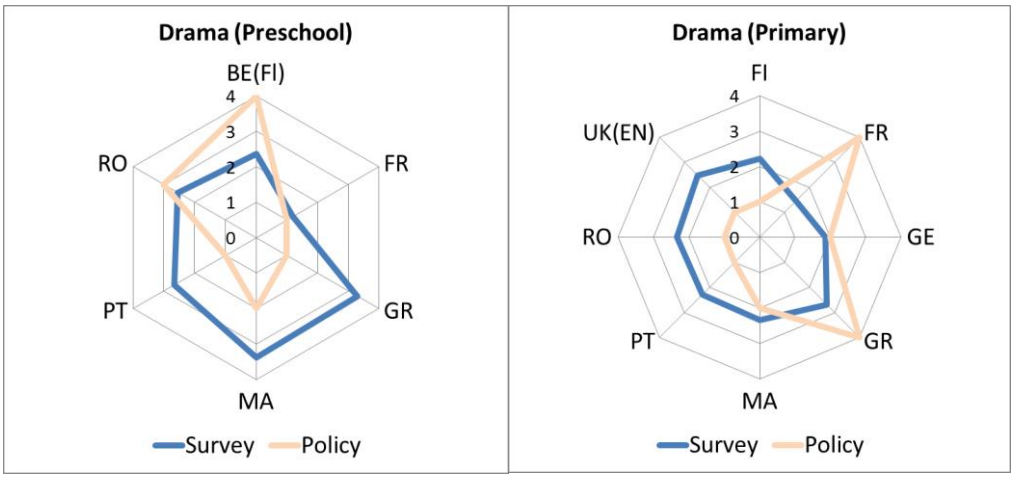

Policy
0: Not rated **1**: Not mentioned **2**: Single mention **3**: Various mentions **4**: Emphasised
Survey
1: Never **2:** Rarely **3:** Quite often **4:** Very often

Figure 21. "Drama": results from policy review and teachers responses (means), per partner country.

The largest deviation between the findings of both reviews was observed in French primary education (Figure 21). Only a very small portion of teachers in France seems to include drama during their science in both preschool and primary science lessons, as France has the lowest mean among all partner countries. In comparison, the curriculum for preschool does not mention drama as a learning context in preschool while emphasising on its frequent use in primary education.

The survey results for both reviews regarding other learning contexts paint a similar picture with limited curriculum guidance offered and teachers frequently using these contexts.

In the survey the dialogue and collaboration synergy was represented by the following three learning contexts and approaches: working in small groups; fostering collaboration; fostering classroom discussion and evaluation of alternative ideas. For the contexts under dialogue and collaboration, it is worth mentioning that teachers according to their responses to the survey overwhelmingly reported to using all the relevant learning contexts and approaches quite or very often in in their lessons (Table 23).

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	Working in small groups				Fostering collaboration			
	Preschool		Primary		Preschool		Primary	
	Policy survey	Teacher survey	Policy survey	Teacher survey	Policy survey	Teacher survey	Policy survey	Teacher survey
Belgium (Flanders)								
Finland								
France								
Germany								
Greece								
Malta								
Portugal								
Romania								
UK: England								

Not rated Not emphasised/Never/Rarely Emphasised/Quite often/Very often

Table 23. Emphasis on 'Working in small groups, Fostering collaboration': results from policy review and teacher survey, per partner country.

In comparison, teachers' frequent use of the contexts and approaches linked to dialogue and collaboration seem to agree with guidance offered in curricula across partner countries. This is particularly appropriate for promoting small group work and collaboration among children and less so for children being allowed to evaluate alternative ideas where policy presents a more varied picture. As evident in Figure 22 below, exceptions to this alignment of policy and reported practice appear in the cases of: preschool education in Greece and primary education in Germany and England for small group work.

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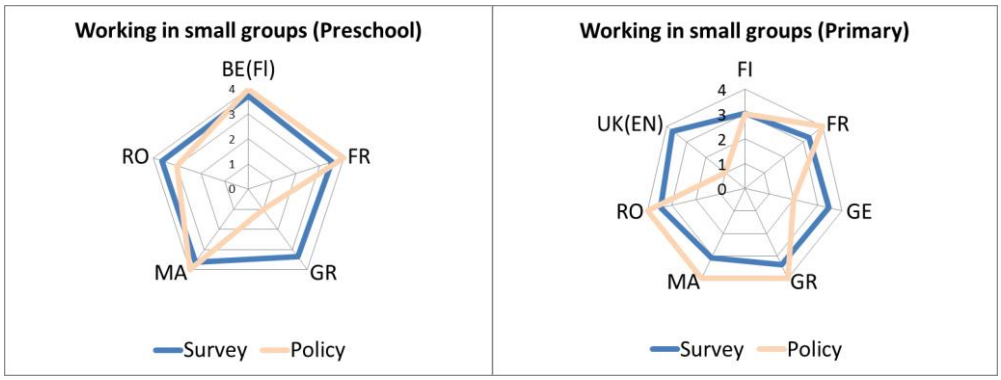
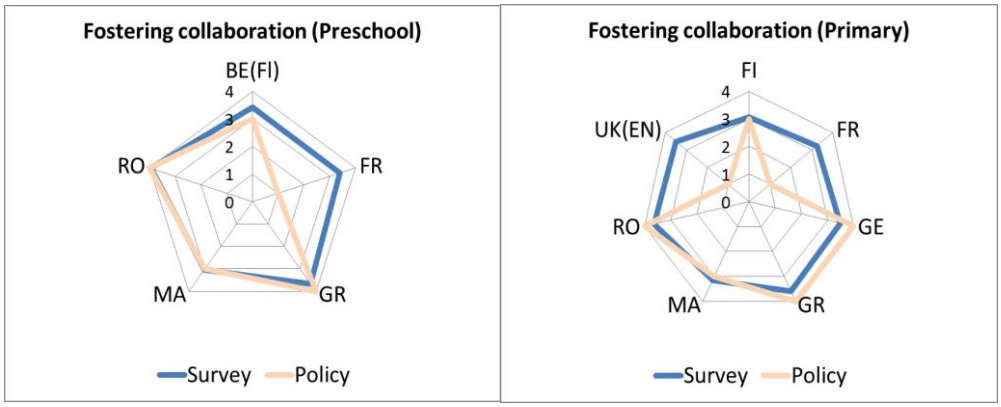


Policy
0: Not rated **1**: Not mentioned **2**: Single mention **3**: Various mentions **4**: Emphasised
Survey
1: Never **2:** Rarely **3:** Quite often **4:** Very often

Figure 22. "Working in small groups": results from policy review and teachers responses (means), per partner country.

The same can be said about English primary education and French education for both phases regarding teachers fostering collaborative work (Figure 23). In all these countries, the corresponding policy documents appear to underemphasise small group work, whereas teachers overwhelmingly include it frequently in their lessons. All the remaining countries have reported to emphasise collaborative work both in official policy guidance and teachers' reported practice.



Policy
0: Not rated **1**: Not mentioned **2**: Single mention **3**: Various mentions **4**: Emphasised
Survey
1: Never **2:** Rarely **3:** Quite often **4:** Very often

Figure 23. "Fostering collaboration": results from policy review and teachers responses (means), per partner country.

Fostering classroom discussion and evaluation of alternative ideas is an approach that also represents the IBSE/CA synergy of reflection and reasoning, since both in the context of IBSE participating in the process of evaluating ideas can foster an appreciation of scientific argumentation and

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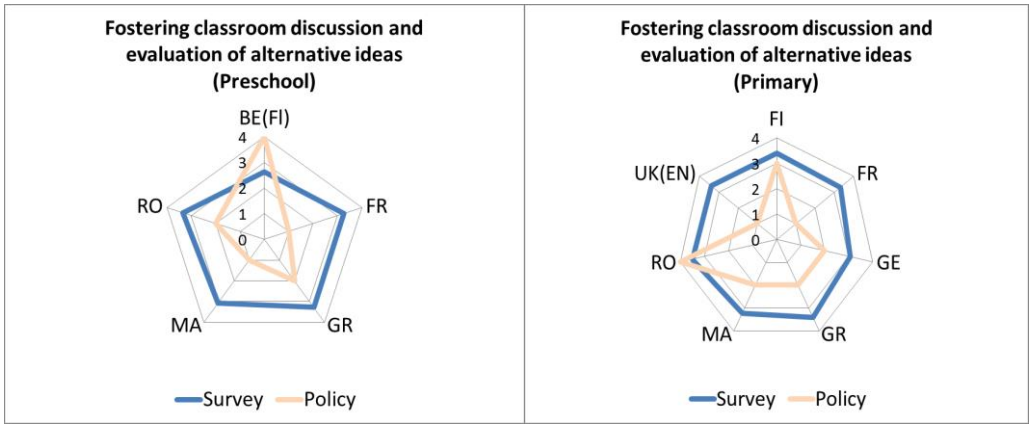
explanation, and for creativity evaluation of ideas and reflection are considered important.

The figure below shows that similar to the previously mentioned contexts in the dialogue and collaboration synergy teachers seem to include quite or very often discussions among children as well as trying to motivate children to reflect and evaluate their ideas in science (Figure 24). The difference in the case of classroom discussions is that this particular approach is undervalued in policy guidance considerably more than the previous two. The majority of curricula either provide a single reference to this approach or fail to mention it altogether. Classroom discussions is emphasised as a suggested learning approach in policy only in the cases of the Flemish community in Belgium (in preschool) as well as in Finland and Romania (in primary).



Policy
0: Not rated **1**: Not mentioned **2**: Single mention **3**: Various mentions **4**: Emphasised
Survey
1: Never **2:** Rarely **3:** Quite often **4:** Very often

Figure 24. "Fostering classroom discussion and evaluation of alternative ideas": results from policy review and teachers responses (means), per partner country.

In both the policy and teacher surveys, the IBSE/CA synergy questioning and curiosity was represented by four teaching/learning approaches: using questioning as a tool in science teaching; encouraging problem finding – e.g. children asking questions; encouraging different ways of recording and expressing ideas – oral, visual, digital, practical; and fostering imagination.

Questioning as a learning tool in science is featured frequently in science lesson according to the teachers across all the partner countries. The findings of the policy review however show that curricula do not place similar emphasis on questioning in early years science. As evident by the figure below, there is a significant dissonance between policy and reported practice (Figure 25). The majority of curricula in the partner countries do

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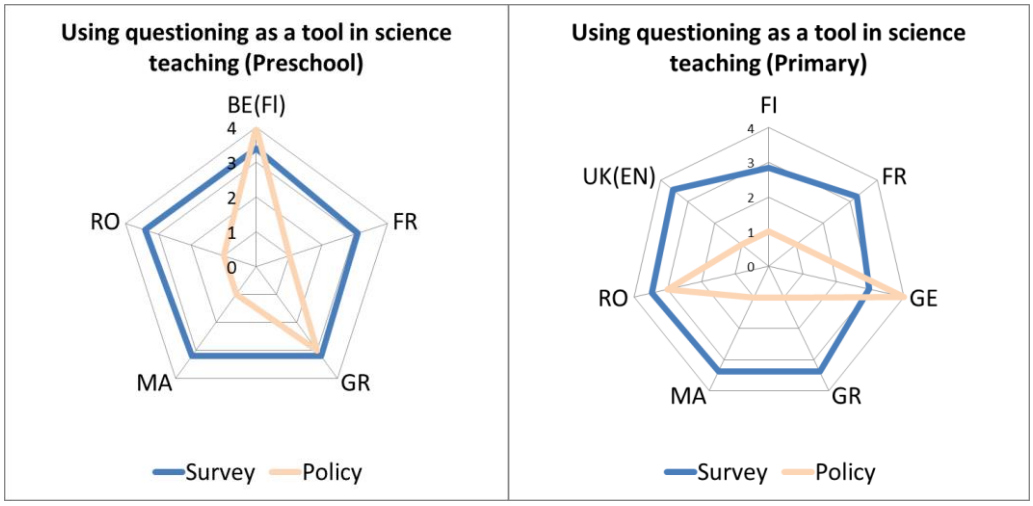
not provide a single mention to promote questioning in the pedagogy promoted for science.



Policy
0: Not rated **1**: Not mentioned **2**: Single mention **3**: Various mentions **4**: Emphasised
Survey
1: Never **2:** Rarely **3:** Quite often **4:** Very often

Figure 25. "Using questioning as a tool in science teaching": results from policy review and teachers responses (means), per partner country.

Fostering imagination is one more questionnaire item that revealed a distinct dissonance between policy and practice across the partner countries. As evident in Figure 26 below, the cases of countries where policy and practice are aligned are very limited. Collaborative work is consistently used quite or very frequently by teachers in science lessons in all partner countries, while policy seems to consistently diminish its importance in the majority of countries, particularly for primary education. Only in preschools in the Flemish community in Belgium and Romania collaborative work is highlighted in the curriculum for science and used by teachers frequently in the classroom.

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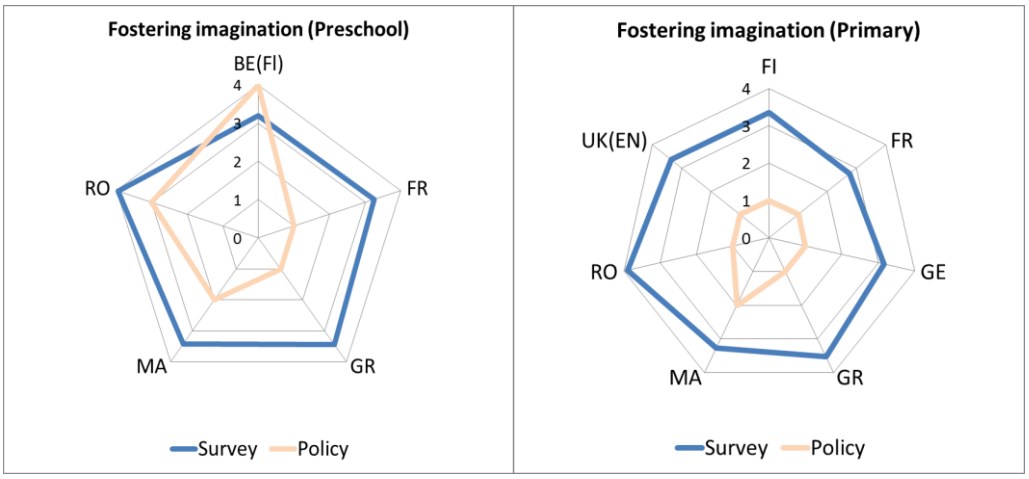

Policy
0: Not rated **1**: Not mentioned **2**: Single mention **3**: Various mentions **4**: Emphasised
Survey
1: Never **2:** Rarely **3:** Quite often **4:** Very often

Figure 26. "Fostering imagination": results from policy review and teachers responses (means), per partner country.

