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

D6.7 Final Project Workshop

www.creative-little-scientists.eu

The project CREATIVE LITTLE SCIENTISTS has received funding from the European Union's Seventh Framework Programme (FP7/2007-2013) for research, technological development and demonstration under grant agreement no 289081.

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INTRODUCTION

The *Creative Little Scientists* Final Project Workshop served as an opportunity to round up the academic discussion of all concepts covered by the project, but, most importantly, present and explain the research findings to an audience consisting of selected key players, who can mobilise their organisations and professional networks to get to know and exploit the project results. The audience consisted of representatives of collective bodies as well as individuals, covering all stakeholder groups (policy makers, curriculum designers, teacher trainers, teachers, school administrators, parents).

The Final Workshop was titled “Enabling Creativity through Science and Mathematics in Early Years Education” and took place under the auspices of the Greek Ministry of Education and the Greek Presidency of the European Council at Ellinogermaniki Agogi school premises in Pallini, Attica, Greece, on 22-23 March 2014. Over 100 participants from a variety of EU countries attended the two-day event and came together to discuss the project findings and important outcomes such as the Final Report on Creativity and Science and Mathematics Education for Young Children (D6.5), the Recommendations to Policy Makers and Stakeholders on Creativity and Early Years Science (D6.6) and the Exemplary Teacher Training Materials (D5.3).

Saturday 22 March, the first day of the conference began with a keynote speech by Patricia Cochrane, the Chief Executive of CapeUK, a not-for-profit organisation committed to improving the lives of children and young people, preparing them to face the future with creativity and self-belief. The day continued with the Project Coordinator presenting the background to the project and the key findings and implications of the entire 30-month research project. A round table discussion on the main messages coming out of the *Creative Little Scientists* Final Report followed and the day concluded with three Parallel Thematic Workshops with invited stakeholders on policy, teacher education and reflections on research respectively.

The second day of the conference began with a presentation of the project results for Greek preschool and primary science and mathematics education and continued with a session where other relevant EU projects such as SECURE, SiS-Catalyst, Pri-Sci-Net, Early Change and CREANET were presented. Four parallel teacher workshops on creativity-enabling teaching approaches were carried out by members of the *Creative Little Scientists* consortium and invited participants. The conference continued with a plenary session, in which the important issues raised during Saturday’s three Thematic Workshops were presented by the rapporteur of each workshop, and discussed widely with all the conference participants. The conference concluded with a keynote address given by Dr. Costas Constantinou, Professor in Science Education and Director of the Learning in Science Group at the University of Cyprus on the role of design-based research in inquiry-oriented science teaching. The detailed programme of the conference can be found in Appendix A.

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A website was built especially for the purposes of the conference and contained all the necessary information about the conference programme, travel and venue, registration and about the project *Creative Little Scientists* in general. The conference website can be found at the address: http://conference.creative-little-scientists.eu/

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DAY 1: Saturday 22 March 2014

Plenary 1

Keynote Address: Journeys in creativity by Patricia Cochrane, CapeUK

Dr. Patricia Cochrane' s keynote address took the audience through creativity's journey departing from the early initiatives of research projects focusing on establishing a definition of creativity to the present development of creativity in today's education system. She described *Creative Little Scientists*' research project as a significant contribution to this latter development. Following is a commentary summarizing the main points delivered in her presentation.

Why creativity?

Quoting Ken Robinson, divergent thinking seems to differ across different age groups with the age group of 3 to 5-year old children having the greatest ability to experience divergent thinking (98%), whilst adults appear to lose this ability all together (2%).

The interest towards creativity stems from different sources and mainly an economic imperative. The need for the EU to level the competition from the East has required the development of collaboration in the workforce and creativity has been identified as helping this collaboration to flourish. Therefore, dialogue within the business community has influenced schools, which wanting to cater for this need introduced the teaching of creativity starting from primary education.

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What is creativity?

Ms Cochrane was involved in the research project 'Education for the Future' with a focus on fostering creativity. This was not an easy feat since in 1997 there was no working definition of creativity especially in relation to pedagogy. Various definitions began to emerge in 1999, which include:

- NACCE: Creativity involves imaginative activities fashioned so as to produce outcomes that are original and of value.
- Fisher & Williams came up with something more focused to schools that include children coming up with critical responses to problems across all subjects across the curriculum.
- Anna Craft describes creativity as a choice.

However, these definitions do not translate well to the school system and thus are not that useful for teachers. Fisher and Williams present a definition, which is more relevant to the teachers' pedagogy that includes factors such as moving out of the comfort zone, confidence to make mistakes, playfulness and imagination, openness to doubt and uncertainty. These still do not entirely help the practitioner in the classroom.

