



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

**D5.2 Guidelines and Curricula for Teacher Training
Executive Summary**

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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D5.2 Guidelines and Curricula for Teacher Training

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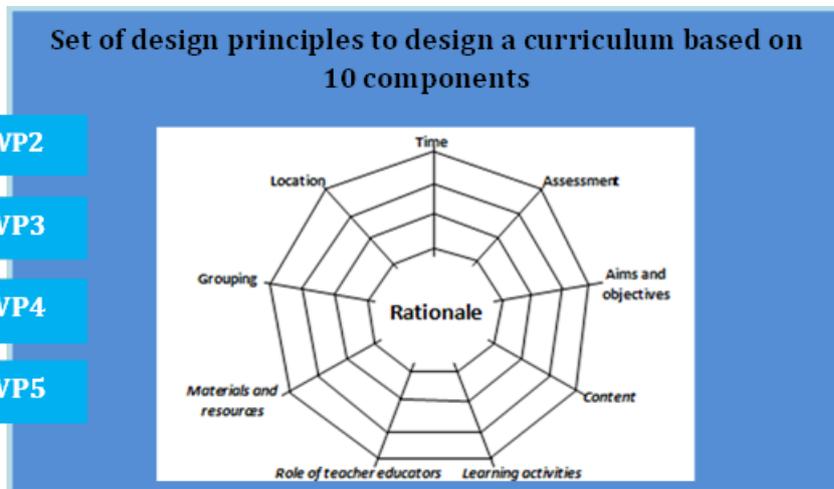
EXECUTIVE SUMMARY

Introduction

One of the key objectives of the *Creative Little Scientists* project is to propose a set of curriculum design principles as guidelines for European initial teacher education (ITE) and continuous professional development (CPD) programmes that will foster creative approaches to science and mathematics learning in preschool and the first years of primary education in the frame of inquiry-based educational environments. Work Package 5 is based on the findings of the theoretical review (Work Package 2), comparative studies (Work Package 3), and in-depth field research (Work Package 4). In addition it has been informed by the involvement of communities of stakeholders – teachers, student teachers, school staff members, teacher educators, researchers, out-of-the box thinkers, policy makers and experts in the field of inquiry, creativity or science – in online and face-to-face focus groups.

This document offers teacher education policy makers and institutions a set of curriculum design principles and accompanying conceptual recommendations in order to design and apply curricula that will foster creative approaches to science and mathematics learning in preschool and first years of primary education. Furthermore it offers teacher education institutions a related set of teacher outcomes about what teachers should know and be able to do in order to develop such creative approaches. These can be seen as concrete recommendations for teacher educators and teacher education institutions to frame their sessions, workshops and courses. They are directly linked to the implications for teacher training which arose from deliverables D2.2 *Conceptual Framework*, D3.2 *Report on Mapping and Comparing Recorded Practices*, D3.3 *Report on First Survey of School Practice* and D4.4 *Report on Practices and their Implications* (see also Figure below).





Conceptual recommendations to implement the design principles
Based on findings in WP2 and WP5

WP2 WP5

Concrete Content recommendations: Teacher Outcomes
Based on findings in WP2, WP3 and WP4

WP2 WP3 WP4

Methodology for developing the curricular principles

Within this project the research model developed and refined was based on both distinct educational design phases: analytical, prototyping and assessment (Plomp, 2009), and characteristics of curriculum design research (van den Akker, 2009).

During the *analytical phase*, a conceptual framework (Creative Little Scientists, 2012a) was developed based on four literature reviews, namely: science and mathematics education in preschool and early years of primary school; creativity in education; teacher training for early years educators and primary teachers; and comparative education. Moreover, a literature research was carried out concerning curriculum design and curriculum design research (Creative Little Scientists, 2012b). The ‘spider web’ model, described by Jan van den Akker (2009), was used as an instrument for structuring issues and ideas originating from the project’s conceptual framework, the state-of-the-art, and discussions with the consortium partners. Informed by these elements and feedback from the consortium partners, draft curriculum design principles for teacher education (prototype 1) were written.