Finally, the role of problem solving and agency is central to IBSE (National Research Council, 2000), as well as widely recognised within creative approaches to education. In the survey this synergy, by means of the relevant teaching/learning approaches, includes the following approaches: encouraging problem finding; encouraging problem solving; encouraging children to try out their own ideas in investigations and fostering autonomous learning.

Both synergies, problem solving and agency as well as questioning and curiosity, share a questionnaire item that is particularly relevant in both, to encourage problem finding in science. Similar to the survey items that were presented above for the two relevant synergies, teachers overwhelmingly see themselves as facilitators of problem finding opportunities for children. This is consistent throughout the partner countries in both phases. Curricula on the other hand, more so in primary education than preschool, present a more varied picture in regard to encouraging problem solving in science, as a number of countries do not offer any specific guidance to teachers, thus limiting its importance in the suggested pedagogy promoted in official policy (Table 24).

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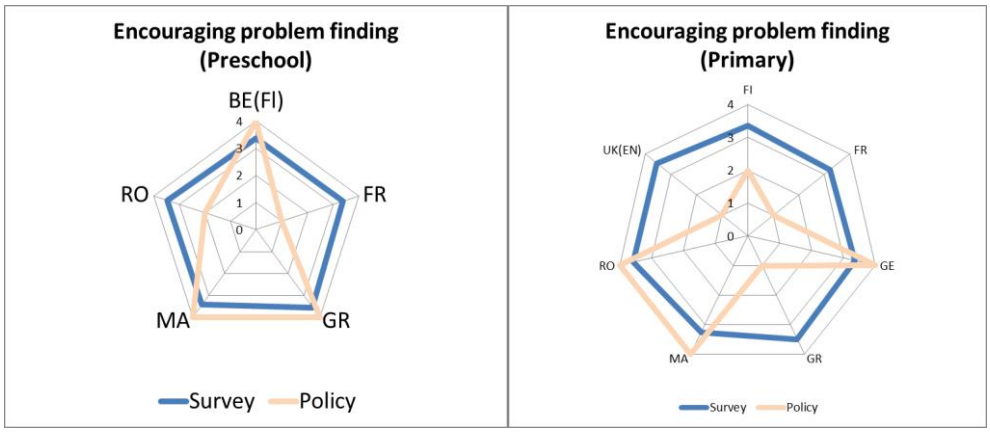
Encouraging problem finding	Preschool		Primary	
	Policy survey	Teacher survey	Policy survey	Teacher survey
Belgium (Flanders)				
Finland				
France				
Germany				
Greece				
Malta				
Romania				
UK: England				

■ Not rated ■ Not emphasised/Never/Rarely ■ Emphasised/Quite often/Very often

Table 24. Emphasis on '*Encouraging problem finding*: results from policy review and teacher survey, per partner country.

As evident in Figure 27 below, exceptions to the overall alignment of policy and reported practice on the importance of encouraging problem solving in pedagogy appear in the cases of: primary education in Finland, France, Greece and England, and preschool education in France and Romania. In all these countries, the corresponding policy documents appear to underemphasise this learning approach for science education, whereas teachers overwhelmingly use it frequently in their teaching.



Policy
0: Not rated **1**: Not mentioned **2**: Single mention **3**: Various mentions **4**: Emphasised
Survey
1: Never **2:** Rarely **3:** Quite often **4:** Very often

Figure 27. "Encouraging problem finding": results from policy review and teachers responses (means), per partner country.

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The role of creative teaching/learning contexts and approaches in early years science and mathematics education

Although all the science and mathematics education contexts and approaches presented to teachers to report about their frequency of use in the classroom have been identified as 'creativity enabling' in the project's theoretical conceptual framework (Deliverable D2.2), it was thought as important to explore teachers' own conceptions about these contexts and approaches and their potential for children's creativity development. Therefore in questions Q26 and Q27 of the survey we asked teachers to choose up to three contexts and three approaches they thought as most likely to contribute to the development of children's creativity. The findings from this process are compared to the relevant findings concerning the role of creativity in curricula across the partner countries which have been presented in the policy review (Deliverable D3.2).

Responses to the Policy Questionnaire varied considerably across partner countries. Responses for the preschool phase highlight in particular the role for creativity in relation to play. This was the only item considered to have a highly creative emphasis in policy in the majority of partner countries. Other areas most strongly associated with creativity for this phase (although not in a majority of countries) were problem finding, problem solving and using questioning. The approaches judged to be given the least creative emphasis in policy were use of stories, history and field trips as contexts for teaching, building on children's prior experiences and fostering discussion of alternative ideas.

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TOP THREE PRESCHOOL SCIENCE CREATIVE CONTEXTS		N	TOP THREE EARLY PRIMARY SCIENCE CREATIVE CONTEXTS		N
1	g. Physical exploration of materials	160	1	g. Physical exploration of materials	226
2	a. Open/unstructured play	160	2	j. Integrating science with other curricular areas	206
3	b. Role/Pretend play	123	3	h. Using outdoor learning activities	168
4	j. Integrating science with other curricular areas	116	4	f. Working in small groups	162
5	f. Working in small groups	110	5	a. Open/unstructured play	130
6	d. Teaching science from stories	89	6	b. Role/Pretend play	125
7	h. Using outdoor learning activities	82	7	i. Taking children on field trips and/or visits to science museums and industry	103
8	i. Taking children on field trips and/or visits to science museums and industry	65	8	d. Teaching science from stories	100
9	c. Drama	47	9	c. Drama	62
10	e. Using history to teach science (e.g. transport, the work of scientists)	12	10	e. Using history to teach science (e.g. transport, the work of scientists)	28

Table 25. Top 3 'creativity enabling' science education contexts, according to preschool and early primary school teachers.

Some similar patterns were evident in the evaluation of the role of creativity in policy related to the early primary age phase. There were no items that were rated as having a highly creative emphasis in a majority of partner countries, however a role for creativity was again most strongly associated with play, problem solving and children trying out their own ideas in investigations. As in preschool very low ratings were given for the use of stories, building on children's prior experiences and evaluation of alternative ideas. Group working and fostering autonomous learning were given lower rating in the early primary age phase in terms of the role for creativity. Slightly higher ratings were recorded for the use of drama and history. Comments in the National Reports indicate again very limited explicit reference to creativity. They however identify a strong implicit role for creativity in relation to opportunities for play in pre-school and problem solving in primary school.

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TOP THREE PRESCHOOL SCIENCE CREATIVE APPROACHES		N	TOP THREE EARLY PRIMARY SCIENCE CREATIVE APPROACHES		N
1	f. Encouraging pupils to try out their own ideas in investigations	168	1	f. Encouraging pupils to try out their own ideas in investigations	216
2	h. Fostering imagination	121	2	d. Encouraging problem finding – e.g. children asking questions	187
3	d. Encouraging problem finding – e.g. children asking questions	119	3	e. Encouraging problem solving – e.g. children solving practical tasks	161
4	e. Encouraging problem solving – e.g. children solving practical tasks	109	4	i. Relating science to everyday life	145
5	i. Relating science to everyday life	97	5	h. Fostering imagination	138
6	a. Building on children's prior experiences	93	6	c. Encouraging different ways of recording and expressing ideas – oral, visual, digital, practical	118
7	c. Encouraging different ways of recording and expressing ideas – oral, visual, digital, practical	85	7	a. Building on children's prior experiences	99
8	b. Fostering collaboration	70	8	b. Fostering collaboration	95
9	g. Fostering classroom discussion and evaluation of alternative ideas	50	9	g. Fostering classroom discussion and evaluation of alternative ideas	77
10	l. Fostering autonomous learning	33	10	j. Using questioning as a tool in science teaching	41
11	k. Using digital technologies with children for science teaching and learning	23	11	k. Using digital technologies with children for science teaching and learning	39
12	j. Using questioning as a tool in science teaching	21	12	l. Fostering autonomous learning	34

Table 26. Top 3 'creativity enabling' science education approaches, according to preschool and early primary school teachers.

According to the teacher survey, the contexts considered by most teachers amongst the three most 'creativity enabling' ones, are the ones also used most frequently. These are: children actively exploring material to extend their senses, integrating science with other curricular areas and both forms of play. Comparing now the three top choices of science 'creativity enabling' contexts of preschool and early primary school teachers, we notice interesting differences. 'Open/unstructured play' and 'role pretend play' are contexts that are considered amongst the top three 'creativity enabling' by more preschool than early primary teachers, mirroring the trends in their frequency of use by them. Since all these contexts have been identified as central and important candidates for fostering learner creativity in science and mathematics learning it will be interesting for the Creative Little Scientists project to probe deeper into teachers' conceptualisations and practice regarding these.

Considering now teachers' choices for the three top 'creativity enabling' science approaches (Table 26) in relation to their declared use of them we do not see the same trends as we did with the three top 'creativity

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enabling' contexts. For example, 'encouraging children to try out their own ideas in investigations' is an approach considered amongst the top three 'creativity enabling' by the largest proportion of teachers, but not the most frequently used by them. On the other hand 'building on children's prior experiences' and 'fostering collaboration' are the most frequently used approaches, but few teachers respectively consider them as having potential for nurturing children's creativity. Similarly, 'using questioning as a tool in science teaching' is used very frequently almost half of the teacher sample, but is considered a potentially 'creative' learning approach by significantly less teachers.

4.2.2.4 Overall findings

Bringing together the results discussed in the Report on First Survey of School Practice (D3.3) and the Report on Mapping and Comparing Recorded Practices (D3.2) about policy and teachers' conceptualisations of the various learning contexts and approaches linked to pedagogy it can be concluded that:

Teachers overall appreciate the role of dialogue and collaboration in their practice, but fail to see their potential for creativity development in children. This is consistent with the very limited guidance provided by policy documents to enable creativity using classroom discussions and collaborative work.

There is an uneven treatment of the contexts and approaches grouped under the synergy motivation and affect. The contexts of 'drama' and 'using history to teach science' are used the least frequently and are least considered as 'creativity enabling' by teachers while curricula also fail to promote the potential for creativity of these two learning contexts. The approaches of 'building on children's prior experiences' and 'relating science to everyday life' on the other hand are amongst the most frequently used, though still not considered as similarly 'creativity enabling' by both teachers and policy guidance. Finally, the cross-disciplinary teaching of science ('integrating science with other curricular areas') is a context used frequently by both preschool and early primary school teachers, but not considered equally as 'creativity enabling' by them; many more early primary than preschool teachers consider this context as 'creativity enabling'. Integrating science with other curricular areas in official policy is very similarly framed with only a few countries recognising its potential to enable children's creativity, particularly in preschools (Finland, Germany and Greece in preschool, Finland in primary).

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There is also an uneven treatment of the contexts and approaches grouped under the synergy play and exploration. Preschool use significantly more than early primary school teachers 'open/unstructured play' and 'role/pretend play', and more also conceptualise these as 'creativity enabling'. This is also reflected in curricula across the partner countries, as the majority of countries promote playful exploration in preschool while recognising its creativity-enabling value considerably more than in primary education. On the other hand both groups agree in the frequent use and 'creative' perception of 'physical exploration of materials'. This agreement between the teachers of both phases is however lost in policy guidance. Even if curricula across the partner countries promote the physical exploration of materials by the children in both phases, their perspective as to whether they can be creativity-enabling noticeably differs between the two phases. Similar to the findings presented above primary policy seems to undervalue the creative potential of this learning approach compared to official guidance offered in preschool.

In terms of the synergy problem solving and agency, official policy emphasises on almost all relevant approaches and contexts across both phases. This emphasis on problem solving in policy guidance in policy expands to its suggested potential to enabling children's creativity as the majority of countries, particularly in preschool. According to teachers' responses, almost all problem solving and agency contexts and approaches are thought of amongst the most 'creativity enabling' by a large number of teachers, who also report to use them quite or very frequently.

Concerning the areas of questioning and curiosity, the learning approaches included are either given various mentions or emphasised in preschool policy in the majority of countries. However in contrast to preschool, more limited emphasis is given to questioning. In terms of teaching practice, there is correspondence between teachers' use of practices that encourage children to ask questions and foster their imagination and teachers' perceptions of these practices as 'creativity enabling'. However, the same cannot be said for the use of questioning by teachers and their encouraging of different ways of recording and expressing ideas. Although both practices are reportedly used quite or very often by the large majority of teachers, they are not considered amongst the three most 'creativity enabling' by many of them, something which is also reflected in policy guidance. This big difference, supported by official guidance, given the importance of modelling and fostering by

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teachers of positive attitudes toward curiosity and questioning, rather points to an important gap that needs to be bridged by teacher education.

4.2.3 Assessment: How to measure how far children's learning has progressed?

It is often argued that assessment practice drives teaching and learning (Black, 2001). It is therefore important to consider the climate of assessment practice. Changing perspectives on learning and teaching and development in the field of assessment have led to a growing debate about the purposes of assessment and an increased emphasis on the importance of assessment for learning as well as of learning (Black, 2001; Gipps and Stobart, 1997). Two different purposes of assessment are highlighted, formative and summative. Internationally the tension between formative and summative uses of assessment in relation to assessment for learning versus assessment for comparative purposes, is evident. There is pressure on teachers to address specific assessment criteria rather than assess the holistic development of the individual, which the increase in formative assessment strategies has helped to ameliorate. Attempting to meet both purposes in the classroom is complex, particularly when summative uses of assessment, e.g. using tests, may need to be undertaken using context-free approaches.

Given the above tensions and emphases identified in the literature, the project's conceptual framework (Deliverable D2.2, p69) has suggested that in relation to early years science and mathematics assessment the project could examine:

- The formative and summative ways in which assessment is used in science and mathematics in the early years;
- The involvement of children in assessment processes;
- The development of multimodal approaches to assessment sensitive to young children's capabilities and learning processes;
- The role of context and authenticity of assessment tasks;
- Broadening the assessment and evaluation of science and mathematics through employing a creativity lens in the context of inquiry;
- The person/people considered to be responsible for making judgements in assessing creativity in science and mathematics.

In the list of factors (D3.1) identified in the project, assessment is reflected through two approaches: assessment function/purpose and assessment ways/processes.