Another approach is to look at what creativity is not. Creativity is not always a good thing, nor is it easy to access. It does not involve solitary work and is not something you can spontaneously release when need be. However, it involves rigor, working in a team and being able to pull a team together and make something happen whilst overcoming challenges and problems. Creativity should also move away from its automatic association to the arts.

The *Creative Little Scientists* definition of creativity presents a useful platform especially to teachers as it highlights what the teachers should expect when their students are being creative.

Creativity and Science

One important question concerning science is: Can you actually support children to be creative in science? With regards to art children can simulate the professionals' experiences when on stage in front of an audience. Yet, in science children are not put in a position where they can experience what adult scientists do. And what does creativity in science look like? Painting pictures of bacteria does not per se involve science but is again linked back to the arts.

Instead activities such as modelling and drawing were illustrated as good enablers of the understanding of scientific processes, which engage children in imagination.

In order to develop creativity in children, research projects show that we need to involve adults in their own creative development, for example to allow time for teachers to immerse themselves in the process of creativity. This would involve issues such as how to use the physical space, time and create conceptual space.

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What are the conditions that enable the children?

A focus on the children's creativity instead of the teachers' creativity is needed. Teachers need to stand back but prepare the space needed for children to engage in this process. Working toward an end product is also discussed as important to drive children toward the creative process (conferences, expeditions, and performances).

It is also important to make teachers aware of what to expect when children are being creative. These expectations should include: making connections, challenging, keeping options open and exploring ideas, reflecting on ideas, calculated risk taking and resilience. These skills need to also have been developed in teachers, especially when it comes to resilience to see creative ideas through. Dr. Cochrane outlined certain conditions that need to be present for creativity to flourish that include: relevant and contextualized knowledge and understanding, dialogue, discourse, democratic relationships and learning structured around a real outcome.

Challenges to creativity found in research projects

- The context teachers are in creates challenges since they need school leaders to support them in allowing time for them to be creative and for the children to engage in creative processes.
- Isolation of teachers is also an obstacle. Without a shared understanding of creativity within the school and other teachers, creativity cannot be fostered.
- Another challenge presented revolves around the question of how far do you let the children pursue something that is wrong, scientifically not sound and how important is the right answer?

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Examples of Creativity in Science taken from research projects

- Following the life of an insect – mapping its movement
- Investigating an alien planet – imagining that the children arrive in an alien planet and need to investigate the conditions of this planet by collecting samples and exploring them - with the end product of organising a science exhibition explaining the purpose of the items they found.
- Setting up a science learning centre – giving older children the responsibility to work in small groups and set up scientific learning activities for younger children to experience.
- Working wonders – enabling children to ask questions by presenting a wonder box for them to ask different questions (how does gravity work, why do you cry when you are sad?) For this activity, teachers needed confidence in order to answer the children's questions. Therefore, these teachers were supported by providing a 2-day immersion in scientific content.

How do we recognise creativity and how do we assess it?

At the heart of any assessment process conversation between teacher and child is essential. This dialogue should be informed by the child's own self-reflection, elicited through the use of diagrams and pictures. This needs to be followed by teachers' feedback with the inclusion of peer and family feedback as the child progresses through school. Essentially assessment needs to involve the creative process. This should include observation of children when being creative.

Conclusion

To conclude Dr. Cochrane listed a number of recommendations in order to continue to foster creativity in our education system as a whole school approach and in relation to science.

- Invest in teacher's professional development – immersion in creative process and opportunities to take part in action research.
- Focus on inquiry as a process for CPD.
- Focus on the common understanding of inquiry.
- Engage in dialogue with children.
- Develop and nurture communities of practice, which combine research, teachers and the knowledge of the community.

(Dr. Cochrane's full presentation exists on the website: http://conference.creative-little-scientists.eu/)

Plenary 2
"What have we learned?" The Final Report from the EU Creative Little Scientists Project, by Fani Stylianidou, Ellinogermaniki Agogi

Dr. Fani Stylianidou, who is the *Creative Little Scientists* project coordinator, gave the audience a background to the project by providing a description of the project's context and

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aims. The project was also described as providing a new exploration of what it means to be creative in science and mathematics and how children's creativity can be fostered in early years education. The research questions and project partners were also outlined with an emphasis on finding a common language and understanding as a main challenge in this project.

The research stages involved in *Creative Little Scientists* were outlined including the conceptual framework, list of mapping and comparison factors, policy and teacher surveys, report of practices and fieldwork in schools, outcomes in the form of guidelines to teacher training, the production of exemplary teacher training materials and the final report and recommendations.

Dr. Stylianidou also listed the important synergies and difference between IBSE and CA and common pedagogical practices that take advantage of these synergies. A definition of creativity was also given with an emphasis on little c creativity and creativity in Science and Mathematics.