During the *prototypical phase*, this draft was further adjusted and evaluated through iterative cycles. In the first cycle, the draft of the prototypical curriculum design principles was adjusted to the purposes of teacher education using a web-based expert appraisal panel, consisting of the *Creative Little Scientists* consortium partners. In particular, online forums set up in Moodle served as asynchronous discussion groups. Participants were

requested to comment, discuss, and/or feedback on the guidelines with an example of practice. The principles were rephrased according to participant feedback. Finally, 87 curriculum design principles were proposed (prototype 2) (D5.1). In a second iteration, prototype 2 of the curriculum principles was further adjusted and evaluated using online focus groups that ran simultaneously in the 9 European partners' countries. Each online focus group consisted of a heterogeneous group of key stakeholders in the field of education who were encouraged to exchange experiences and knowledge during three weeks on an online group assignment, supervised by an e-moderator.

The new result of this second cycle after data-analysis at both country- and consortium level (prototype 3) was again validated through partner-specific focus groups comprised of key stakeholders, focusing on particular evaluation criteria. The final prototype was followed by critical analysis by the consortium partners using the findings of WP2, WP3 and WP4. This resulted in a definite set of design principles and successive conceptual recommendations useful for teacher education contexts willing to improve creativity in science and mathematics education for young children.

In conclusion, the methodology of curriculum design research, which highlights collaboration, prototyping and vision-building with different stakeholders, whilst it was challenging to use in the project, it was very effective in designing curricula principles and guidelines for teacher education.

Teacher Education Curricula promoting Creativity in Early Years Science and Mathematics

In the *Creative Little Scientists* project, the work of van den Akker (2007) was used to develop a curriculum for teacher education in order to foster creativity in science and mathematics education for early years. Ten components relating to a curriculum were identified as the basis for a set of curriculum design principles for teacher education. These 10 components were: Rationale or Vision of the curriculum; Aims and Objectives; Content; Learning activities; Role of Teacher Educator; Materials and Resources; Grouping; Location; Time; and Assessment. In this document the components and design principles are presented as a list in section D1. It should be noted that the components are not in any hierarchical order and should not be viewed in isolation; they are both interconnected and interdependent.

The curriculum design principles developed are intended to be used as a means to promote creativity in science and mathematics education in both ITE and CPD. All of the design principles are meant to be seen as equally important and a foundation for different curricula development routes in Europe. They also represent the starting point for discussions with various groups of stakeholders, amongst them teacher education policy makers and teacher educators in training institutions, who may wish to develop and modify them according to context in order to meet a wide range of purposes and audiences.

However, in order to use the design principles appropriately and effectively, teacher education needs to consider three elements:



- The concept of the spider web and its components;
- The starting situation of the (student) teacher;
- Differences between ITE and CPD.

These elements and the use of the design principles are discussed in section D.

Teacher Outcomes: a set of concrete guidelines

Based on the findings of the literature reviews (D2.2), the comparative policy and teacher survey studies (D3.2 and D3.3), the in-depth fieldwork (D4.4) and the focus groups (Work Package 5), desired teacher outcomes were formulated (section E). These were closely linked to the design principles of the 'content' component of the spider web, and make these more concrete. As such they can be seen as contributing to the recommendations for teacher education institutions and teacher educators to frame their sessions, workshops or courses.

In D5.3 *Exemplary Teacher Training Materials* advice will be given as to how these teacher outcomes and the set of design principles can be used to frame sessions or workshops for ITE and CPD. Furthermore, based on these outcomes, exemplary teacher training materials originating from the data of WP4 will be available. Some suggestions will also be given about how to apply these materials in the framed sessions or workshops.

CURRICULUM DESIGN PRINCIPLES

| <p>Rationale</p> <p><i>Why are teachers learning?</i></p> <p>Teachers (incl. student teachers) should foster inquiry and creativity in science and mathematics learning¹ in preschool and the first years of primary school.</p> | |
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| <p>Aims and Objectives</p> <p><i>Towards which goals are teachers learning?</i></p> | <p>Competences for teachers</p> <p>In teacher education teachers should:</p> <ol style="list-style-type: none"> 1.1 Acquire secure content knowledge of science and mathematics ideas and processes, as well as the skills and competences to carry out inquiries. 1.2 Acquire the pedagogical content knowledge to foster inquiry and creativity in early years science and mathematics, including the use of inquiry approaches. 1.3 Become confident and develop positive attitudes towards learning and teaching science, mathematics using inquiry and creativity based approaches. 1.4 Acquire the skills to act as researchers and reflective practitioners in learning and teaching science and mathematics, and should become able to discern and reflect on innovative ideas. 1.5 Acquire the knowledge and skills to support the diverse interests and needs of young children in engaging creatively within the fields of science and mathematics. <p>Foci of teacher education</p> <p>Teacher education should:</p> <ol style="list-style-type: none"> 1.6 Emphasise the importance of science and mathematics education for personal and society development by advocating its role in the preparation of scientific and mathematic literate citizens as well as the role of creativity in these domains and in human development. 1.7 Emphasise the pedagogical synergies between IBSE and creative approaches in both science and mathematics learning and teaching. 1.8 Foster teacher learning outcomes aligned with creative science and mathematics teaching strategies and assessment methods. 1.9 Foster teachers' creativity and their potential to be creative in science and mathematics. |