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Priorities for assessment

Assessment priorities have been discussed within cognitive and affective dimensions; comparisons have been made using the following statements:

1. **Cognitive dimension**

   knowledge/understanding of science content (ideas and processes)

   understanding about scientific inquiry (nature of science)

   capabilities to carry out scientific inquiry

2. **Affective dimension of science learning**

   attitudes to science

   attitudes to science learning

Assessment process

Ways of assessment have been reflected through the following three factors:

1. **Strategies**

   formative (self-assessment, peer assessment, ongoing)

   summative

   focus on product vs. process

2. **Forms of evidence**

   multimodal

   context-based

   authentic problem-based

   portfolios

   tests

   checklists

   homework

3. **Locus of judgment**

   teacher

   child

4.2.3.1 Key themes from the policy review and teacher survey

There is wide variation in policy requirements for assessment across the partner countries. In addition, assessment guidance is rather limited and there is often a mismatch between rationale and aims. In general, assessment priorities in policy documents seem to place the greatest emphasis on cognitive dimension, particularly in primary education. Understandings and competencies in relation to scientific inquiry are emphasised in assessment policy in a minority of countries and in only a

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few instances are attitudes a priority for assessment in science. Some references to understanding and skills of inquiry do exist, but social and affective dimensions are neglected and only limited attention is given to multimodal assessment or the involvement of children.

According to the teacher survey, priorities correspond to two separate dimensions of science learning, cognitive and affective; more emphasis is on affective dimensions, which seems to be consistent with teachers' rationale, vision, aims and objectives for science education. However, teachers in the majority of the partner countries do not consider assessment of scientific ideas and processes, or scientific inquiry in early years science education as important.

Based on the comparison of policy and teacher surveys regarding assessment, there seems to be some disparity between policy documents and teachers' priorities. Policy documents tend to recommend assessment predominantly on the cognitive dimensions of science education such as assessing the knowledge and understanding of science, while teachers highlight the affective dimensions, aiming to promote children's positive attitudes towards science and science learning. In addition, according to policy documents in most countries, assessing the competencies to carry out scientific inquiries is not the aim (except UK and Finland, primary school) but more variation exists among the teachers. Teachers' tendency is more positive with examples cited of assessment of pupils' competences to carry out inquiries.

4.2.3.2 Differences between Preschool and Early Primary School

The National Reports have highlighted a number of differences in assessment policy between preschool and early primary school across partner countries. First, there is much greater extent of guidance and regulation related to assessment in the early primary age phase, particularly in specific learning goals or criteria provided for assessment and in national and statutory requirements for assessment and testing. Second, in terms of priorities for assessment, there is greater attention to knowledge of understanding of scientific ideas in the early primary phase and a stronger focus on the development of attitudes in preschool. Third, in the early primary phase there is greater focus on improvement in children's learning and the provision of feedback in comparison to preschool. Finally, while limited guidance is provided on ways of assessing for either phases of education, where guidance is provided, there was some indication that a broader range of assessment approaches is advocated in preschool.

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Comparing teachers' responses in the survey did not reveal significant differences in the importance attributed to the majority of assessment priorities, except from those concerning children's knowledge of important scientific ideas and processes. These are considered as more important by primary than preschool teachers, as it might be expected. In terms of the use of various assessment ways and processes, primary teachers appear to be using a number of assessment processes significantly more, showing a distinct divergence between the assessment practices of the two cohorts of teachers. The largest difference was noticed for the practice of 'marking homework', which primary teachers use with average frequency, whereas preschool teacher use between never and rarely. On the other hand, the only practice which is significantly more used by preschool teachers is the evaluation of children's visual representations of their scientific reasoning. This is an interesting finding from the project's viewpoint, as both fostering and attending to children's multimodal expression has been found to support creative learning and inquiry.

4.2.3.3 Comparisons between the policy and teacher surveys at partner country level

According to the policy review, decisions about priorities and approaches in assessment are left to teachers; although guidance may be provided in relation to methods or criteria. (Examples include pre-school policy in Finland, France, Germany, Greece and UK (Scotland)). In other countries, statutory assessment criteria or requirements are set at national level, for example for early primary school in France, Portugal, Romania and UK (England and Wales). In a number of partner countries, national assessments and tests are used to monitor standards and evaluate school effectiveness. For example in Belgium (Flanders) national sample surveys are carried out of children's attainment. In France there are statutory diagnostic assessments to be undertaken at the end of each cycle of education and in the UK (England and Wales) national testing in mathematics at the end of each stage of education. In Germany, national standards and testing have recently been introduced for mathematics.

The comparison of findings between the policy review and the teacher survey at the country level further solidifies assessment as an underdeveloped aspect of teaching and learning. The policy questionnaires as well as the National Reports on policy do not tend to include specific guidance concerning priorities, functions and methods for assessment. On the other hand, teachers overwhelmingly reported to taking under consideration these aspects for assessment regardless of their absence in policy. It is unclear however how these assessment practices are implemented by the teachers during their lessons.

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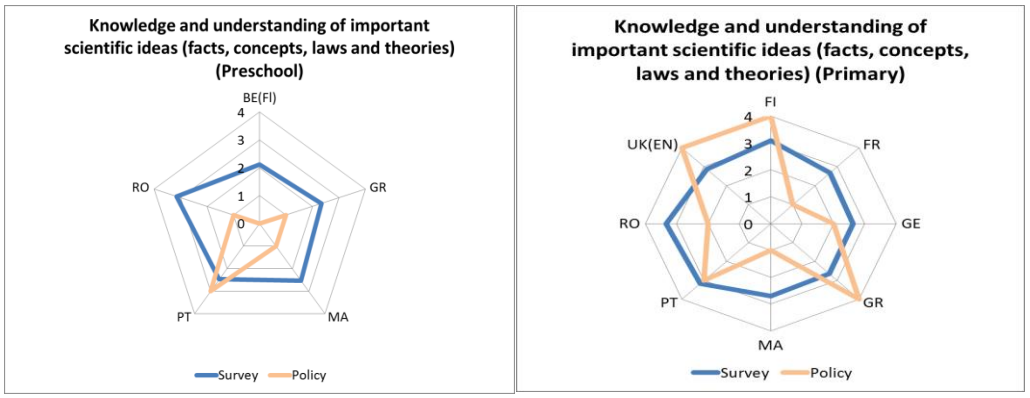
The following part of his report will display the limited specific guidance in this area of policy which leaves assessment in the hands of the teacher in the majority of countries for both primary and preschool education.

As indicated in Figures 28, 29 and 30 below, responses to the two questionnaires indicate variation in the priorities identified for science assessment in partner countries. In the majority of partner countries, priorities for assessment were not mentioned in curricula (Rating=0), particularly in preschool. Only in Flanders, Malta and Portugal were priorities for assessment provided by policy for preschools. In the Flemish community, priorities linked to developing positive attitudes and competences to carry out scientific inquiry were emphasised in agreement with the overall scope of the curriculum, while Portuguese policy focuses on assessing cognitive aspects of learning, such as understandings about important scientific ideas.



Policy
0: Not rated **1**: Not mentioned **2**: Single mention **3**: Various mentions **4**: Emphasised
Survey
1: Never **2:** Rarely **3:** Quite often **4:** Very often

Figure 28. "Open/unstructured play": results from policy review and teachers responses (means), per partner country.

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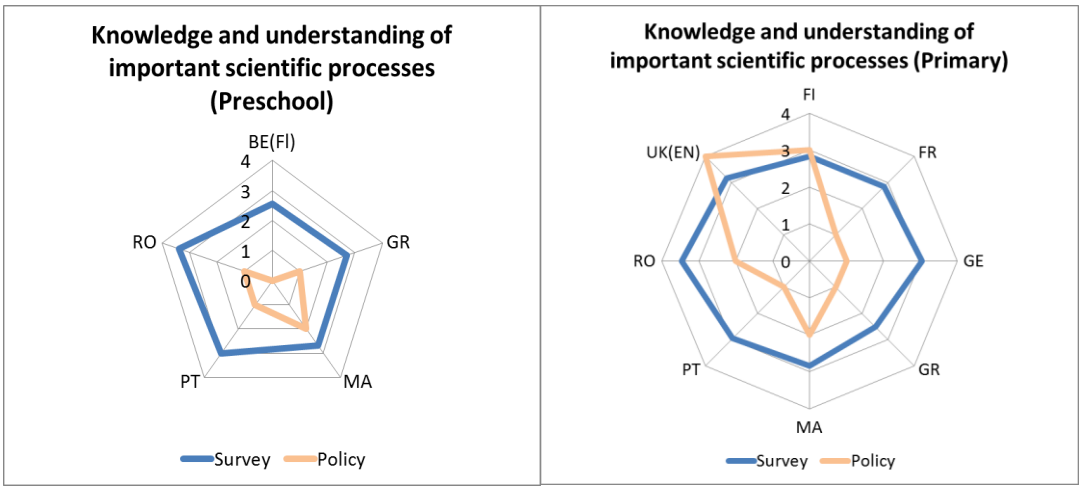
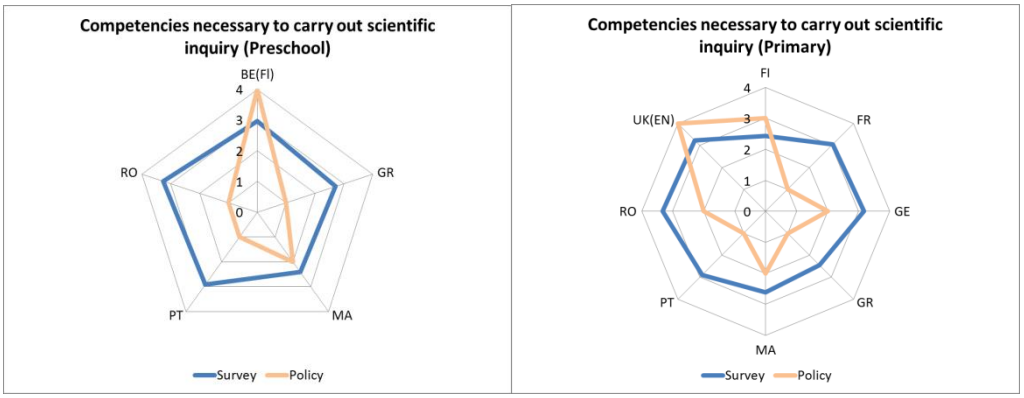


Policy
0: Not rated **1**: Not mentioned **2**: Single mention **3**: Various mentions **4**: Emphasised
Survey
1: Never **2:** Rarely **3:** Quite often **4:** Very often

Figure 29. "Open/unstructured play": results from policy review and teachers responses (means), per partner country.



Policy
0: Not rated **1**: Not mentioned **2**: Single mention **3**: Various mentions **4**: Emphasised
Survey
1: Never **2:** Rarely **3:** Quite often **4:** Very often

Figure 30. "Open/unstructured play": results from policy review and teachers responses (means), per partner country.

No single priority is emphasised across the majority of countries. Knowledge and understanding of ideas is given the greatest significance for assessment in both phases in policy guidance. This is particularly valid for the primary phase where a number of countries either place significant emphasis (Finland, England and Greece) or provides various mentions (Portugal) on assessment of knowledge of important scientific ideas (Figure 28). Knowledge and skills associated with scientific processes also feature strongly in some countries such as England and Finland. According to teachers' responses to the teacher survey, priorities for assessment

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linked to cognitive dimensions of learning are less considered compared to priorities linked to affective dimensions of learning. Even so, amongst these cognitive assessment priorities there seems to be a preference amongst teachers for the ones that refer to science processes and inquiry competences and less for the ones that refer to science ideas (facts, concepts, laws and theories) French and Flemish teachers place a relatively lower importance on the cognitive assessment priorities that refer to children's knowledge of scientific ideas and processes than on those referring to understandings about and competences of scientific inquiry, and in this they differ significantly from Romanian and Finnish teachers. Assessment of understandings about science inquiry is mentioned in curricula of a number of countries (England, Finland, Germany, Malta and Flanders), but only emphasised in Flemish preschools and English primary schools. Sampled teachers in all partner countries place the importance of assessing children's 'understandings about scientific inquiry' lower than all other priorities; significant variations exist only between Romanian teachers at the higher end and Flemish, Finnish and Maltese teachers at the lower end.

More limited focus on priorities for assessment linked to affective factors of learning is indicated in policy guidance across the partner countries. Overall, assessment of positive attitudes to science and science learning is undervalued in policy, as only Flemish preschool and Finnish primary curricula place any emphasis on either questionnaire item. The absence of guidance to promote assessment of affective factors of learning in official policy is in contrast to the findings of the teacher survey, where the overwhelming majority of teachers considers these priorities as quite or very important. Both items – 'positive attitudes and increase of interest in learning science'; and 'positive attitudes and increase of interest in science' - connected to affective assessment priorities are considered quite or very important by the overwhelming majority of teachers - 93.6% and 93.2% respectively. These priorities are rated higher in Romania than all other partner countries. The importance of affective assessment priorities is also rated similarly high by English, German and Portuguese teachers and statistically significantly lower by Maltese and French teachers (Figure 31).

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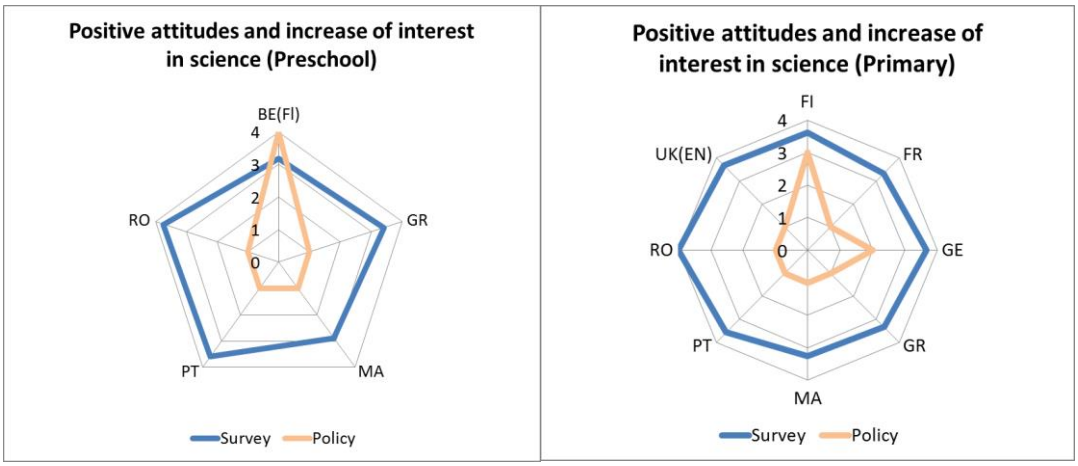

Policy
0: Not rated **1**: Not mentioned **2**: Single mention **3**: Various mentions **4**: Emphasised
Survey
1: Never **2:** Rarely **3:** Quite often **4:** Very often

Figure 31. "Open/unstructured play": results from policy review and teachers responses (means), per partner country.