Findings: What do we mean by creativity?
Following are some findings outlined in Dr. Stylianidou's presentation.

Findings from Policy and Teacher Survey

1. **Aim and Purpose:**
    - Policy has given limited attention to the social and affective dimensions of the teaching of science, the nature of science and to the role of creativity in development of scientific ideas.

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- With regards to the teacher survey, the teachers highlighted that facilitating positive attitudes is an important aspect of teaching and learning science. However, similar to policy, teachers did not seem to give importance to the nature of science.

2. **Learning Activities**
   - Policy across the countries presented different levels of guidance with regards to the teaching and learning activities. Observation, communication and questioning were teaching and learning elements deemed as important in preschool, whilst an emphasis on investigation was seen in policy concerning primary schools.
   - With regards to the teacher survey observing nature was outlined as the most common activity in science.
3. **Pedagogy**
   - Mention of collaboration and imagination was not frequent in policy but frequent in the teacher survey.
   - Pretend play was also rated differently in importance across the different partner countries, as was unstructured play.
4. **Assessment**
   - A mismatch between the rational, aims and assessment in policy was outlined, that neglected the social and affective factors in assessment even though these factors are highlighted in the aims. There was also a vey limited attention to multimodal or child/ collaborative assessment.
   - Teachers did highlight the importance of assessing positive attitudes and increase of interest in science but did not give importance to assessing understanding about nature of science.

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In-field research

Learning activities most commonly involved observing, making connection and inquiry in science and mathematics. However few examples of using outdoor resources were noted along with limited involvement of children in assessment.

Implication of findings

There is great potential for IBSE and CA in early years however presently there is tension within policy and between policy and teaching. An area of improvement revolves around the increase in importance of the social and affective dimension of science and mathematics teaching and learning. The fieldwork presents rich materials and context for both indoor and outdoor science and mathematics learning activities that foster both IBSE and CA. Even though limited explicit attention was given to the nature of science, potential in the teachers practice was observed. This presents a ray of hope for future improvements for practice to move towards the direction of creativity. Guidelines for teacher training and their implications to teacher education were collected and generated with exemplary teacher training materials, in order to work on the identified potential.

(Dr. Stylianidou’s full presentation exists on the website: http://conference.creative-little-scientists.eu/)

Plenary 3
Round table: Responses to the Final Report from Stakeholder Organizations

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Dr. Katerina Plakitsi, Associate Professor at University of Ioannina, Greece

Dr. Plakitsi presented a series of reflections based on the comparison between *Creative Little Scientists* project results and the development of the new Greek science education curriculum. Both *Creative Little Scientists* and the curriculum changes share the same view about how to reform the Greek curriculum in order to achieve better performance in PISA as both provide ways of overcoming the present financial crisis through educating the future generation. Dr. Plakitsi commented that both research projects and curriculum development have to be based on the Science-Technology-Societal-Environment Approach in order to foster creativity and develop it throughout subjects. Another objective that both new changes in curriculum and the results of *Creative Little Scientists* have in common in the promotion of inquiry-based approaches is to increase motivation and interest in science. Dr. Plakitsi also pointed out the responsibility to respect the differential learning of each student according to their needs and culture, promote outdoor activities as much as possible and motivate teacher to use the outdoors as a science resource.

Dr. Plakitsi also commented on some major characteristics of creativity that we could tap into to foster this promoted pedagogy. Materials such as technological artefacts should be used to connect both school science and school technology. An effort has to be made to link schools with society through using the outdoors to make learning appropriate and significant. We should also provide our students with multimodal data sources and work towards a conscious involvement in inquiry activities.

The new Greek curriculum changes and the project should also work with different interactive systems such as policy makers, teacher associations, parents and schools to create shared and common objectives, common tools, rules, hierarchy in order to achieve some expected outcomes in which the top priority is creativity. Dr. Plakitsi concluded with praise comments about the *Creative Little Scientists* project's very well documented final report.

Jukka Rahkonen, Teacher and Advisor to the Finnish National Board of Education, Finland

Mr Rahkonen presented his thoughts on how the results and outcomes of the *Creative Little Scientists* project can inform recent attempts to reform the Finnish science education curriculum. Some identified changes presented involve environmental science, biology, geography, health education, physics and chemistry subject areas. Mr Rahkonen focused on the final report's findings and recommendations and looked at the work and development in the new Finnish curriculum with regards to *Creative Little Scientists'* recommendations.

With regards to an important finding of the Final Report that concerns the lack of emphasis on the development of creativity within national core curricula, Mr Rahkonen commented that the new Finnish curriculum aims will emphasise on the familiarization of teachers with technology and the use of collaboration, invention and exploration in class. Amongst other changes, the curriculum aims at decreasing content in order to give space and time for creativity in the future classrooms.