¹ Creativity in mathematics and science - Generating alternative ideas and strategies as an individual or community and reasoning critically amongst these and between them and existing, widely accepted explanations and strategies.

Rationale

Why are teachers learning?

Teachers (incl. student teachers) should foster inquiry and creativity in science and mathematics learning¹ in preschool and the first years of primary school.

Role of teacher educator
How is the teacher educator facilitating learning?

Teacher educator profile

Teacher educators of science and mathematics education should:

- 2.1 Combine content knowledge, pedagogical content knowledge, and teaching practice of science and mathematics.
- 2.2 Be reflective practitioners who promote creative approaches in their practice, including inquiry and problem solving.
- 2.3 Be willing to try new things and be open to taking risks in their practice, so they can bring in (new) effective pedagogy and approaches in the fields of science and mathematics.
- 2.4 Have the skills to build partnerships (e.g. communities) with different science and mathematics education stakeholders such as schools, science research centers, science museums, scientific and mathematics associations at national and local level, etc.
- 2.5 Be encouraged to be actively involved in research and discussion networks about science and mathematics education pedagogy.

Teacher educator role

Teacher educators should:

- 2.6 Take into consideration teachers' prior knowledge, skills, attitudes, beliefs, fears, preconceptions (incl. stereotypical images), learning styles and experiences associated with learning and teaching science, mathematics, and creativity, and organize appropriate learning activities.
- 2.7 Make explicit connections among content knowledge, pedagogical content knowledge and teaching practice of science and mathematics, as well as between these and the development of creativity.
- 2.8 Practically demonstrate a variety of roles in their interactions with teachers e.g. facilitator, supporter, coordinator, leader, motivator, role model.
- 2.9 Model inquiry- and creativity-based learning, teaching and assessment practices, by for example encouraging teachers' decision making during inquiry processes, and sharing, evaluating and reflecting on outcomes.
- 2.10 Model how teachers should select science and mathematics materials and resources for fostering creativity in mathematics and science.

Rationale

Why are teachers learning?

Teachers (incl. student teachers) should foster inquiry and creativity in science and mathematics learning¹ in preschool and the first years of primary school.

Learning activities

How are teachers learning?

Teacher education should provide learning activities in science and mathematics which:

3.1 Are inquiry-based, addressing all essential features of inquiry (questioning, designing or planning investigations, gathering evidence, making connections, explaining evidence, communicating and reflecting on explanations), and their various purposes and degrees of structure and guidance (including open, guided and structured inquiries).

3.2 Bring out the synergies between inquiry-based science and mathematics and approaches directed at developing learner creativity.

3.3 Are interactive, within a rich, motivating context, and should encompass a range of formal and informal learning approaches and strategies. Examples of such activities include lesson planning, discussions focused on fostering creativity; demonstrations of good practice; outdoor learning; field trips; project work.

3.4 Integrate science and mathematics learning, making use of real life, meaningful and interactive contexts, and illustrating the potential of such interdisciplinary approaches for inquiry and creativity.

3.5 Provide teachers with opportunities to recognize and better understand both young children’s learning of science and mathematics and the role of creativity within this, through for example classroom observations, collection and analysis of evidence, talking to children.

3.6 Attend to teachers’ different approaches to their own learning and encourage their expression and representation of scientific and mathematics ideas in various modes.

3.7 Help teachers reflect on their own prior knowledge, (mis)conceptions (incl. stereotypical images) beliefs and attitudes about science, mathematics and creativity, using a variety of approaches, such as microteaching, peer-observations, learning journals.