Assessment functions/purposes

The tension between formative and summative assessment is one of the main interests the project wishes to explore in regard to assessment. In the Policy Questionnaires varied purposes of assessment are identified in policy related to assessment in preschool and early primary school across partner countries. In preschool education, the most common purposes either emphasised or mentioned on various occasions in the majority of partner countries are to inform parents and monitor progress against learning outcomes. The findings of the teacher survey show that sampled teachers' replies suggest no overall clear predominance of formative or summative purposes in their assessment practices.

Assessment to improve children's learning is given some emphasis in policy in a number of countries, such as Greece and Malta and curricula for primary education in Romania, England and Finland. The majority of teachers report to be using assessment quite or very frequently to identify ways to improve child science learning in primary education, but less so in preschools (Figure 32). This is particularly evident in Malta where preschool teachers tend to include this assessment purpose less frequently than their primary counterparts.

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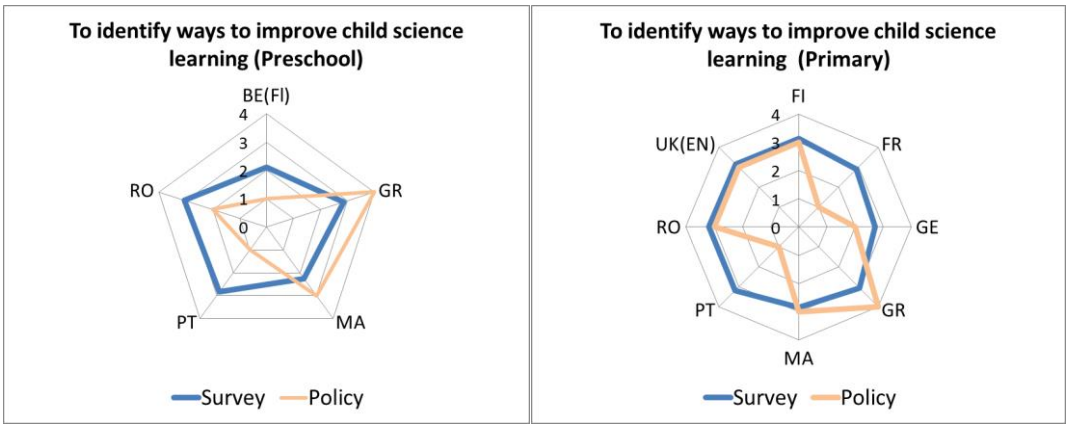
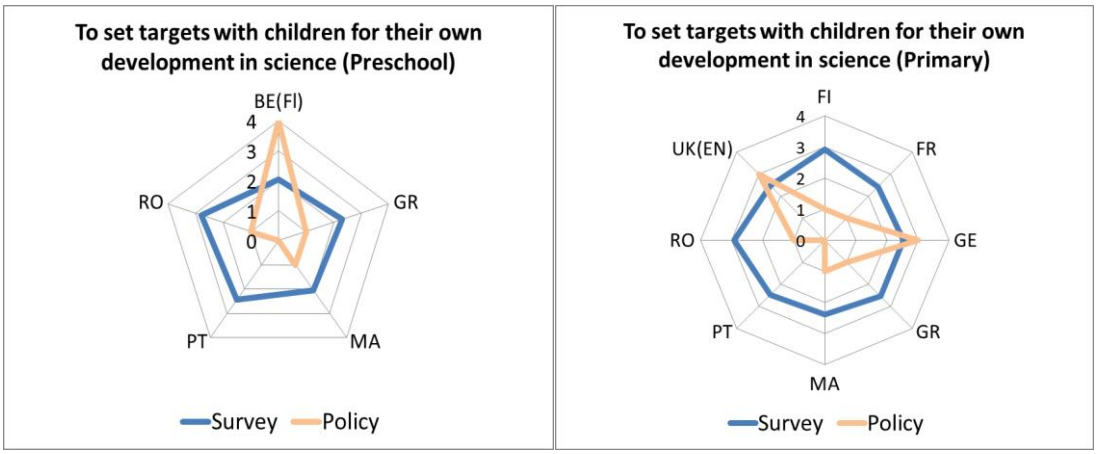


Policy
0: Not rated **1**: Not mentioned **2**: Single mention **3**: Various mentions **4**: Emphasised
Survey
1: Never **2:** Rarely **3:** Quite often **4:** Very often

Figure 32. "Open/unstructured play": results from policy review and teachers responses (means), per partner country.

Assessment for grouping for instruction and for setting targets with children are purposes given the most limited emphasis in policy documents across partner countries. Setting learning targets with children is quite or very frequently used by a little more than half of the teachers who responded to the survey, although it is one of the purposes that are among the least frequently used by teachers. Setting science learning targets in consultation with children is an assessment function used quite frequently by Romanian teachers, and significantly more frequently than English, Greek, German and Maltese teachers who do this with average and low frequency (Figure 33).



Policy
0: Not rated **1**: Not mentioned **2**: Single mention **3**: Various mentions **4**: Emphasised
Survey
1: Never **2:** Rarely **3:** Quite often **4:** Very often

Figure 33. "Open/unstructured play": results from policy review and teachers responses (means), per partner country.

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The other items related to the purposes of assessment, to support improvement in the curriculum or teaching, for providing feedback to children and monitoring year on year progress of individuals are all emphasised in official guidance in only a small number of partner countries. In primary education, identifying ways to improve science learning is given greatest priority alongside monitoring progress against learning outcomes and informing parents of children's progress. In comparison to preschool, greater priority is given to providing feedback to children in primary education, while in agreement to the preschool findings assessment to inform grouping or for setting targets with children is little emphasised. A number of differences between preschool and early primary school teachers in the frequency they use assessment for various purposes were found according to the results teacher survey. Primary teachers appear to be using assessment significantly more frequently for most of the functions that are traditionally associated with child-centered formative objectives, that is to:

- identify areas for improvement in the teaching of science;
- identify ways to improve child science learning;
- monitor regularly children's progress towards a set of desirable science learning outcomes;
- provide feedback to children about their progress in science; and
- set targets with children for their own development in science.

The latter two practices have a particular interest for the project as they place the child as the direct recipient of assessment results. It would be interesting to investigate further the reasons behind these differences between preschool and primary school teachers.

Assessment of creative dispositions in science

Responses to the Policy Questionnaire suggest that there is limited representation of creative attributes and in assessment policy across partner countries, indicated in the high number of not rated or not mentioned responses in partner questionnaires. On the other hand, an impressive proportion (more than 90%) of the sample of all teachers across the partner countries said to be praising and rewarding all these dispositions in their pupils in science quite or very frequently.

In terms of the creative attributes identified in partner policy, thinking skills feature most strongly along with curiosity (greater emphasis in preschool), ability to work together (greater emphasis in primary) and ability to make connections with learning in other subjects. The findings of the teacher survey reveal that the most frequently (quite and very often)

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rewarded dispositions are children's ability to work together, a finding consistent with previous findings of the analysis, and children's sense of initiative.

Amongst the sampled teachers of all partner countries, only French teachers systematically praise/reward less frequently all eight creative dispositions presented to them, as part of their science assessment. Teachers' infrequent use of creative dispositions for assessment purposes in France is consistent to the lack of guidance found in French curricula for both preschool and primary education. On the other hand, Romanian teachers, joined in most cases also by Greek and/or Maltese teachers, used praise/reward significantly more frequently than others most of these creative dispositions, even though Maltese curricula only provide a single mention for three dispositions in preschool and one in primary. With reference to these three overall high averaging in the assessment of creativity national samples, English and German sampled teachers average significantly lower than all three of them in the use of praise/reward of children's imagination, and their ability to connect what they have learnt in science with topics in other subjects respectively. Moreover, English teachers average significantly lower than the Romanian teachers also in the assessment of children's sense of initiative and ability to come up with something new, and German teachers in the assessment of children's sense of initiative and thinking skills.

Assessment ways and processes

Policy across partner countries provides limited specific guidance in ways and processes for assessment reflected in the number of not rated or single mentions recorded in partner questionnaires. In preschool use of checklists to record observations, classroom interaction and portfolios feature most strongly. Checklists are promoted in official policy for preschool education in France, Germany, Romania, England, N. Ireland and Wales; assessment of classroom interaction is mentioned in all the sample countries except Portugal; and portfolios in Finland, Germany, Greece, Romania and England (Figures 35 and 36). These assessment processes are also represented, but with more limited emphasis, in policy at primary level. Responses to the relevant questionnaire items for primary school teachers reveal that two of the abovementioned processes, using portfolios and assessing classroom interaction, are used most frequently by primary teachers during their lessons as well. Significant variations to the overall findings regarding these questionnaire items include German teachers assessing children during classroom interaction significantly less frequently than all other national samples and Romanian teachers who reported using portfolios of children's work and progress

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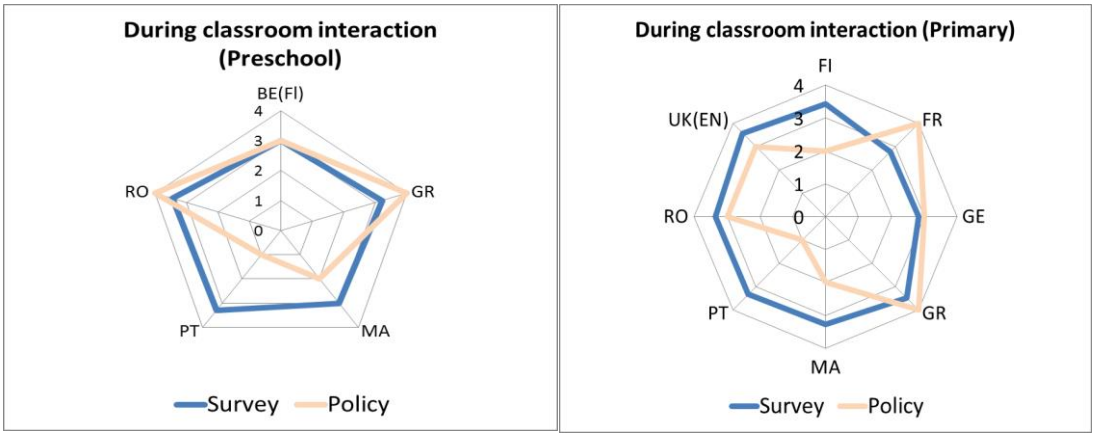
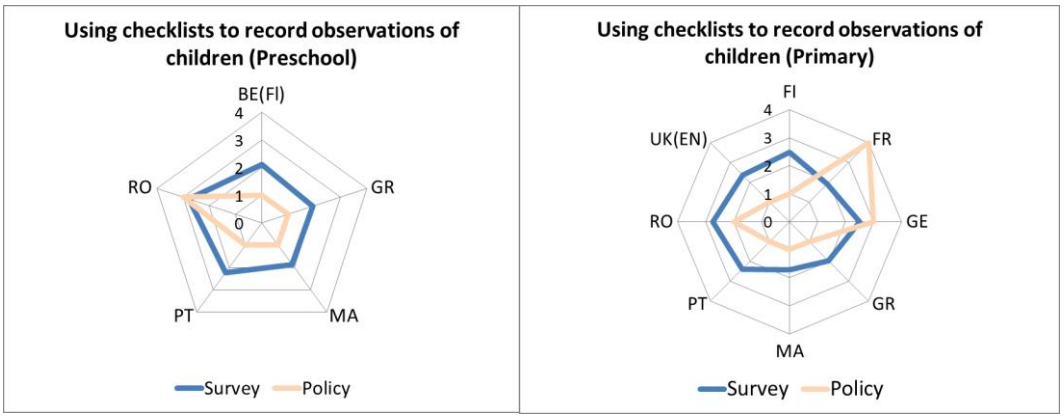
overall more than quite often and significantly more frequently that almost all other national teacher samples. On the other hand, using checklists is an assessment process that is used significantly less frequently by teachers during their primary science lessons compared to their frequent use found in preschools across the sample countries (Figure 35).



Policy
0: Not rated **1**: Not mentioned **2**: Single mention **3**: Various mentions **4**: Emphasised
Survey
1: Never **2:** Rarely **3:** Quite often **4:** Very often

Figure 34. "Open/unstructured play": results from policy review and teachers responses (means), per partner country.



Policy
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Survey
1: Never **2:** Rarely **3:** Quite often **4:** Very often

Figure 35. "Open/unstructured play": results from policy review and teachers responses (means), per partner country.

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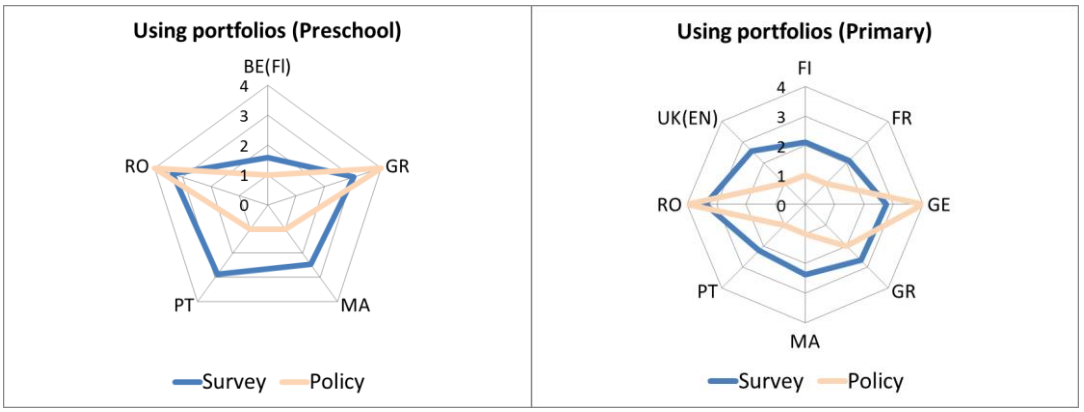

Policy
0: Not rated **1**: Not mentioned **2**: Single mention **3**: Various mentions **4**: Emphasised
Survey
1: Never **2:** Rarely **3:** Quite often **4:** Very often

Figure 36. "Open/unstructured play": results from policy review and teachers responses (means), per partner country.