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With regards to another finding mentioned in the Final Report that highlights the existing emphasis on cognitive versus affective factors among the learning aims and objectives of science curricula across the consortium, Mr Rahkonen declared that the aims for science in the revised Finnish curriculum will be structured around meaning, values, attitude, investigation and also conceptual skills.

With regards to the third finding that described that creativity does not have a definition or framework in policy, Mr Rahkonen spoke about future plans to discuss this issue with a possibility to add background material and a definition to this concept of creativity in the new curriculum.

Mr Rahkonen reported that as part of curriculum development Finnish children from grade 1 to 6, were asked about their preferences with regards to their future learning. Their preferences involved learning through playing, testing, trying and acting, working in teams especially during maths, doing lessons outside and using ICT, games, magazines and tablets instead of books. However, the most striking response was that the children did not want anyone to be left alone and preferred to study and work together. Based on these preferences teachers need to be trained with regards to the use of ICT and how to record, conduct observation and present their work through ICT. They should also be encouraged to use group work, which will be also emphasised in the new curriculum. To conclude, Mr Rahkonen identified that there are still more things to be done in order to take up the project's recommendations for children to engage in creativity in schools.

Peter Gray, Research manager, European Projects, NTNU, Norway

Mr Gray's first reaction was the nature of the final report and its implications. Similar to many other EU projects the final report marks the end of a journey. Unfortunately there is no real mechanism of continuing dissemination. Effort should be placed on thinking about what we can do with this work in order to transfer it to practice.

With regards to the final project report and other projects there is a consensus of what counts as creative teaching, IBSE and formative assessment for inquiry. We are moving towards a model of good teaching, which is a very valuable resource we can use. However, the next direction is to implement this model across the EU countries. A trend identified with similar projects is the obstacle this entails as most often progress gets stunted on the level of school management, local authorities and government authorities. There is also no effort or possibilities to review the changes and to evaluate if they have been taken up.

An important point raised by Mr Gray involved that if certain elements and recommendations are not put in place in initial teacher training (ITT_, it is very difficult to put them into practice as we go along. Therefore, inquiry and creativity should be embedded in the teacher education culture especially within ITT.

To conclude, Mr Gray left the audience with a note that projects need to find ways of moving outside current framework of EU in order to make use of the very valuable final reports generated.

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Liz Lawrence, past Chair of the Association for Science Education, UK

Ms Lawrence began her contribution with a comment on the apparent disconnection between policy and practice in education. She also posed a question with regards to the representativeness of practice in the project since only exemplary teachers were included in the study. Ms Lawrence called for a need for further and more widespread mapping of what is happening in practice to study if this disconnection is present throughout education whilst reflecting on the implications this might involve.

With regards to practice in England, teachers are often heard commenting that they cannot carry out certain things in the classroom. However, it would be interesting to investigate how many of the barriers are real barriers. Even though on a policy level the early years education includes stages of development that map out content, there is also a focus on characteristics such as affective learning and problem solving. With regards to assessment of creativity, there seems to be a lack of emphasis in policy. However, with regards to creativity, its characteristics, such as expecting children to ask questions, to answer them on their own through investigation, maintaining curiosity, encouraging creative risk taking, linking teaching to social and emotional aspects, are already present in policy. According to Ms Lawrence therefore we have the permission to engage children in creative learning; however, it is still absent in practice. Teachers need to develop the confidence to do so.

With regards to case studies collected as part of the project, Ms Lawrence questioned their future use. She suggested that they need to be accessible and searchable in order for teachers to use them and organized in a way that minimizes the risk of the teachers to take them out of their context. Apart from the use of these resources teachers need to be motivated to undertake CPD around creativity. To conclude, Ms Lawrence declared that she sees opportunities where the resources generated by the project can be used to make a difference and get teachers doing what we deem important with regards to creativity and IBSE.

Wim Peeters, Pedagogic Advisor at vzw PBDKO and Vice President of GIREP, Belgium

Mr Peeters began his contribution by illustrating that in Belgium there is a new movement towards the renewal of secondary curriculum, which will have effects on primary education. A particular change concerning the field of science involves the separation of world orientation learning area that takes up 4 to 6 hours a week into two different areas: man and society and technology and science.

The parallel efforts of SECURE and *Creative Little Scientists* project are also highlighted by Mr Peeters who describes SECURE's aim as evaluating the science education curriculum to identify gaps in the transition between primary and secondary levels. A similar recommendations generated from SECURE involves stimulating the motivation of children in science education especially during the critical age of 10 years.