3.8 Support teachers’ learning, by providing them with illustrative examples of diverse practices for them to critically examine opportunities for creativity and inquiry in learning, teaching and assessment.

3.9 Are a variety of individual and collaborative to promote teachers’ creative thinking skills and dispositions.

| <p>Rationale</p> <p><i>Why are teachers learning?</i></p> <p>Teachers (incl. student teachers) should foster inquiry and creativity in science and mathematics learning¹ in preschool and the first years of primary school.</p> | |
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| <p>Assessment</p> <p><i>How to measure how far teachers' learning has progressed? How is assessment information used to inform planning and develop practice?</i></p> | <p>Focus of assessment</p> <p>In teacher education:</p> <p>4.1 Teachers' acquisition and development of science/mathematics content and pedagogical content knowledge, skills and attitudes should be assessed.</p> <p>4.2 The development of teachers' inquiry and creativity-based teaching and assessment approaches should be assessed.</p> <p>4.3 Teachers' acquisition and development of understanding about what it is to foster children's creativity in science and mathematics should be assessed.</p> <p>4.4 The development of teachers' abilities to plan for, foster, reflect upon and assess children's creativity in science and mathematics education should be assessed.</p> <p>Process of assessment</p> <p>Teacher education should:</p> <p>4.5 Promote teachers' independence and responsibility in identifying their own progress and areas for development both in the fields of science and mathematics education and in the fostering of creativity within these fields.</p> <p>4.6 Use different assessment strategies in order to assess holistically cognitive, social and affective aspects of science and mathematics learning, as well as tap into the potential for peer and self-assessment.</p> <p>4.7 Use different forms of evidence (e.g. portfolios, teacher diary, observation lists, tests, essays, project work, teaching practice) for assessment purposes.</p> |

Rationale

Why are teachers learning?

Teachers (incl. student teachers) should foster inquiry and creativity in science and mathematics learning² in preschool and the first years of primary school.

Content

What are teachers learning?

Teacher education should:

- 5.1 Provide content knowledge about science and mathematics, including interesting and current topics, to be used in activities linked with everyday life.
- 5.2 Provide teachers with skills and competences to carry out practical investigations of science and mathematics in the classroom.
- 5.3 Advance teachers' understandings about the nature of science and how scientists work, confronting stereotypical images of science and scientists.
- 5.4 Promote understandings about the nature and framings of creativity, characteristics of creative teaching and learning, and how creativity is manifest in early years science and mathematics.
- 5.5 Provide knowledge about how children's creativity development could be enhanced and assessed within science and mathematics education.
- 5.6 Provide pedagogical content knowledge to stimulate inquiry and problem solving in science and mathematics education.
- 5.7 Familiarise teachers with a range of formal and informal inquiry- and creativity-based learning, teaching and assessment approaches and strategies and their use in relation to authentic problems within the areas of science and mathematics.
- 5.8 Enable teachers to design and assess creativity-enabling inquiry-based activities which are child-friendly and include both guided and open inquiries.
- 5.9 Enable teachers to make best use of and assess the various modes of expression and representation of science and mathematics learning to support inquiry and the development of creativity.
- 5.10 Enable teachers to recognize and build on children's questionings, ideas, theories and interests for the teaching of science and mathematics.
- 5.11 Enable teachers to use questioning effectively and encourage children's questions in order to foster creativity and inquiry.
- 5.12 Provide knowledge about early child development, the purposes and aims of science and mathematics education, and their place in the early years curriculum.

² Creativity in mathematics and science - Generating alternative ideas and strategies as an individual or community and reasoning critically amongst these and between them and existing, widely accepted explanations and strategies.