Overall, the majority of the sampled teachers report to be assessing children quite or very often, attending to the pictures and other visual materials they produce, as well as to their gestures or physical activity, using questions in-context and authentic problem-based tasks. All these point to a formative emphasis of science assessment by teachers for the particular age range examined by *Creative Little Scientists*. Having said this, only about half the teachers surveyed use the formative approaches of self-assessment (i.e. ask children to reflect on their own learning and progress) or peer assessment (i.e. ask children to correct each other's work and give each other feedback) quite or very frequently (56.4% and 50.7% respectively). Asking children to reflect on their progress is also an approach mentioned in some countries – more strongly at primary level and particularly in France and England (Figure 37). Using peer assessment (i.e. children correcting each other's work and giving each other feedback) on the other hand is the assessment process that is least mentioned in official policy guidance out of all the processes included in the questionnaire (Figure 38). It should be noted that these two items characterize also assessment where the locus of the judgment is on children rather than on teachers.

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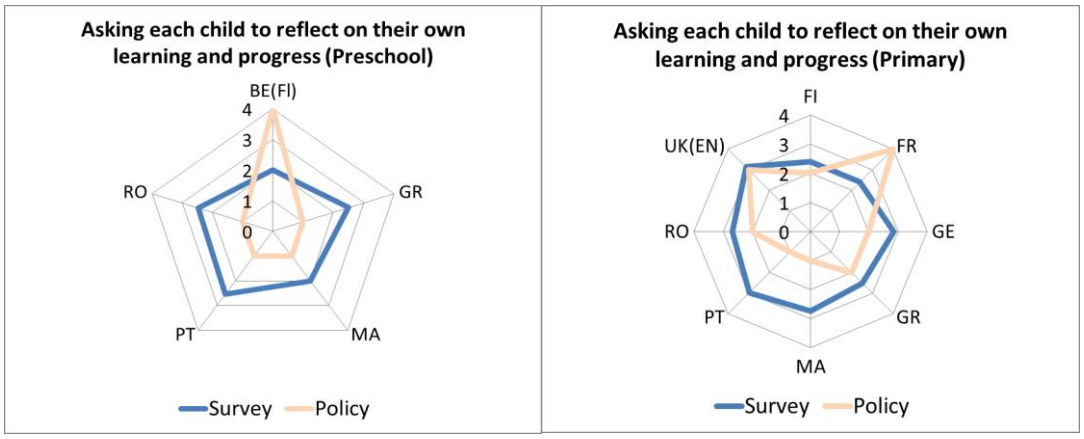
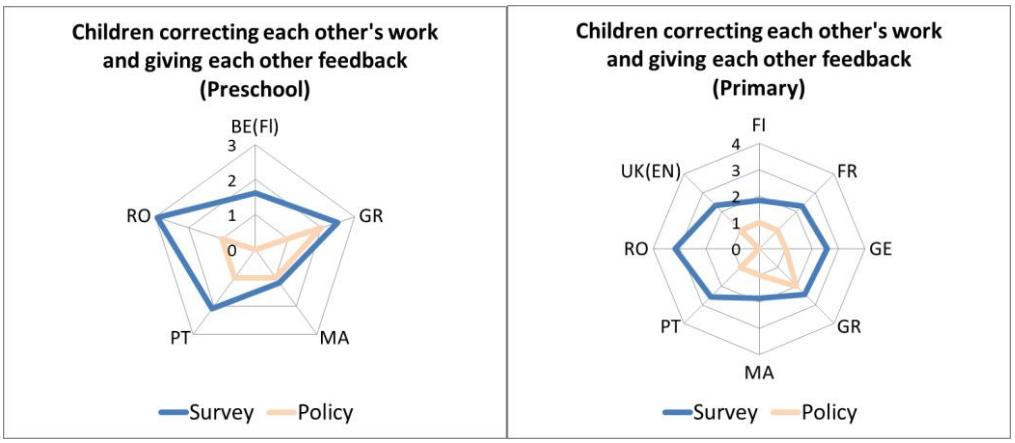


Policy
0: Not rated **1**: Not mentioned **2**: Single mention **3**: Various mentions **4**: Emphasised
Survey
1: Never **2:** Rarely **3:** Quite often **4:** Very often

Figure 37. "Open/unstructured play": results from policy review and teachers responses (means), per partner country.



Policy
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Survey
1: Never **2:** Rarely **3:** Quite often **4:** Very often

Figure 38. "Open/unstructured play": results from policy review and teachers responses (means), per partner country.

4.3 Contextual factors

Contextual factors have been reviewed in this report through curriculum related factors including the content of learning, location of learning, materials and resources, grouping and time.

4.3.1 Content: What are children learning?

A review of the policy and teacher survey reports reveals a number of differences in the presentation and nature of curriculum content for science in partner countries. As mentioned in the Report on Mapping and

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Comparing Recorded Practices (D3.2), in preschool, science is generally included within broader areas of learning such as 'Discovery of the World' (France) or 'Child and the Environment' (Greece) or 'Knowledge and Understanding of the World' (UK (Wales)), and thus integrated cross-curricular approaches to learning and teaching are advocated. In addition, in a number of instances there is limited specification of subject specific content for science in this phase of education. The emphasis is rather on the development of skills and attitudes in the context of content selected to build on children's interests and prior experiences (for example Belgium (Flanders), France, Finland, Germany, Malta and UK (England)).

In early primary school, many countries continue to specify science within broader areas of learning (Belgium (Flanders), Finland, Germany, Greece, UK (Northern Ireland and Wales)), whereas in others, science is presented as a separate area of learning (for example Belgium (Wallonia), France, Malta, Romania). In both cases, there is much greater emphasis on the development of specific concepts associated with learning objectives for the primary age phase.

Partner policy documents reveal a number of differences in the presentation and the nature of their curriculum content for science. In addition, large variation is apparent in policies referring to the ways in which skills and processes associated with inquiry are included within the content built on children's interests and prior experiences.

In primary level policy documents, content focuses on the development of specific concepts associated with learning objectives. However, the curriculum content for primary school presents limited references regarding the development of social and affective dimensions. At the preschool level, affective dimensions are given greater attention and curiosity is explicitly mentioned by the majority of countries. This tendency can also be seen in teacher survey responses. Teachers often include the learning content within broader areas of learning, integrated cross-curricular approaches to learning and teaching, thus limited attention is given to subject specific content for science education. The content of science education seems to develop children's skills and attitudes in the same everyday contexts built on the children's interest and prior experience.

In comparison to science, mathematics is more commonly set out as a distinct area of learning in partner countries at both phases of education, and receives greater attention in preschool. However, in some countries (e.g. UK (Wales)) it is also treated as a cross-curricular dimension, with its application to general science knowledge emphasized (Romania). (For

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more detailed analysis of the curriculum content in the partner countries see Deliverable D3.2 Report on Mapping and Comparing Recorded Practices).

4.3.2 Location: Where are children learning?

There was no dedicated section in both questionnaires for policy and teaching practice focusing on where children are learning, incorporating the different settings for learning and the social and physical characteristics of the learning environments provided. However, relevant features of policy in relation to the physical and social environments provided for science learning are indicated in the National Reports provided by partners and in the following spider web dimensions of Materials and Resources, Grouping and Time. Key features are summarised here with any notable differences in policy related to preschool and early primary phases of education.

According to the review of policy with respect to the physical environment, the importance of physical exploration of materials, the provision of equipment and use of digital technologies, were mentioned as important in the majority of countries. In several countries, attention has also been given to the social environment such as collaboration and working in small groups. This approach has been noted both in the preschool and primary school phases of education. However, more limited attention is given to opportunities for learning offered by field trips or visits to science museums. Countries where such opportunities were particularly highlighted include France, Germany and Greece.

In the teacher survey, the pedagogical environment emphasises collaboration amongst peers and working in small groups are approaches employed by the majority of teachers as recommended in policies. With regards to outdoor learning environments there is conformity between policy and teacher surveys. Outdoor environments are also used by teachers; with the exception of primary school teachers in Belgium Flanders and in Portugal. Informal learning environments such as visits are not regularly used by teachers.

4.3.3 Materials and resources: With what are children learning?

According to the conceptual framework of the project, a wide range of materials can be seen to foster children's motivation and ways of presenting their ideas. Indoor and outdoor activities are also seen to be important for learning according to the Conceptual Framework (D.2.2). In both questionnaires, the use and availability of materials and resources were divided in the following categories:

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- Rich physical environment for exploration
- ICT and digital resources
- Sufficient human resources
- Use of outdoor environment
- Availability of different kind of resources

Policy documents provide limited guidance about the materials to be used in science and mathematics in the early years, although there does appear to be a range of resources provided for teachers text-books, assessment tools online, computers and ICT resources are the materials most strongly featured in partner policies for science at both the preschool and primary school level. However, little emphasis is placed on a budget for teaching or technical support for science and the emphasis on instructional materials and audio-visual resources vary across partner countries. Preschool policies give more attention to relevant library materials.

Teachers' views about materials seem to be quite uniform. They do not see that their schools are eminently well equipped in science or in mathematics education, but mainly happy with the amount of text books, computers and library materials. There seems to be some distinction between the partner countries in respect of resources:

Well –resourced: England, Northern Ireland, Scotland and Finland

Not particularly well-resourced: Greece, France, Romania and Wales

No item is emphasised in policy in the majority of partner countries. However, equipment for hands on experience, computers and ICT resources are the materials most strongly featured in partner policies for science in both preschool and early primary school. Interestingly about 80% of the teachers who responded to the survey use quite or very frequently equipment and materials for hands-on exploration in the classroom (e.g. magnets, building blocks, sorting activity games, rulers) despite the fact that only a little over 60% (for mathematics) and a little over 50% (for science) reported that their schools are fairly or well-equipped in these resources. The declared frequency of use of audio visual materials, relevant library materials, ICT science resources and student textbooks for science also exceeds significantly the reported availability of these resources in schools by their teachers. On the other hand, the availability of computers and other digital technologies (such as interactive whiteboards) appears to match and exceed respectively their use in schools.

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About the use of these resources, the findings from the teacher survey reveal that overwhelmingly teachers use materials prepared by themselves or downloaded from the internet for the teaching of science and mathematics. Finally, materials prepared collaboratively by teachers in the school are the least commonly used resource by teachers after digital technologies.

It is notable that there is very little emphasis on a budget or teaching or technical support for science. Emphases on instructional materials and audio-visual resources vary across partner countries. There is a greater emphasis on relevant library materials in preschool policy.

4.3.4 Grouping: With whom are children learning?

The grouping variables focused on the school size and classroom size. In addition, the ways of grouping in pedagogy has been also considered.

The social forms of studying at school are reflected in grouping. This is an aspect of practice where policy guidance is limited and teachers are free to make their own decisions about groupings for particular purposes. It seems that collaborative working in pairs or groups is most commonly highlighted, but generally there are a number of common themes in the guidance provided. Implicit links to creativity are identified; the use of group work in fostering 'a spirit of collaboration' or the role of individual work in encouraging autonomy and self-reliance

According to the teacher survey, class groups comprise of between 20-30 children and there were only a few larger or smaller exceptions to this classroom size in the partner countries. As indicated in policy documents, this makes the option of collaboration and group work possible in science; teachers also fostered collaborative approaches in their pedagogy.

4.3.5 Time: When are children learning?

The study examines the factor of 'time' with regards to the allocated amount indicated in policy documents, and the teachers' viewpoint on how much time they consider to be sufficient to teach science and mathematics effectively.

Only a few countries set requirements or provide national guidelines for the time allocated to science in the curriculum, and these relate only to primary education. The exceptions are in Romania where there is a requirement of 4 to 5 hours of combined mathematics and science teaching and in the England and Northern Ireland, where daily mathematics teaching is advocated. As in preschool, set requirements concerning the time allocated for science and mathematics are absent

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from all official documentation in the majority of countries. In Germany, Finland, France and Malta there are specific time allocations for science. As in preschool, in Romania, 4 to 5 hours of combined mathematics and science teaching are required and there are more specific recommendations in relation to the time to be spent on mathematics. Seven countries recommend a specific time allocation (Finland, France, Germany, Malta, UK (England and Wales)).

Teachers' responses about the amount of time dedicated to teaching science and mathematics per week point out that overall more time is spent teaching mathematics than science. Preschool teachers in the majority of partner countries reported to teaching 1 to 2 hours of science and mathematics per week. Only Finnish teachers have responded to teaching extra hours for both subjects each week (3 to 4 hours for science and more than 4 hours for mathematics). In primary schools, there is a more varied picture for science with teachers spending 1 to 2 hours teaching per week in France, Germany, Malta and England; 3 to 4 hours in Finland and Greece, while Portuguese primary teachers spend over 4 hours per week teaching science. In regard to mathematics teaching, teachers in all sample countries reported to dedicating more than 4 hours per week without any exceptions. Overall, Maltese teachers seem to spend the fewest hours per week in the teaching of science whereas Finnish teachers spend the most. Finnish and UK (English) teachers also spend the most hours per week for the teaching of mathematics, whereas Belgium (Flemish) teachers spend the fewest.

4.4 Comparisons of teacher education

In this section, we compare how far policy requirements and practice reflect each other with regards to initial teacher education, and how well the requirements of continuing professional development are fulfilled in practice. In addition, how well the standards and competencies for continuing teacher development, if any, are realised in practice.

Comparison of teacher education is conducted, based on teacher related contextual factors such as the level of general education and training, work experience, and confidence in science and mathematics knowledge and skills. In addition, as the surveys focused on the same themes, initial teacher education and continuing professional development factors are naturally included.

4.4.1 Initial teacher education

Training in most partner countries is at Bachelor or Masters level in accordance with EU frameworks - exceptions are Malta and Germany

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where training for preschool education is provided at Diploma level (confirmed through teachers' responses to the questionnaire, where 45.8% and 44.9% of the sampled teachers respectively do not have a Bachelor's or equivalent degree). However change in policy for both countries is pending. In Malta the intention is that by 2015 all teachers will have a degree. In Germany, policy varies according to the different federal states. In some states training at University level is beginning to be introduced although currently only 3% of kindergarten teachers have received academic training. On the other hand, a Master's degree is required from primary teachers in France, Portugal and Finland. In all the countries of the UK, those interested in working as teachers can either obtain a degree in education with Qualified Teacher Status, or a degree in any subject followed by a one year course of teacher training leading to either a Professional or Postgraduate Certificate in Education.

As to be expected, the vast majority of teachers who responded in the survey has obtained at least a Bachelor's (or equivalent) degree (88%) and 27% have obtained a higher than Bachelor's (or equivalent) degree in compliance to the official policy requirements. However, preschool and primary teachers differ significantly in their educational background. Whereas the proportion (about 61%) of teachers with Bachelor's (or equivalent) level of education is similar in the preschool and primary school samples, the proportion of teachers with education higher than Bachelor's (or equivalent) is much larger in the primary school teachers sample (32.0%) than in the preschool teachers sample (20.2%) (Figure 39).