Mr Peeters also outlined some additional ideas for further questions and research as certain neurological research points out the importance of stimulating young children as early as possible, which in fact corresponds to the project's findings. He also commented on how

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SECURE was not able to cover the thoughts of 5 years old children. Therefore, *Creative Little Scientists* complements SECURE through providing data concerning this young age group. Mr Peeters suggested that the results from both projects should be put together.

A concern that was highlighted included that even if a lot of work is needed with regards to stimulating children in the early years, this must be followed by support beyond the age of 8. There's no use in changing things in early years if these changes are not continuous throughout different ages.

To conclude, Mr Peeters discussed that even though teachers strive to do the "good" thing in class, their perspective of what is good is sometimes too optimistic and not always efficient. Therefore, teachers should be assisted in becoming aware of what they are doing and of the opinion of children in their classroom. They should develop reflection tools such as to try to investigate and gather some data on their own efficiency, the learning that takes place, in order to become researchers themselves.

Parallel Thematic Workshops

The conference was attended by people from a variety of EU countries. The participants include senior policy makers and representatives of the wider education community – professional associations, student teachers, teacher educators, school leaders, academics and researchers. The Workshops were intended to foster discussion and the sharing of experiences among a wide range of people and organizations concerned with these issues around the world. Participation to the Parallel Thematic Workshops were by invitation only. This ensured that stakeholders with both relevant and wide background and interest were represented in each Workshop. Specifically, the objectives for the Workshops were to:

- Identify and clarify the main challenges in a range of areas concerned with enabling creativity in early years science and mathematics education;
- Review and respond to the directions and recommendations in the *Creative Little Scientists* reports to policy makers and teacher educators;
- Identify priorities for further action at national and international levels.

To help structure the discussions, a brief summary of each theme was provided to participants. However, since the themes are inter-related and overlap to a considerable extent, participants were encouraged to draw on the range of issues canvassed throughout the three documents and the *Creative Little Scientists* Final Report as a whole.

Each session comprised of two hours of discussion. Each session had a Chair responsible for managing the discussion. A Presenter from the *Creative Little Scientists* project initiated the discussion by outlining the main relevant issues and/or policy directions in the *Creative Little Scientists* Final Report. Three Rapporteurs, one for each workshop, took notes of the discussion and prepared a summary of the discussion for presentation to the conference plenary session on Sunday 23 March 2014.

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The three Themes for the Parallel Thematic Workshops were:

THEME A: Policies for enabling Creativity through Science and Mathematics in Early Years Education

THEME B: Teacher Education for Enabling Creativity through Science & Mathematics in Early Years Education

THEME C: Reflections on Research into enabling Creativity through Science and Mathematics in Early Years Education

The descriptions and materials handed out for all three Thematic Workshops can be found in Appendix B.

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DAY 2: Sunday 23 March 2014

Plenary 1 (in Greek – interpretation to English available) What have we learned about creativity in the Greek early years science and mathematics education? by Dimitris Rossis, Ellinogermaniki Agogi

Mr Rossis introduced the *Creative Little Scientists* research project to the audience, in order to give a background of the research especially to the participants who did not attend the first day of the conference. The research questions, purpose and aims, partners and research procedures followed were highlighted. Mr Rossis noted that the main difficulty encountered was to find a common code between partners' different experiences and traditions in the education system to come up with a common language and research tools. The different stages of the project including the conceptual framework, framing of factors that were used to compare practices in the different partner countries, the policy desk research, teacher survey and fieldwork where classroom practice was observed were outlined. The final outcomes of the project were also presented as involving guidelines for teacher education, the presentation of exemplary teacher training materials and the Final Report.

Presentation of Results

Aims and objective in policy: Policy focuses on; producing conscious and responsible citizens also with regards to mathematics and science, developing and promoting the cognitive aspects of learning and teaching, and helping children be creative in broader society. However, creativity is not directly mentioned, but discussed through the mention of imagination and initiative in policy. The policy also promotes cooperation, positive stances

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to learning and acquiring knowledge through creative procedures. What is lacking is the importance of understanding the nature of science. Creativity is indirectly mentioned through a mention to research and curiosity in preschool but most commonly in primary schools. What is common for EU countries and Greece includes the limited attention given to creativity and its role in children's cognitive development and understanding of scientific ideas.

Aims and objectives and teachers' perspectives: The teacher's perspective with regards to aims and objectives is in line with the curricula as they also highlight the importance of developing awareness in children and developing responsible citizens. The above mentioned limitation of policy is mirrored in the teacher's perspectives as they also do not use or focus on the nature of science.

Learning activities in policy: Policy focuses on activities that include hands on activities that involve making conclusions and communicating them, with certain freedom regarding the choice of topics for exploration. Emphasis is also given to procedures that allow these activities to be connected to reality and linked to the children's life, especially in pre-school. With regards to primary education there is a greater focus on children acquiring science and mathematics knowledge.