| <p>Rationale</p> <p><i>Why are teachers learning?</i></p> <p>Teachers (incl. student teachers) should foster inquiry and creativity in science and mathematics learning³ in preschool and the first years of primary school.</p> | |
|---|--|
| <p>Content (cont.)</p> <p><i>What are teachers learning?</i></p> | <p>5.13 Provide teachers with knowledge about the relevant education policy guidelines and documents for science, and mathematics education (and the role of creativity in them) at national level, as well as about the corresponding policy trends at European level.</p> <p>5.14 Equip teachers with knowledge and skills to use a range of formal, non-formal and informal learning environments, including the outdoor environment, both the school grounds and the wider environment beyond the school, in their teaching of science and mathematics.</p> <p>5.15 Promote teachers' use of group work to support children's inquiry processes and creative learning.</p> <p>5.16 Provide teachers with knowledge of approaches to timetabling and organizing cross-curricular project work.</p> <p>5.17 Address with teachers issues in ensuring rich provision, planning and use of resources (including digital resources) in and out of the classroom to support children's inquiry and creativity.</p> <p>5.18 Encourage and assess the development of teachers' literacy, numeracy and digital literacy skills through science and mathematics.</p> |
| <p>Materials and resources</p> <p><i>With what are teachers learning?</i></p> | <p>Teacher education should:</p> <p>6.1 Provide ICT infrastructure and logistical support to teachers to access diverse learning materials and resources, which may include web-based resources, social media, videogames, online academic journals and databases, as well as other digital technologies, such as cameras, tablets, and other digital devices.</p> <p>6.2 Facilitate and promote access to a variety of early years science and mathematics curriculum materials and resources fostering inquiry and creativity. These should be both for indoor and outdoor use and include everyday materials, picture and story books, building blocks, equipment for hands-on exploration.</p> <p>6.3 Facilitate and promote access to materials and resources (including everyday materials) fostering inquiry and creativity in early years science and mathematics.</p> |

³ Creativity in mathematics and science - Generating alternative ideas and strategies as an individual or community and reasoning critically amongst these and between them and existing, widely accepted explanations and strategies.

| <p>Rationale</p> <p><i>Why are teachers learning?</i></p> <p>Teachers (incl. student teachers) should foster inquiry and creativity in science and mathematics learning⁴ in preschool and the first years of primary school.</p> | |
|---|--|
| <p>Grouping</p> <p><i>With whom are teachers learning? How are they allocated to various learning trajectories? Are they learning individually, in small groups, or whole-class?</i></p> | <p>Teacher education should:</p> <p>7.1 Provide a range of learning trajectories to teachers to choose from according to their needs and preferences.</p> <p>7.2 Promote collaborative learning practices, including peer learning, in science and mathematics education in order to foster creativity and inquiry.</p> <p>7.3 Promote team teaching and working in the fields of science and mathematics education.</p> <p>7.4 Support teacher collaboration, including at a distance through digital media and other ICT tools that make this possible.</p> <p>7.5 Provide interaction and interdisciplinary collaboration opportunities amongst student teachers, in-service teachers, science experts, research scientists, teacher educators, children, and educational establishments and organizations.</p> |
| <p>Location</p> <p><i>Where are teachers learning? Are they learning in class, in the library, at home or elsewhere? What are the social/physical characteristics of the learning environment?</i></p> | <p>Teacher education should:</p> <p>8.1 Take place in a variety of learning environments (formal, non-formal and informal, indoor and outdoor), including e.g. science museums, science research centers, natural habitats, etc., modelling their subsequent use for inquiry and creativity in the classroom.</p> <p>8.2 Facilitate access to industries and research centres of science and mathematics to promote collaboration, sharing, visiting, and networking of teachers.</p> <p>8.3 Provide opportunities for place-independent and collaborative learning, i.e. flexibility and variety of teaching locations.</p> |

⁴ Creativity in mathematics and science - Generating alternative ideas and strategies as an individual or community and reasoning critically amongst these and between them and existing, widely accepted explanations and strategies.

| <p>Rationale</p> <p><i>Why are teachers learning?</i></p> <p>Teachers (incl. student teachers) should foster inquiry and creativity in science and mathematics learning⁵ in preschool and the first years of primary school.</p> | |
|---|--|
| <p>Time</p> <p><i>When are teachers learning? How much time is available for various subject matter domains? How much time can be spent on specific learning tasks?</i></p> | <p>Teacher education should:</p> <p>9.1 Provide time for teachers to interact with colleagues: e.g. collegial consultation/reflection, teamwork, mind mapping, vision-building.</p> <p>9.2 Allow sufficient time for teachers to explore opportunities for creativity in learning and teaching in early science and mathematics and to gain confidence through the process.</p> <p>9.3 Provide opportunities for time-independent (distance) learning.</p> <p>9.4 Model different approaches to timetabling science and mathematics education, encouraging interdisciplinary and project work.</p> |

⁵ Creativity in mathematics and science - Generating alternative ideas and strategies as an individual or community and reasoning critically amongst these and between them and existing, widely accepted explanations and strategies.