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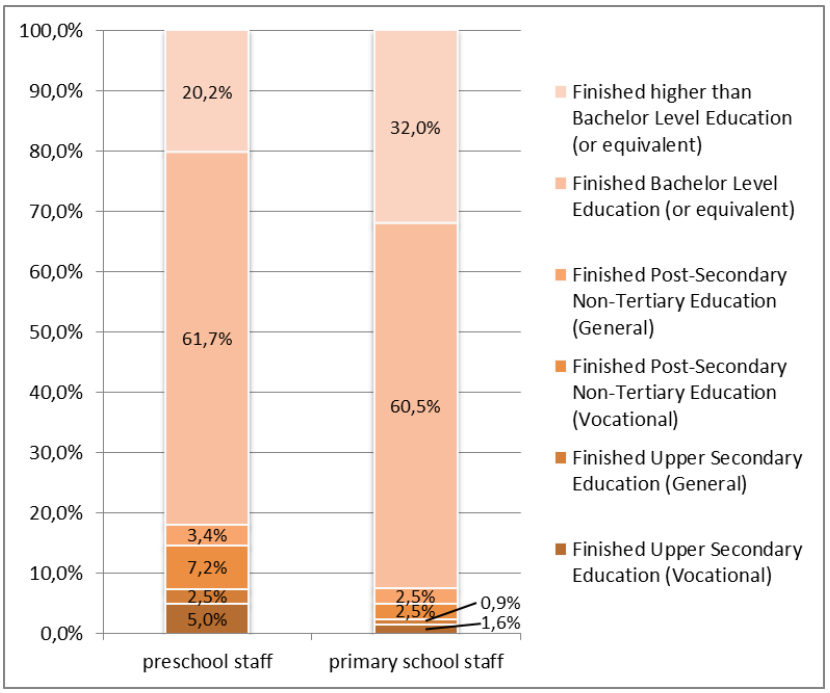

Figure 39. Teachers' professional qualification in the teacher survey

As indicated in the Conceptual Framework (D2.2), two models of training are commonly found that combine theory and practice in different ways – the concurrent model and the consecutive model. In the concurrent model theory and practice are combined across a teacher education. In the consecutive model students first attend a theoretical course followed by practical training once this is complete. Different models are used across partner countries as follows:

- *Concurrent* – Belgium, Finland, Greece, Malta, Romania, UK.
- *Consecutive* – France, Germany, Portugal.

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Key features of initial teacher education across all the partner countries are presented in Table 27 below.

Partner Country	Phase of education	Length of training	Degree	Institution(s)	Entry requirements
Belgium (Flanders)	Early childhood and primary	3 years	Bachelor	University colleges	Anyone who has a Diploma of secondary education
Belgium (Wallonia)	Pre- primary and primary	3 years	Bachelor 'section normale préscolaire' or 'section normal primaire'	Haute écoles	Upper secondary education certificate or equivalent, or Special exam for admission to engineering science or admission exam organised by a university. Some 'haute écoles' also arrange interviews to assess motivation and suitability.
Finland	Early childhood education	3 years	Bachelor	University	Matriculation examination and passed entrance examination (written test and interviews)
Finland	Primary education	5 years	Master	University	Matriculation examination and passed entrance examination (written test and interviews)
France	Early childhood education	5 years	Master	First three years university; last two years -''University Institutes of Teacher education'' IUFM (which will be gradually integrated into the universities).	Students must have the degree of 'Licence' obtained after the first 3 years of university study. After entrance to the IUFM is through examination.

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Partner Country	Phase of education	Length of training	Degree	Institution(s)	Entry requirements
France	Primary education	5 years	Master	First three years university; last two years -''University Institutes of Teacher education'' IUFM (which will be gradually integrated into the universities).	Students must have the degree of 'Licence' obtained after the first 3 years of university study. After entrance to the IUFM is through examination.
Germany Varies from State to State	Early Childhood education	Minimum 3 years up to 5 years	National diploma or Bachelor in Childhood Education	Specific Berufsschulen (vocational schools) includes 2 years internship in kindergarten. New in some federal states: University	Either lower secondary school level 1 or level 2 certificate plus vocational training. General upper secondary school certificate 'Abitur' for university studies. Seldom entry examinations or personal interviews.
Germany Varies from state to state	Primary education	Minimal 5 and a half years	State examination for accreditation as primary school teacher (or in some states Bachelor or master degrees e.g NRW) followed by practical training	Two consecutive phases 1st phase – University, degree: bachelor/master or 1st state examination 2nd phase -Teacher training colleges and schools 2nd State examination (needed by all primary teachers regardless of degree gained in 1st phase)	Final secondary school examination 'Abitur'. Often internship at a school (e.g. Hesse and North Rhine Westphalia (NRW)).
Greece	Early childhood and primary	4 years	Bachelor	State University	Pan-hellenic examinations following completion of primary education.

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Partner Country	Phase of education	Length of training	Degree	Institution(s)	Entry requirements
Malta	Early Childhood education 2 to 8 years	2 years full time 5 years part-time	BTEC - National diploma Bachelor	University of Malta	For MCAST-BTEC Diploma in Children's Care – Diploma in Health and Social Care or 4 Sec/O level passes including English language, Maltese and Mathematics. For MCAST-BTEC Higher National Diploma in Advanced Study in Early years Diploma in Children's care plus O level passes English Language, Maltese and Mathematics OR 2 A level and 2 1 level passes – including Mathematics, English and Maltese. For Bachelor degree in Early Years see requirements for primary below.
Malta	Primary education 5 to 11 years	5 years part -time	Bachelor	University of Malta	General entry requirements – Matriculation certificate and Secondary Education Certificate passes at Grade 5 or above in Maltese English Language and Mathematics. Special course requirements - one Advanced Level pass at grade C or better, 2 passes at intermediate level grade C or better, passes in proficiency tests in English and Maltese (or their equivalent). Certificate or logbook showing pass in all 7 European Computer Driving Licence modules. Interviews may also be used for selection for mature students.

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Partner Country	Phase of education	Length of training	Degree	Institution(s)	Entry requirements
Portugal	Early childhood and primary education	5 years 3 years – degree + 2 years - Masters	Master	University and Higher Education Schools	Pass in upper-secondary education course or legally equivalent qualification. Minimum mark of 95/200 in entrance exams for the course plus other pre-requisites for particular courses/institutions.
Romania	Pre-school and primary education (new regulations)	3 years	Bachelor	University	Baccalaureate (higher school examination) degree. Different criteria established by each institution concerning marks obtained in Baccalaureate examinations or a subject test (e.g. Psychology, linguistic competence in foreign language, physical education). Interviews to assess communication skills and motivation.

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Partner Country	Phase of education	Length of training	Degree	Institution(s)	Entry requirements
UK (England and Wales)	Early childhood and primary education	3 or 4 years	Bachelor or Master All teachers must have a degree and Qualified Teacher Status (QTS) gained through Bachelor degree in education with QTS or Bachelor degree (3 years) followed by either Professional Graduate Certificate in Education (PGCE) (Bachelor level – 1 year) or Postgraduate Certificate in Education (Master level credits) or school-based training.	University – in varied partnerships with schools Routes for school-based training are being expanded where following their degree they gain QTS through a programme of experience in school. Assessment of QTS is usually carried out in conjunction with a Higher Education Institution.	For all programmes Grade C or equivalent in English, mathematics and Science. Entrants after 1 August 2013 will also need to have passed QTS professional skills tests in literacy and numeracy. In addition – rigorous selection processes to assess suitability to teach, Criminal records check and fitness to teach test. For undergraduate programmes at least 2 passes at A level (but varies according to institution) For graduate programmes first degree of UK higher education institution or equivalent qualification.
UK (Northern Ireland)	Pre-school and primary education	4 years	Bachelor 4 years BEd degree or 3 years degree followed by 1 year Postgraduate Certificate in Education (PGCE)	University	Minimum of 2 A levels plus 3 GCSEs for BEd courses Undergraduate degree for PGCE

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Partner Country	Phase of education	Length of training	Degree	Institution(s)	Entry requirements
UK (Scotland)	Nursery (3-5) and primary education (5-12)	4 years or 1 year	The four year Bachelor of Education (BEd) degree course in Primary Education or the one-year Professional Graduate Diploma in Education (PGDE) course.	University – in varied partnerships with schools	For BEd - 3 Higher grades, one must be English pass at grade C or above and Standard Grade Mathematics at Level 1 or 2 For PGDE – Degree from UK university or the equivalent, Higher grade English at C or above, Standard grade mathematics at Level 1 or 2 (Entry is competitive for both routes so Universities often ask for higher grades e.g. BBBB).

Table 27. Teacher Education programmes in partner countries – key features

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In some partner countries, national requirements or guidelines are provided for the competencies to be achieved, to be interpreted and implemented by the different providers for example in Belgium, France, Germany, Portugal, Romania, UK (England, Wales, Scotland). In others, there are no national regulations for example in Finland, Greece, Malta (preschool). However, the main emphasis is on general pedagogical knowledge and skills and pedagogical content knowledge. According to teachers' responses to the relevant questionnaire items, the aspect most teachers feel very confident about is their general pedagogic knowledge. Over a fifth of them also feels very confident in their mathematics and science teaching and assessment, and their knowledge of mathematics and science pedagogy. It should however be noted that more teachers feel confident in their mathematics teaching, assessment and pedagogic knowledge, than in their science teaching, assessment and pedagogic knowledge.

Although pedagogical, psychological content areas, including creative teaching approaches, are emphasized in initial teacher education, science and mathematics are also included in ITE. However, 20 % of the teachers stated that they had last been taught science and mathematics in upper secondary education and only 40% had studied science or mathematics during their undergraduate studies; this implies that science and mathematics are not always provided or they may not be compulsory.

4.4.2 Continuing professional development (CPD)

Requirements for CPD vary across the partner countries and possibilities for in-service training are limited. In addition, although there are no common official standards for continuing teacher development, national opportunities for teachers to develop their competencies are provided.

The need for provision of appropriate training to support continued development and support new initiatives and practices in science and mathematics associated with inquiry and creativity is a theme that emerged across a number of country reports.

- Entitlement and requirements in relation to CPD vary across partner countries. In a number of countries opportunities and support for teachers to participate in CPD is limited.
- In some countries teachers are entitled to certain number of days CPD per year for example Belgium (Wallonia) (6 half days), Finland (3 days per year) and in Malta (set number of half days for professional or school development).

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- In some cases teachers are required to undertake training for example (Romania every 5 years, Malta every 2 years)
- In other countries CPD is voluntary, depends on personal initiative and takes place at weekends, evenings for example France, Germany.

In some countries, CPD is accredited; for example Romania (accredited by Ministry of Education), UK (England) (some CPD is accredited by association with Universities). In some federal states in Germany professional development courses have to be accredited by the federal 'Institute for quality development'. Regulations vary from state to state and there is no such institute at a national level.

In most countries there are no official standards for in-service teachers apart from those needed to gain teacher status. However there are varied ways in which teachers may extend their knowledge and skills, gain further qualifications and recognition of their developing knowledge and competences.

The teacher survey included a question about professional development activities teachers participated during the previous 18 months and their impact. A total of 16 CPD activities were included covering both individual and group, as well as formal and informal activities, which teachers may have had the opportunity to participate and could have had an impact on their teaching of science and mathematics. Responses to this particular question revealed that preschool and primary teachers predominantly engage in informal dialogue with colleagues on how to improve their science and mathematics across all partner countries does. The individual informal activity of reading professional literature on science and mathematics is the second most common activity for 65.8% and 59.8% of the teachers respectively, and finally attending courses and workshops on science and mathematics subject matter and methods the third and last most common activity for the majority of respondents. Fewer than half of the sampled teachers (but over 40%) have recently participated in formal school-based CPD opportunities involving peer teaching observations and mentoring or coaching of science and/or mathematics teaching, and in science education research conferences or seminars. Finally, only about a third of them have participated in teacher networks formed specifically to promote the professional development of teachers in science and mathematics.

The CPD activities that appear to have had larger impact on teachers' practices are not necessarily the ones attended by most teachers, with the exception of the professional development practice of engaging in

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informal dialogue with colleagues, which is both highly used and considered most effective. Interestingly, overall the majority of teachers report a moderate or high impact for all CPD activities, with over 70% acknowledging a moderate or high impact for 9 out of the 16 activities, including CPD courses and workshops on science/mathematics knowledge and methods, and school-based CPD activities. It is worth noting that participation in individual or collaborative research projects on science or mathematics topics of interest has had a moderate or high impact on teaching practice according to a large majority (about 70%) of teachers, but has been offered to and taken up as a professional development activity by fewer than half of the total sample (about 45%). Finally, participation in networks of teachers formed specifically for the professional development of teachers in science and mathematics is considered a less effective means of professional development, in line with the low proportion of teachers who state to have done so.

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5 Conclusions

5.1 Rationale and Vision

The overall picture formed by the policy review and teacher survey in regard to the rationale or vision for science learning in the early years and compulsory education shows that even though policy in the partner countries tends to focus its guidance on specific drivers for science education, teachers do not clearly focus on one specific rationale, but rather follow a more holistic approach considering all priorities as important.

Commentary included by partners in their National Reports provides information on the main foci for the rationale and vision presented in their policy documents. In almost all the partner countries, the purposes of education are focused on enhancing children's lives now and in the future as well as their roles as citizens, with particular emphasis on environmental awareness. The development of skills and dispositions for future learning takes on a more prominent role in Belgium, Germany, Malta and Romania, while attention to the economic benefits of developing children's basic skills and dispositions is given in France, but also in Flanders. In terms of reported practice as revealed through the teacher survey, only one purpose of compulsory science education is singled out by teachers as less important than the others, to produce future scientists and engineers, although this is still given greater emphasis than in preschool and primary policy documents. This particular rationale has the largest variance in policy evidencing the diverse focus on the economic driver of education in early years education settings across the partner countries, in response to the view that today's knowledge economy dictates an imperative for countries to have scientists capable of competing globally (European Commission, 2006).

The rationale, according to van der Akker (2007) is placed in the middle of the spider web and is referring to the central mission of the curriculum. The rationale is the major orientation point and the nine other components should be linked to the rationale, as well as being consistent with each other. It is thus important for this particular dimension of the curriculum to be aligned for policy and teaching practice in order to provide a steady basis for the rest of the dimensions.