Learning activities and teachers' perspectives: Their perspective was in line with the approach promoted in policy as they deemed IBSE, the use of simple equipment, and focusing on questions asked by children as important.

Fieldwork Results: Fieldwork was characterised by activities that involved explaining facts, observation and investigating issues linked to real life. An important factor identified as influencing practice comprised the overall philosophy and environment of the classroom and the school settings that in turn influenced the time and space teachers had to foster creativity. In pre-schools free play was considered as an appropriate approach to motivate children's interest whilst in primary school this was replaced by more structured play, such as role-playing and problem solving. Again it could be observed that limited attention was given to affective factors, to drama, natural science, play, questions especially children's questions, use of the outdoors to facilitate learning and to mental processes such as reflection and imagination.

Evaluation of Greek findings

- There is a present emphasis on acquiring knowledge, promoting children's communication skills through collaboration, communication and reflection.
- Limited space for creativity and individual aspects of creativity.
- Emphasis on building positive stances.
- Limited use of self- and peer- assessment
- Creativity in curriculum not clearly defined - only indirectly through imagination and curiosity.

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- Fieldwork shows potential with regards to promoting creativity through investigation, problem solving, the use of variety of materials and the promotion of social and affective aspects of learning.
- However, the climate and philosophy of the school may cause obstacles, limiting the teaching and learning about the nature of science. Other obstacles include not establishing a common definition or meaning of creativity between different teachers within the same school and the lack of time in primary school as perceived by teachers.
- An established need is the need for coherence between the curriculum's objectives and forms of assessment in order to promote creativity throughout early years.

(Mr Rossis' full presentation exists on the website: http://conference.creative-little-scientists.eu/)

Plenary 2
Other relevant EU Projects

Pri-Sci-Net

Prof. Suzanne Gatt, University of Malta, Malta

PRI-SCI-Net aims at promoting inquiry-based learning in early years science education, making primary science an area of knowledge in itself, and changing pedagogy in doing science with young children from the age of 3 to 11 years. It aims to do so through gathering and involving a number of key players and stakeholders in science education. In this project IBSE at primary level is viewed as a teaching and learning framework with implications about

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learning science, learning to do science, and learning about science. In this framework children are encouraged to engage actively in the learning process, that is characterised by asking questions of interest to the children, child initiated questions, testing out phenomena together, observing, collecting evidence and drawing conclusions to put forward an argument. This can only be achieved through collaboration, where children construct knowledge together and as a result develop autonomy and self-regulation. The teacher should take the role of an expert inquirer who uses scaffolding and encourages and facilitates collaborative problem solving.

How do we achieve this?

This project involves the collection and dissemination of 45 IBSE activities that are going to be translated in languages other than English to break the language barriers and make the resources as accessible to teachers in different countries as possible. It also involves 52 national training courses, 3 international training courses and 2 international conferences with the joint aim to create collaborative networking between teachers and researchers. In order to promote science this project also intends to recognize and value the achievements of teachers, schools and young researchers to keep supporting and encouraging good practice. Teachers are also supported financially and sponsored to attend teachers, workshops from different partners, international from provider to the teachers. There is also the ambition to create a platform that is accessible to teachers to download and use the collected resources.

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SECURE

Wim Peeters, Pedagogic Advisor at vzw PBDKO and Vice President of GIREP, Belgium

This project entails pedagogic coaching between the Ministry of Education and schools in order to help teachers with regards to teaching physics and natural sciences. With an international team of participating countries the project sets to balance the needs between training for future scientist and the broader societal needs whilst also exploring how these needs are present in curricula. The curricula are evaluated in terms of the intended, implemented and attained outcomes with regards to natural sciences.

The participants ranged from different school systems representing 5 years old, 8 year olds, 11 year olds and 13 year olds to cover all the educational systems. The subject of sciences involved the investigation of mathematics and natural sciences. Similar to *Creative Little Scientists* this project also made use of Van den Akker's spider web framework with the addition of motivation and interest variable, as the perception of children was sought after. Apart from evaluating science the curricula were also evaluated against the broader societal needs, such as health aspects and environmental awareness. Research tools such as questionnaires and interviews were used with no intention to generate statistical indications or representative data of the countries.

According to Wim Peeters the weakest point of the project involved the 5-year old cohort since curricula involving this particular age group are often general and at times separate or a part of the primary years curriculum in different countries. An example of an aim declared in the Cypriot curriculum of 5-year olds included developing self-confidence and perceiving mathematics as creative activity along with developing conceptual understanding and familiarizing with the methodology used.