Curriculum Design Principles about Content and linked Teacher Outcomes

5.1 Teacher education should provide content knowledge about science and mathematics, including interesting and current topics, to be used in activities linked with everyday life.

5.1.1 *Teachers should be able to pursue the social and affective objectives of children's science and mathematics learning, in synergy with the corresponding cognitive ones.*

5.1.2 *Teachers should be able to make children aware of connections between science and mathematics learning and their everyday lives, in order to engage their motivation, interest and enjoyment in science and mathematics and foster curiosity and creativity.*

5.2 Teacher education should provide teachers with skills and competences to carry out practical investigations of science and mathematics in the classroom.

5.2.1 *Teachers should be able to instigate and involve children in the design and conduct of practical investigations of science and mathematics in the classroom, as such activities can contribute to the development of children's creativity.*

5.2.2 *Teachers should have detailed knowledge about the nature of inquiry and investigations in early years science and mathematics in order to be able to recognise the opportunities they offer both for creative learning and developing children's creativity.*

5.3 Teacher education should advance teachers' understandings about the nature of science and how scientists work, confronting stereotypical images of science and scientists.

5.3.1 *Teachers should be able to advance children's understanding about the nature of science and how scientists work, confronting stereotypical images of science and scientists.*

5.3.2 *Teachers should be able to recognize young children's capabilities to engage with processes associated with the evaluation as well as generation of ideas in science and mathematics, since these processes are also important for the development of learner creativity.*

5.3.3 *Teachers should be able to foster the processes of imagination, reflection and consideration of alternative ideas in supporting children's understanding of scientific ideas and procedures and development of creativity*

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| 5.4 | Teacher education should promote understandings about the nature and framings of creativity, characteristics of creative teaching and learning, and how creativity is manifest in early years science and mathematics. |
| 5.4.1 | <i>Teachers should be able to recognize how creativity is manifest in early years science and mathematics and have knowledge of distinctions between features of creative teaching and creative learning.</i> |
| 5.5 | Teacher education should provide knowledge about how children's creativity development could be enhanced and assessed within science and mathematics education. |
| 5.5.1 | <i>Teachers should have detailed knowledge about the synergies between inquiry and creativity, such as play and exploration, motivation and affect, dialogue and collaboration, problem solving and agency, questioning and curiosity, reflection and reasoning; and teacher scaffolding and involvement, to support children's creative learning and advance their creativity within science and mathematics education</i> |
| 5.6 | Teacher education should provide pedagogical content knowledge to stimulate inquiry and problem solving in science and mathematics education. |
| 5.6.1 | <i>Teachers should have knowledge of all essential features of inquiry and problem solving (questioning, designing or planning investigations, gathering evidence, making connections, explaining evidence, communicating and reflecting on explanations), their different purposes, degrees of structure and guidance (including open, guided and structured inquiries), and varied opportunities they offer for creativity.</i> |
| 5.6.2 | <i>Teachers should be able to open up everyday learning activities to allow greater opportunities for inquiry, problem solving and scope for creativity.</i> |
| 5.6.3 | <i>Teachers should be able to recognise the key roles of children's questioning and existing ideas (both implicit and explicit) of science and mathematics.</i> |
| 5.6.4 | <i>Teachers should be able to use a variety of strategies for eliciting and building on children's questions and ideas during inquiry processes (before, during and after explorations and investigations).</i> |
| 5.6.5 | <i>Teachers should be able to foster opportunities for children's agency and creativity in learning in inquiry and problem solving – in particular the importance of children making their own decisions during inquiry processes, making their own connections between questions, planning and evaluating evidence, and reflecting on outcomes.</i> |
| 5.7 | Teacher education should familiarise teachers with a range of formal and informal inquiry- and creativity-based learning, teaching and assessment approaches and strategies and their use in relation to authentic problems within the areas of science and mathematics. |
| 5.7.1 | <i>Teachers should have knowledge of a range of formal, non-formal and informal learning, teaching and assessment approaches and strategies to promote creativity in their early years science and mathematics classroom.</i> |
| 5.7.2 | <i>Teacher should be able to use a range of strategies both formal and informal for supporting children's extended engagement with an area of study and progression in learning in science and mathematics.</i> |

5.7.3 Teachers should be able to recognize and exploit the value of play and exploration in science and mathematics for fostering and extending inquiry and creativity, by for example prompting questions, eliciting ideas, providing opportunities for consideration of alternative strategies during children's familiarisation with phenomena and events.