5.2 Aims and Objectives

Comparisons between the policy review and teacher survey reveal an interesting imbalance in the framing of learning outcomes linked to science in preschool and early primary education across the partner

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countries. The learning aims and objectives of the science curriculum in partner countries tend to focus on cognitive factors of science learning and particularly on the development of process skills associated with scientific inquiry and of knowledge and understanding of science ideas (the latter particularly in primary school). Such learning outcomes take on a dominant place in the curricula of Finland, France, Greece, Portugal, Romania and England. The findings from the teacher survey on the other hand suggest that teachers perceive the teaching of science overall as contributing primarily towards affective and social aspects of teaching and learning. Teachers view their role in the early years as mainly one that places at the forefront fostering positive attitudes and dispositions for science and lifelong learning and the development of children as socially and environmentally aware and responsible citizens.

Learning outcomes connected to the cognitive dimensions of science learning, even though used quite often by teachers, are featured less strongly in teachers' responses in comparison to outcomes linked to the social and affective dimensions. In contrast to responses to the teacher survey, the review of policy across partner countries showed that social and affective dimensions of learning are given more limited attention compared to cognitive dimensions. More particularly, the majority of policy documentation inspected lacked emphasis on promoting positive attitudes to learning and interest in science among the intended learning aims of early years science education. Exceptions to this are the Flemish community in Belgium, Germany and Malta where raising interest in science is seen as one of the main learning outcomes of early years science education. The vast majority of teachers on the other hand reported including such learning outcomes very frequently in their teaching.

In the teacher survey of practice, learning outcomes linked to the social aspects of teaching and learning were reported by teachers as very frequently included in their planning for learning and teaching. Here the comparison between findings of the teacher survey and policy review reveal a significant correspondence in the strong emphasis placed in both on including learning outcomes connected to fostering children's abilities to collaborate with others in science learning.

Learning outcomes related to how science works and scientists develop knowledge are under-emphasised in both policy and reported practice. As indicated in The Report on Mapping and Comparing Recorded Practices (D3.2) policy documents across the consortium make limited reference to knowledge and understanding of the nature of science. Items in the

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policy survey related to knowledge and understandings associated with the nature of science are not strongly emphasised in policy documents in either phase of education. Similarly, learning outcomes related to the nature of science and thus understandings about scientific inquiry (that is about how scientists develop knowledge and understanding of the surrounding world) are the least frequently pursued by teachers overall in comparison to other aims and objectives.

5.3 Learning Activities

The comparison of the two separate reviews, one for policy and one for reported practice, reveals interesting findings on the significance that features of inquiry-based science education play in terms of conceptions of learning activities in early years science education. Overall the surveys of policy and teachers' views found that features of inquiry were both promoted in curricular policies among suggested learning activities, as well as frequently included by teachers in the preschool and early primary science classroom. In particular, learning activities associated with observation, questioning, communication and the use of simple tools took a dominant place among inquiry related activities.

On the other hand the survey results indicated that inquiry skills associated with planning and conducting investigations and using data to construct explanations, that are linked to the development and use of scientific concepts and procedural knowledge, were given a less prominent place in the learning activities carried out in the classroom and in curriculum guidance. In particular, learning activities that involve children planning and designing their investigations are the least common of all the learning activities tied to scientific inquiry, despite the fact that they are thought of by many teachers as amongst the three most likely to contribute to children's creativity. The low frequency of use of these activities is consistent with the findings about teachers' inquiry-related science learning priorities. Even though no major differences were found between countries in terms of teachers' use of learning activities that promote children's observational and questioning skills, the same cannot be said for activities that involve children designing (or planning) and conducting simple investigations or projects. Finnish and Maltese teachers occupy the lower end of the spectrum in the use of these activities, while English teachers the upper end. The responses of Greek and German teachers suggest they involve children more in the conduct of investigations but less in their planning.

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5.4 Pedagogy

Bringing together the results discussed in the Report on First Survey of School Practice (D3.3) and the Report on Mapping and Comparing Recorded Practices (D3.2) about policy and teachers' conceptualisations of the various learning contexts and approaches linked to pedagogy it can be concluded that teachers overall appreciate the role of dialogue and collaboration in their practice, but fail to see their potential for development of creativity in children. This is consistent with policy in partner countries which puts some emphasis on the importance of dialogue and collaboration but includes very limited reference to features of creativity that might be fostered through dialogue and collaboration and very limited guidance to support teachers in enabling creativity using classroom discussions and collaborative work.

There is an uneven treatment in both policy and reported practice of the contexts and approaches grouped under the synergy motivation and affect. The contexts of 'drama' and 'using history to teach science' are used the least frequently and are least considered as 'creativity enabling' by teachers while curricula also fail to promote these approaches or make reference to the potential for creativity of these two learning contexts. The approaches of 'building on children's prior experiences' and 'relating science to everyday life' on the other hand are amongst those reported as most frequently used by teachers and referenced in policy, though still not highlighted as similarly 'creativity enabling' by both teachers and policy guidance. Finally, the teacher survey indicated that the cross-disciplinary teaching of science ('integrating science with other curricular areas') is a context used frequently by both preschool and early primary school teachers, but not considered equally as 'creativity enabling' by them. Many more early primary than preschool teachers consider this context as 'creativity enabling'. Integrating science with other curricular areas in official policy is very similarly framed. It is more strongly emphasised in the preschool phase and only a few countries include commentary that suggests its potential to enable the development of children's creativity (for example preschool policy in Finland, Germany and Greece or primary policy in Finland).

There is also an uneven treatment of the contexts and approaches grouped under the synergy play and exploration. Preschool teachers use 'open/unstructured play' and 'role/pretend play' significantly more than early primary school teachers, and a greater proportion of preschool teachers also conceptualise these as 'creativity enabling'. This is also reflected in curricula across the partner countries. Policy in the majority of partner countries promotes playful exploration in preschool

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considerably more than in primary education, with guidance that suggests a recognition of its value in promoting creative skills and dispositions. On the other hand teachers who responded to the survey from both preschool and primary phases were in agreement in reporting frequent use of physical exploration of materials and identifying its 'creative' This agreement across phases is however not reflected in policy guidance. Even if curricula and policy guidance across the partner countries advocate children's physical exploration of materials in both phases, references to the opportunities this can provide for fostering creative skills and dispositions differs between the two phases. Here too there is more limited reference to the creative potential of this learning approach in primary policy in comparison to official guidance offered for the preschool phase of education.

In terms of the synergy problem solving and agency, official policy across partner countries emphasises almost all relevant approaches and contexts identified by the project across both phases of early years education. In the majority of partner countries, this emphasis on problem solving in policy is often also linked to suggestions about its potential to foster children's creativity, particularly in preschool. According to responses to the teacher survey, teachers use problem solving approaches quite or very frequently. A large majority of teachers across both phases of early years education considered almost all problem solving and agency contexts and approaches to be amongst the most 'creativity enabling' approaches to learning and teaching.

Concerning the learning approaches associated with questioning and curiosity, these are either given various mentions or emphasised in preschool policy in the majority of partner countries. However in contrast to preschool, more limited emphasis is given to questioning in the primary age phase. In terms of teachers' reported practices, there is correspondence between teachers' use of practices that encourage children to ask questions and foster their imagination and teachers' perceptions of these practices as 'creativity enabling'. However, the same cannot be said for the use of questioning by teachers and their encouragement of different ways of recording and expressing ideas. Although results from the teacher survey indicated that both practices are used quite or very often by the large majority of teachers, they are not considered amongst the three most 'creativity enabling' by many of them. These findings are also reflected in policy guidance across partner countries. There is a common emphasis on children's questioning and curiosity and suggestion of their importance in fostering creativity. However the roles of teacher questioning and the value of varied

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approaches to recording in supporting creative learning are given more limited recognition. Given the importance of modelling and fostering by teachers of positive attitudes of curiosity and questioning, these differences in recognition, reflected in both the teacher and policy surveys, rather point to an important gap that needs to be bridged by teacher education.

5.5 Assessment

Assessment, especially formative assessment, was widely highlighted as a particular area for development in both policy and practice in both preschool and primary phases. A common theme to emerge across the two research surveys was lack of policy guidance in terms of both methods of assessment and criteria for assessing on-going progress, resulting in considerable variability in approaches adopted among partner countries. The findings from the policy and teacher surveys also reveal particular challenges in assessment related to inquiry and creativity, linked to a common tendency to focus on product rather than process in assessment requirements, allied with the pressures of statutory summative assessment processes in a number of partner countries.

The policy review highlights the need for a closer match between the aims and rationale for science education and assessment priorities and approaches. For example while assessment of science ideas is widely emphasised in policy, more limited attention is given to assessment of inquiry processes and procedural understanding and even less to social and affective dimensions of learning, although these dimensions are often highlighted in the rationale and aims set out for early science and mathematics education. For example, while assessment of affective dimensions of learning (such as interest in science) is prioritised in curriculum policy in the Flemish community in Belgium (for both phases) and in Finland (for the primary age phase), guidance to promote assessment of affective dimensions of learning is absent from the curriculum policy in the majority of partner countries. In contrast, teachers who responded to the survey overwhelmingly gave greatest priority to the assessment of affective dimensions of learning, judging them to be more important than cognitive dimensions, such as acquiring knowledge and understanding of science ideas and processes. Interestingly, the cognitive dimensions rated most highly among teachers were children's understanding of important science processes and inquiry competences, highlighted as given little emphasis in the survey of policy. Teachers' responses to the survey regarding their priorities for science assessment were consistent with the frequency with which they say they

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pursue the corresponding aims and objectives in their science teaching. This is in contrast with the mismatch identified between rationale, aims and assessment priorities in official policy across partner countries.

While the importance of formative assessment is increasingly recognised in policy, the Report on Mapping and Comparing Recorded Practices (D3.2) indicates that further guidance would be valuable to support classroom practices in assessment. Areas highlighted in particular include: the use of multimodal forms of assessment to give young children opportunities to show best what they understand and can do; ways of involving children in peer and self-assessment to support children's reflection on inquiry processes and outcomes; and criteria to assess progression in learning, particularly in relation to inquiry and the development of dispositions associated with creativity. For example, guidance in official documentation regarding the value of children's multimodal expression for assessment purposes was identified in Romanian policy and some consideration of this particular dimension of assessment is provided in Finnish preschool policy. In the majority of partner countries however, there is very limited or no mention of the value of drawing on a variety of evidence such as pictures, graphs and relevant gestures for assessment purposes. Again here a contrast was noted between findings from the policy and teacher surveys as the teachers' responses to the relevant survey items showed that teachers' approaches to assessment tend to include evaluation of children's responses in varied modes, particularly in Greece and Romania. The same cannot be said concerning teachers' employment of peer and self-assessment practices, as only about half the teachers surveyed reported that they use the formative approaches of peer or self-assessment quite or very frequently. Only in English preschools teachers reported to taking account of children's multimodal expressions for assessment purposes. The alignment in findings from both policy and teacher surveys concerning the limited role of peer and self-assessment suggests that the locus of the judgment in assessment in early years education is firmly in the hands of teachers with limited involvement of children.

In terms of the creative attributes that were identified in partner policy, thinking skills feature most strongly, especially in the early primary age phase. The other creative attributes most commonly emphasised or mentioned include curiosity (greater emphasis in preschool), ability to work together (greater emphasis in primary) and ability to make connections with learning in other subjects. The teacher survey showed that a large majority of the sample of all teachers across the partner countries reported praising and rewarding creative dispositions in their

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pupils in science quite or very frequently. The dispositions most frequently rewarded were children's ability to work together, their curiosity and imagination. Some differences were noted in response across partner countries. French teachers systematically praised all eight creative dispositions less frequently presented to them, as part of their science assessment. On the other hand, Romanian teachers, joined in most cases also by Greek and/or Maltese teachers reward most of these creative dispositions significantly more frequently than others.

5.6 Content

The findings from both the policy and teacher surveys suggest a number of differences in the presentation and nature of curriculum content for science and mathematics across partner countries.

In preschool, science is generally included within broader areas of learning such as 'Discovery of the World' (France) or 'Child and the environment' (Greece) or 'Knowledge and Understanding of the World' (UK (Wales)) with the majority of official guidance advocating integrated cross-curricular approaches to learning and teaching. In addition, overall there is limited specification of subject specific content for science in this phase of education. The emphasis is rather on the development of basic skills and positive attitudes in the context of content selected to build on children's prior experiences and interests. This is the case for the Flemish community in Belgium, France, Finland, Germany, Malta and England. In early primary school, many national curricula such as of the Flemish community in Belgium, Finland, Germany, Greece, Northern Ireland and Wales continue to specify science within broader areas of learning. In Wallonia, France, Malta and Romania on the other hand, science is presented as a separate area of learning. In both cases, the emphasis is placed on developing specific scientific concepts associated with learning objectives for the primary age phase.

Large variation was also observed in the sections of the curriculum that present the teaching methodology to promote the specific skills and processes associated with inquiry. In some countries there are separate sections devoted to inquiry (for example UK (England) 'Scientific Enquiry' or Belgium (Flanders) 'General skills in science') or requirements may be integrated within subject content for example in Portugal 'Conducting experiments with Light' as part of the area of learning 'Discovering objects and materials'. A further approach to the inclusion of skills and processes within requirements for curriculum content is that of specifying skills and processes within cross-curricular themes and competencies

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(Belgium (Wallonia) or UK (Northern Ireland)) to be developed across all areas of learning.

While skills and processes related to inquiry feature strongly at both phases, in general a more specific focus on the development of concepts and on a broader range of investigative skills and processes is evident in primary curriculum content.

A greater role for creativity was generally identified as implicit in policy, indicated for example in the common presentation of the curriculum in terms of experiences, the importance given to play and exploration, building on children's interests, and the greater attention to affective and social factors within curriculum content.

However, primary school curricula across the partner countries rarely offer explicit guidance on the development of social and affective dimensions. Affective dimensions of teaching and learning are given far greater attention in preschool education. Examples include references to 'aesthetic sensitivity and imagination' (Portugal) and 'motivation to learn' (Romania). Social factors are little mentioned within the content specified for particular areas of learning but often feature within generic curriculum requirements or guidance.

The policy survey indicate limited explicit references to creativity related to curriculum content. Explicit references include for example 'develop pupils' curiosity, creativity and critical thought' (France), 'develop creative approaches to problems' (Germany), 'stimulate creative potential', 'develop creativity' (Romania)or in UK (Northern Ireland) 'learning experiences that encourage creativity'. A greater role for creativity was generally identified as implicit in policy, indicated for example in the common presentation of the preschool curriculum in terms of experiences, the importance given to play and exploration, building on children's interests, and the greater attention to affective and social factors within curriculum content.