The most interesting finding involved the drop in motivation and interest towards MST education between the age of 8 and 11 years old. The research also noted a gender difference in attitudes both in the child and teacher questionnaires. In using groupwork the class teachers do not tackle present gender differences. Having said so, group work does not occur as frequently as suggested in policy. Other results demonstrate that context-based learning encouraged in policy is also not frequent in practice. The results also show that teachers declare that 22% of low achieving pupils never receive separate and adapted instruction. On the whole the results also show that mathematics is faring better than science, as the teacher take more responsibility for this subject.

Some recommendations brought forward include:

- Focus on presenting more challenges and support for all in early years
- New and challenging general MST framework needs to be established to support innovative MST education
- IBSE needs to be more structurally and consistently implemented in early years
- Integrated use of ICT
- Better trained teachers with a focus on lifelong training

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- Design and promote formative and summative assessment as teachers need more knowledge on how to assess
- Provide stimulating and interesting MST education during the crucial age of 10 years and also in the early years
- Promote MST's interest in both boys and girls taking in consideration the possible gender differences.

SiS-CATALYST

Peter Gray, Research manager, NTNU, Norway

This project presents children as 'change agents' for science and society. Its aims involve shedding light on the relationship between science and different children from different backgrounds and contexts. A unique feature of this project's aims includes giving children's voices primacy when talking about science, since not enough energy is directed towards understanding what children think during science activities. The project also looks at young people's access to science education and why some young people have limited access to university in the future.

Work is being done with locally defined minorities, where a group in a certain locality is identified with less access to the education system. The inclusive excellence concept drives this project to find ways of dealing with people from disadvantaged backgrounds, helping them to stay in the system and do well. In order to do so, success stories from these minorities are sought and shared with the group itself to propel people in danger of failing to succeed. The project also Identifies what change needs to be taken and who can make these changes happen to change certain societal structures that create barriers.

CREANET

Nicola Catellani, Coordinator, SERN, Italy

The main objective of this project is to develop a forum for discussion of research and for the exchange of best practices of creativity in early years education. There are in all 12 partners from 10 different countries together with 35 associated partners that include pre-schools. The target groups for this project include practitioners such as teachers, pre-school managers, local level managers of pre-school and policy makers. As the title indicates the purpose is to create networking strategies, to initiate and strengthen connections and links in order to establish a shared understanding of creativity in pre-school and exchange best practices among pre-school teachers. This networking enables both international and local links.

The project arrived at a common understanding with regards to features of creativity in preschools that include: novelty, independence, self-esteem, self-expression, risk, curiosity and inventiveness. The project also aimed at analysing the teachers' point of view with regards to creativity through conducting questionnaires, interviews and focus groups. The analysis included finding and reflecting on the good practices, as well as a working group of networking teachers interacting with each other to promote the identified features of creativity. The research outputs of this project include 3 books.

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EARLY CHANGE PROJECT

Vassilis Grammatikopoulos, University of Crete, Greece

The aim of this project is to enhance professional development of early childhood educators through enhancing self-assessment skills and research skills. The ECERS-R observational scale is used and promoted for evaluation and research purposes and also for professional development. The purpose behind this promotion is to get early years teachers familiar with this instrument and learn how to use it in practice to enhance their self-assessment skills.

There are 9 different universities as partners along with 10 municipalities of districts in 6 different countries with various participants ranging from early years experts to early education. The first phase involves the training phase where educators are prepared to acquire skills that enhance their self –assessment skill and to use the observational scale. Afterwards the practical training commences where the educators participate in group discussions. After that the educators are asked to use the observation scale in 5 classrooms and analyse and interpret results with the help of a supervisor. There are no final results yet but there is a strong indication that there was a high level of satisfaction with the scale and that the knowledge acquired was valuable and easy to implement, resulting in an increase in the teachers' self-efficacy.

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Parallel Teacher Workshops

The next session was dedicated to four workshops for teachers which presented a series of teaching activities in early years science and mathematics that have the potential to promote children's creativity. A total of 100 (25 per workshop) registered participants took part in the workshops which covered both preschool and primary education.

The description of the four workshops follows.

Workshop BEE (in English)

Encouraging creativity within problem solving and inquiry in early mathematics and science

led by

Esme Glauert,Institute of Education, University of London
Ashley Compton, Bishop Grosseteste University College Lincoln, UK
Hilde van Houte, Arteveldehogeschool Gent, Belgium

The workshop will combine practical activities with an examination of teacher education materials from the Creative Little Scientists project to explore and reflect upon opportunities for creativity within problem solving activities in science and mathematics.