5.7.4 Teacher should be able both to build in new and to make the most of existing opportunities for child-initiated play, recognising and capitalising on the potential of children's explorations beyond the teacher's original intentions.

5.7.5 Teachers should be able to use a range of creative contexts and approaches for provoking children's interest, motivation and enjoyment in science and mathematics, such as stories, poems, songs, drama, puppets and games.

5.7.6 Teachers should be able to use strategies for making and building on science and mathematics real life connections and applications for engaging creatively young children in science and mathematics learning.

5.7.7 Teachers should be able to assume a variety of roles in their interactions with the children e.g. allowee, leader, afforder, coordinator, supporter, tutor, motivator and facilitator, to support children's creativity and inquiry in science and mathematics.

5.7.8 Teacher should be able to use a variety of scaffolding techniques to promote creativity in science and mathematics, from standing back in order to observe, listen and build from the children's interests, to intervening with appropriate questioning to support and extend inquiries.

5.7.9 Teachers should be able to use different assessment approaches and strategies and in particular those that involve children in the assessment processes, such as peer and self assessment, dialogue and feedback on progress, in the early years science and mathematics classroom.

5.7.10 Teachers should value and be able to make use of varied forms of assessment evidence (including children's portfolios, individual or group records of activities), both to promote creative learning, through reflection and discussion in science and mathematics, and explicitly to inform teaching and longer term planning.

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| 5.8 | Teacher education should enable teachers to design and assess creativity-enabling inquiry-based activities which are child-friendly and include both guided and open inquiries. |
| 5.8.1 | <i>Teachers should be able to design and assess open-ended learning activities.</i> |
| 5.9 | Teacher education should enable teachers to make best use of and assess the various modes of expression and representation of science and mathematics learning to support inquiry and the development of creativity. |
| 5.9.1 | <i>Teachers should be able to recognize and value children's various forms of expression and representation of their ideas and learning in science and mathematics.</i> |
| 5.9.2 | <i>Teachers should be able to make best use of children's preferred forms of expression and representation of their science and mathematics ideas to support inquiry and their creativity development.</i> |
| 5.9.3 | <i>Teachers should be able to select and use different approaches for and forms of recording children's ideas and learning in science and mathematics at different stages of the learning process and for various purposes, including to support children's reflection and reasoning processes.</i> |
| 5.9.4 | <i>Teachers should be able to use the various modes of children's expression and representation of science and mathematics ideas (e.g. pictures, graphs, gestures, physical activities) for assessment purposes.</i> |
| 5.10 | Teacher education should enable teachers to recognize and build on children's ideas, theories and interests for the teaching of science and mathematics. |
| 5.10.1 | <i>Teachers should be able to use a range of strategies for picking up on children's ideas, theories and interests.</i> |
| 5.10.2 | <i>Teachers should be able to build flexibility into planning to take advantage of unexpected events, children's interests and questions.</i> |
| 5.11 | Teacher education should enable teachers to use questioning effectively and encourage children's questions in order to foster creativity and inquiry |
| 5.11.1 | <i>Teacher should be able to use different forms of questioning at appropriate points to scaffold creative learning outcomes in science and mathematics, and in particular to encourage children's reflections and explanations, foster their independence and extend their inquiry.</i> |
| 5.11.2 | <i>Teachers should value and be able to build on the potential of children's own questions to foster their curiosity in science and mathematics, and support their generation and follow up, including those that are investigable.</i> |
| 5.12 | Teacher education should provide knowledge about early child development, the purposes and aims of science and mathematics education, and their place in the early years curriculum. |
| 5.12.1 | <i>Teachers should have knowledge of the various purposes and aims of science and mathematics education in compulsory schooling.</i> |
| 5.12.2 | <i>Teachers should have knowledge of the prevailing academic rationale for the place of science and mathematics in the early years curriculum.</i> |

5.12.3 Teachers should have knowledge of the role of creativity in child development and in the fields of science and mathematics.