In comparison to science, mathematics is more commonly set out as a distinct area of learning in partner policy at both phases of education. As in science, mathematical content specified in the curriculum includes both concepts and processes with increasing focus on concepts and higher order thinking skills across the primary school. Mathematical content of the curriculum receives greater attention in preschool in comparison to science, and in mathematics reference is often made to problem solving rather than inquiry or investigation. In general there is a similar focus on affective and social factors. Mathematics in some countries is also treated as a cross-curricular dimension (UK Wales). In Romania, the application

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of mathematics to general science knowledge is emphasised. This is not the case in science although generic inquiry or thinking skills for example may feature in cross-curricular dimensions.

5.7 Location

The teacher survey indicated that collaboration amongst peers and working in small groups are approaches employed by the majority of teachers, as recommended in policy across partner countries and phases of education. With regards to the use of outdoor learning environments there is also consistency between policy and teacher surveys. Outdoor learning is mentioned in most countries' policy guidance - more strongly for preschool. Similarly, teachers in the majority of partner countries reported making use of teaching and learning opportunities linked to outdoor environments, with the exception of primary school teachers in the Flemish community in Belgium and Portugal. On the other hand, non-formal learning environments such as visits in places of interest were given limited attention in most partner countries' policy and also reported to be used rarely by most teachers across the consortium. Countries where such opportunities were particularly highlighted in policy include France, Germany and Greece.

5.8 Materials and resources

As indicated in the Conceptual Framework (D2.2) provision of a wide range of materials in the classroom, including digital technologies, can be motivating and offer different ways for young children to represent ideas and express their thinking. Research in science, mathematics and creativity also highlights the importance of a rich physical environment and the use of the outdoor environment in promoting opportunities for exploration in the early years. The materials used in the science and mathematics classroom are therefore closely linked with the 'curriculum components' 'Learning Activities' and 'Pedagogy' and could equally be seen as a feature of 'Teaching, Learning and Assessment' approaches, as well one of the 'Contextual Factors' important in fostering creativity in early science and mathematics education. In this chapter, findings regarding materials and resources were included in the latter strand, since they do not study their role and importance in lessons, but instead only cover the frequency of use.

The National Reports on policy indicate that limited guidance is offered about materials in the national policy of many partner countries. In the instances where guidance is provided, equipment associated with inquiry, such as materials to explore or equipment for measuring are most often

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mentioned, as well as digital technologies (for example Belgium (Wallonia), Finland, Germany, Greece, Romania). Teachers' responses regarding the materials used most frequently in the classroom are consistent with the guidance offered in curricula. Interestingly the vast majority of respondents use quite or very frequently equipment and materials for hands-on exploration in the classroom, such as magnets, building blocks, sorting activity games and rulers, despite the fact that only a little over 60% (for mathematics) and a little over 50% (for science) reported that their schools are fairly or well equipped in these resources. Official policy also provides information about a range of resources provided for teachers, such as textbooks (Finland and Greece) and assessment tools online (France). The declared frequency of use of audio-visual materials, relevant library materials, ICT science resources and student textbooks for science also exceeds significantly the reported availability of these resources in schools by their teachers. On the other hand, the availability of computers and other digital technologies (such as interactive whiteboards) appears to match and exceed respectively their use in schools. Teachers who responded to the teacher survey overwhelmingly use materials prepared by themselves or downloaded from the internet for the teaching of science and mathematics.

In preschool, materials for exploration outside the classroom and in primary school computer resources are also given some emphasis in policy. It is notable however that there is very little emphasis on a budget for teaching or technical support for science. Comparing the science and mathematics resources of preschool and primary schools, according to the teacher survey we found that preschool teachers use more frequently relevant library materials and resources for hands-on exploration in the classroom however they use student textbooks, digital technologies and ICT resources significantly less than primary teachers. These findings are consistent with the resources provided to teachers, as preschools are overall better resourced than primary schools in relevant library materials and primary schools are overall better resourced than preschools in relation to computers and technical support personnel for both science and mathematics education.

5.9 Grouping

The surveys of policy and teaching practice indicate that grouping is an aspect of practice where advice in policy is limited and teachers are able to make their own decisions about groupings for particular purposes. There are a number of common themes in the policy guidance provided. In some countries a variety of approaches is advocated in policy,

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appropriate for particular tasks or learning needs (for example in Finland or UK (Scotland)). The benefits of collaborative working in pairs or groups are most commonly highlighted (for example in France, Germany, Greece, Portugal and Romania). References are also made in policy guidance to opportunities for individual work (Finland, Germany, UK (Wales)) and whole class teaching (UK (England and Scotland)).

According to the teacher survey, class groups comprise of between 20-30 children and there were only a few exceptions to this (either smaller or larger classroom sizes) in the partner countries. As indicated in policy documents, this makes the option of collaboration and group work possible in science and mathematics. Teachers in the survey also indicated they fostered collaborative approaches in their pedagogy. Working in small groups is an approach used quite or very frequently by the large majority of all sampled teachers, most frequently used in England and Romania and least frequently in Finland. A further issue explored was whether children are allocated to age or ability groups for learning. Just over half of the teachers in the total sample report to using assessment (quite or very often) to group children for science instruction purposes. This practice is embraced most frequently by Romanian teachers and least frequently by German teachers.

5.10 Time

In all but two of the partner countries there are no specific time requirements for either science or mathematics in preschool policy. The exceptions are in Romania where there is a requirement of 4 to 5 hours of combined mathematics and science teaching and in the England and Northern Ireland, where daily mathematics teaching is advocated. As in preschool, set requirements concerning the time allocated for science and mathematics are absent from all official documentation in the majority of countries. In Germany, Finland, France and Malta there are specific time allocations for science. As in preschool, in Romania, 4 to 5 hours of combined mathematics and science teaching are required and there are more specific recommendations in relation to the time to be spent on mathematics. Seven countries recommend a specific time allocation (Finland, France, Germany, Malta, UK (England and Wales)).

Teachers' responses about the amount of time dedicated to teaching science and mathematics per week point out that overall more time is spent teaching mathematics than science. Preschool teachers in the majority of partner countries reported to teaching 1 to 2 hours of science and mathematics per week. Only Finnish teachers have responded to teaching extra hours for both subjects each week (3 to 4 hours for

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science and more than 4 hours for mathematics). In primary schools, there is a more varied picture for science with teachers spending 1 to 2 hours teaching per week in France, Germany, Malta and England; 3 to 4 hours in Finland and Greece, while Portuguese primary teachers spend over 4 hours per week teaching science. In regard to mathematics teaching, teachers in all sample countries reported to dedicating more than 4 hours per week without any exceptions. Overall, Maltese teachers seem to spend the fewest hours per week in the teaching of science whereas Finnish teachers spend the most. Finnish and UK (English) teachers also spend the most hours per week for the teaching of mathematics, whereas Belgium (Flemish) teachers spend the fewest.

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6 Implications

6.1 Implications for policy development

As suggested in the introduction to the policy report (D3.2), policy needs to be developed and implemented within the particular local context of its application. As a result, implications and priorities for policy, building on this mapping and comparison of recorded practices, will vary across partner countries. However themes and issues discussed in this report offer some general areas for consideration in policy to enhance opportunities for inquiry and creativity in early years science and mathematics. These are outlined below.

6.1.1 Aims and content of the curriculum

The findings from this review of policy suggest that the aims and content of curricula for early years science and mathematics could pay more explicit attention to social and affective dimensions of learning, both also inextricably connected with cognitive dimensions. Greater recognition could also be given to young children's capabilities to engage with processes associated with the evaluation as well as generation of ideas in science and mathematics, and with understandings related to the nature of science.

6.1.2 Approaches to learning and teaching

Policy implications for learning and teaching approaches in early science and mathematics are interlinked with recommendations concerning the aims and content of curricula. Approaches to learning and teaching involving play, practical exploration and investigation feature strongly in policy across most partner countries. However, reflecting the need for attention to affective dimensions in the aims and content of curricula, policy guidance and exemplification could pay greater attention to the provision of varied contexts for science learning shown to promote children's motivation, interest and enjoyment in science and mathematics, such as drama, stories, history projects, field trips and children's everyday experiences.

The Report on Mapping and Comparing Recorded Practices (D3.2) also suggests that in seeking to foster opportunities for inquiry and a role for creativity, greater recognition could be given in policy to the roles of imagination, reflection and consideration of alternative ideas in supporting children's understanding of scientific ideas and procedures. Consideration of alternative ideas is also connected to social factors in learning and the provision of opportunities for development of

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understandings associated with the nature of science. As highlighted above, both these important dimensions of learning deserve greater attention.

6.1.3 Assessment

This report indicates a number of common issues for consideration in the development of policy requirements and guidance in relation to assessment.

It highlights the need for a closer match between the aims and rationale for science education and assessment priorities and approaches. For example while assessment of science ideas is widely prioritised in policy, more limited attention is given to assessment of inquiry processes and even less to social and affective dimensions of learning, although these dimensions are often highlighted in the rationale and aims set out for early science and mathematics education.

While the importance of formative assessment is increasingly recognised in policy, the National Reports indicate that further guidance would be valuable to support classroom practices in assessment. Areas highlighted in particular include: examples of multimodal forms of assessment to give young children opportunities to show best what they understand and can do; ways of involving children in peer and self-assessment to support children's reflection on inquiry processes and outcomes and criteria to assess progression in learning, particularly in relation to inquiry and the development of dispositions associated with creativity.

6.1.4 Role of creativity

Findings from this report suggest that a more explicit and detailed focus in policy on the role of creativity in early science and mathematics would be helpful. Where explicit references are made to creativity in policy they are often in very general terms without provision of guidance about what this might mean in the context of early science and mathematics. The review of policy across partner countries identified implicit connections to creativity in policy for early years science and mathematics, but these need to be drawn out and exemplified to support teachers in translating policy priorities concerning creativity into specific classroom practices. Furthermore, while certain teaching approaches are often signaled as associated with creativity, such as problem solving and the use of digital technologies, there is often limited indication of how such approaches might be used to foster creativity or inquiry in early science and mathematics.

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6.2 Implications for Teacher Professional Development

Commentary in the National Reports underlines a number of implications for policy in relation to teacher education. The reports highlight for example, the importance of the Inclusion of science in programmes of initial teacher education, including inquiry based learning and the role of creativity in early years mathematics and science. The need for teachers' entitlement and opportunity for continuing professional development is emphasised to support new initiatives and approaches related to inquiry based and creative approaches to teaching.

The potential contribution of school based research and inquiry to teacher professional development is highlighted in a number of National Reports. They suggest the need to develop strategies and tools to support self-evaluation by schools and teachers and collaborative approaches to professional development within and between schools.

6.2.1 Aims and priorities for science education

The findings from this survey suggest that teachers perceive the teaching of science overall as contributing towards the development of children as socially and environmentally aware and responsible lifelong learning citizens, and see their role in the early years as mainly one of developing children's attitudes and dispositions for this. Learning outcomes related to science ideas and processes, but also to how science works and scientists develop knowledge are under-pursued. This could be due to teachers not recognising the latter outcomes as relevant to their overall rationale, which could further be linked to the fact that a significant number of them have had only an overview of, or introduction to science as part of their post-compulsory and initial teacher education.

6.2.2 Teaching, learning and assessment approaches

Concerning the use of inquiry-based science activities in the early years and early primary classroom, the findings suggest that this appears to be limited to observation, fostering children's questioning and eliciting their curiosity in natural phenomena. Teachers, who acknowledge their lack of confidence in both their knowledge/understanding of science and their competencies to carry out scientific inquiry, appear to avoid instigating and involving children in the design and conduct of investigations, even though they strongly consider these activities as contributing to the development of children's creativity.

This lack of confidence could be one of the reasons for which teachers also value more a 'guided' approach in respect to most inquiry activities, even though they see their role as facilitators of children's own inquiry,

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delaying instruction until the learner has had a chance to investigate on their own or with others.

Teachers' strong belief in the value of collaborative work for children was a recurring finding of the analysis of the various questions in the survey. Teachers' responses indicate that the practice of children working together is one they commonly use very often and guides the learning activities, pedagogy and assessment. Their commitment to social learning outcomes is also manifested in their more 'open' inquiry approach to children communicating their inquiry results, where teachers tend to allow children to choose freely and independently how to justify their explanations. Having said this, teachers need help to recognise better young children's capabilities to engage with processes associated with the evaluation as well as generation of ideas in science and mathematics.

Outdoor learning activities seem to be much more characteristic of preschool education than of primary education. Teachers could benefit from professional development opportunities which demonstrate the potential of these activities both for the teaching of science/mathematics and the development of children's creativity.

Teachers' knowledge about creative approaches appears to be stereotypical and not much refined, at least in relation to science pedagogical approaches and contexts. Whereas they easily identify creativity development with problem solving activities, children asking questions, imagination and the physical exploration of materials, they fail to do the same for most of the other synergies between IBSE and creative approaches identified in the project's Conceptual Framework based on the literature research. A striking example of this, is that teachers fail to appreciate the creativity potential of questioning as a teaching tool. Given how important it is that teachers model and foster positive attitudes toward curiosity and questioning, this points to an important gap that needs to be bridged by teacher education.

Teachers value science and mathematics assessment for formative purposes for the 3-8 age group of children studied by Creative Little Scientists, however they appear to be less experienced in the use of self- and peer- assessment, where the locus of the assessment judgment is on children, as well as in involving children in the identification of their own learning targets. Moreover, the potential contribution of the various modes of children's work (e.g. pictures, graphs, gestures, physical activities) for assessment purposes is not fully exploited by teachers, who would benefit from relevant training.

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6.2.3 Contextual factors

Science and inquiry-related competences are given less important in the early primary curriculum than mathematics.

Early years and primary classroom would benefit from the existence of support teaching personnel who can attend to the individual children needs and facilitate science and mathematics inquiry.

Schools appear under-resourced in equipment and materials for hands-on exploration outside the classroom.

Digital technologies and ICT resources are under-exploited in preschools. Teachers would benefit from training on best practices of their use and potential for creativity development in science and mathematics.

Systematic and institutionalised teacher collaboration is not widely common amongst the partner countries, nor are teacher networks specifically formed for the professional development of teachers in science and mathematics education. This contradicts teachers' acknowledgement that informal dialogue with colleagues on how to improve their science and mathematics teaching is the professional development activity that has the maximum impact on their practice.

Moreover, school-based professional development opportunities involving peer observations, mentoring and coaching appear not to be the norm, despite their recognized effectiveness in promoting change and innovation, and sustaining impact.

Courses and workshops in science and mathematics education are not as available to early years educators compared to primary teachers.

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