5.12.4 Teachers should be able to contribute towards the goal of preparing creative citizens, who have scientific and mathematic literacy.

5.12.5 Teacher should be able to align the aims and rationale for early years science and mathematics education with their teaching and assessment approaches and priorities.

5.12.6 Teachers should be able to support the diverse interests and needs of young children in engaging creatively within the fields of science and mathematics.

5.13 Teacher education should provide teachers with knowledge about the relevant education policy guidelines and documents for science, and mathematics education (and the role of creativity in them) at national level, as well as about the corresponding policy trends at European level.

5.13.1 Teachers should have knowledge about the relevant education policy guidelines and documents for science and mathematics education (and the role of creativity in them) at national level, as well as about the corresponding policy trends at European level.

5.14 Teacher education should equip teachers with knowledge and skills to use a range of formal, non-formal and informal learning environments, including the outdoor environment, both the school grounds and the wider environment beyond the school, in their teaching of science and mathematics.

5.14.1 Teachers should be able to make use of varied settings for science and mathematics learning, including flexible use of the environment both indoors and out.

5.14.2 Teachers should be able to recognise and build on opportunities for informal learning in science and mathematics within the school environment, for example within day to day routines or child-initiated games and other activities in school classrooms or outdoor play areas.

5.14.3 Teachers should be able to elicit and build on children's informal learning of science and mathematics outside school, at home or in the wider environment.

5.14.4 Teachers should be able to manage visits with children to the outdoor and wider environment beyond the school, addressing issues of health and safety, liaison with parents, building progression in experience inside the classroom.

5.15 Teacher education should promote teachers' use of group work to support children's inquiry processes and creative learning.

5.15.1 Teachers should have knowledge of the value of collaboration for inquiry and creative thinking and learning.

5.15.2 Teachers should be able to purposefully use a variety of patterns of collaboration, shifting between individual and collaborative activity over time, to support children's inquiry processes and creative learning.

5.15.3 Teachers should be able to organize group work, aligning ways of grouping children, task design, teaching and assessment strategies in different ways to promote collaboration amongst children in science and mathematics.

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| 5.15.4 Teachers should be able to use resources and teacher intervention appropriately to foster collaboration in science and mathematics. |
| 5.15.5 Teachers should be able to assess group work. |
| 5.15.6 Teachers should be able to use effective strategies for sharing ideas and discussions from different groups. |
| 5.16 Teacher education should provide teachers with knowledge of approaches to timetabling and organizing cross-curricular project work. |
| 5.16.1 Teacher should be able to use approaches to cross- thematic, cross-curricular and project work to promote creativity in science and mathematics. |
| 5.16.2 Teachers should be able to use a variety of approaches to timetabling, within the existing curriculum and policy expectations to allow space for cross-curricula project work and child-initiated exploration and inquiry. |
| 5.16.3 Teachers should be able to build connections across the curriculum of various kinds and with potential to contribute to children’s inquiry and creativity. |
| 5.17 Teacher education should address with teachers issues in ensuring rich provision, planning and use of resources (including digital resources) in and out of the classroom to support children’s inquiry and creativity. |
| 5.17.1 Teachers should be able to organise and use materials (including everyday materials), resources (including ICT and natural resources) and equipment (including digital equipment and simple laboratory instruments) in the classroom, school and wider environment, both indoors and out, to support independent inquiry and creativity. |
| 5.17.2 Teachers should be able to recognize the nature and potential of different materials and resources both to constrain and extend children’s explorations. |
| 5.17.3 Teachers should be able to evaluate and select creativity enabling ICT resources for children to use in their inquiry. |
| 5.17.4 Teachers should be able to evaluate provision for free flow play in their school settings. |
| 5.17.5 Teachers should be able to develop and extend their own classroom resources to foster creativity in the early years science and mathematics classroom. |
| 5.17.6 Teachers should be able to gain insights into children’s developing explorations and creativity based on their use of resources. |
| 5.17.7 Teachers should be able to develop the school grounds and the outdoor classroom for use in science and mathematics education. |
| 5.18 Teacher education should encourage and assess the development of teachers’ literacy, numeracy and digital literacy skills through science and mathematics. |
| 5.18.1 Teachers should develop their literacy, numeracy and digital literacy skills through science and mathematics. |