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Workshop outline

1. What do we mean by problem solving, inquiry and creativity in mathematics and science?
2. Practical activities - identifying opportunities they provide for inquiry and creativity.
3. Identifying opportunities for children's decision making in the classroom.
4. The roles of the teacher in fostering inquiry and creativity.
5. Implications for teaching, learning and assessment.
6.

Workshop CAT (in Greek)

Teaching about Sound (to 6-8-year olds), Learning activities developed as part of the Pri-Sci-Net project

led by

Marianna Kalaitsidaki and Nektarios Tsagliotis, University of Crete, Greece

The goal of the European funded project PriSciNet (October 2011- August 2014) is to promote inquiry based science teaching in primary and preschool education in Europe. It is a network of academic institutions from 15 countries, one of them being the Department of Primary Education of The University of Crete, Greece. Initially, a framework of inquiry teaching and learning was developed and agreed upon among the partners, and then 45 science activities for children 3-11 years old were developed. At the end of the project these activities will be available in 15 languages, Greek included.

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Teacher training in inquiry based teaching is critical for the dissemination and adoption of this approach throughout Europe. Teacher training is provided by PriSciNet through the organisation of international and national seminars by its partners. To this end, we organise this short hands-on training session in this conference, where, around 20 primary school teachers, in groups, will try out one of the PriSciNet activities for students of 6-8 years , the activity "Sounds: Participants will have the opportunity to share their experiences with inquiry teaching. Participants will also have the opportunity to register with PriSciNet so that they participate in its future activities (award for excellence, for those who implement successfully inquiry teaching in their classrooms, and a final conference in Malta, in July 2014.

Activities from Physics and Astronomy for Pre-primary and Early Primary Education: Ideas, suggestions and classroom experiences

led by

Maria Kallery, Department of Physics, University of Thessaloniki, Greece

In this workshop, teachers were presented with activities coming from physics and astronomy. These activities are devised to address mainly children of preschool and early primary grades and constitute examples, based on which, teachers can develop equivalent activities with topics coming from other fields of science. The workshop touched upon issues such as activities' learning objectives, the activities' process, the science process skills used, as well as methodological suggestions and approaches to learning, and approaches for the final assessment of the children's learning outcomes. Also presented during the workshop were classroom experiences coming from lessons recorded by the six early-years-teachers who implemented the activities with 104 children. Teachers were invited to express their opinions on the rationale and approach to the design of the activities as well as on methodological issues that play an important role for the children's response during the activities and during their final assessment.

Workshop DOLPHIN (in Greek)

Teaching about energy to 5-7-year olds

led by

Dimitris Koliopoulos, University of Patras

In this workshop participants were given the opportunity to learn and comment on activities related to the concept of 'energy' aimed at children aged 5-7. These activities were specifically designed to familiarize children with a variety of materials and situations (lighting a bulbs or moving a small motor using battery or solar cell) that can be described using a precursor mental model for energy.

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Discovering the world of probabilities

led by

Evdoxia Siolou and Jenny Pange, University of Ioannina, Greece

The ability to understand the randomness, to find the set of all possible outcomes of a random experiment and to identify the most possible outcome is referred as probabilistic thinking. The development of probabilistic thinking is evolving through four stages. The initial stage is characterized by subjective thought, the second stage is a transition from subjective thinking in naive quantitative thinking, in the third stage naive quantitative thinking evolves into informal quantitative thinking, while the fourth stage is characterized by numerical reasoning.

At the University of Ioannina, under the supervision of Mrs Jenny Pange, doctoral research entitled: "The use of new technologies in researching the perception and implementation of applied mathematical notions concerning young children: the notion of risk", has been made by Ms Zoe Nikiforidou. According to this research, preschoolers have intuitively developed probabilistic thinking. The results of this research and the fact that children with moderate mental retardation can develop their reasoning to the same extent as preschoolers motive researchers to launch another study about probabilistic thinking of children with moderate mental retardation, as shown by a relevant publication.

The workshop included experiential activities which can be undertaken by teachers along with students in their class. Through these activities, participants were given the opportunity to discover how to identify the interests of children in order to be able to shape the

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children's learning environment, which allows them to promote their probabilistic thinking in a creative way.

Workshop ELEPHANT (in Greek)

Reflecting on creativity in teaching and learning science & mathematics in preschool
Discussion of good examples of practice observed during fieldwork for 'Creative Little Scientists'

led by

Stella Antonakopoulou,13th Kindergarten of Rethymno
Maria Spatoula and Katerina Krokou, Elinogermaniki Agogi

An important part of the Creative Little Scientists project was dedicated to revealing the potential for creativity and the role of inquiry in the current classroom realities of preschool and first years of primary science and mathematics education. To achieve this, researchers carried out fieldwork in preschools and primary schools across the nine participating countries. The resulting research report includes a selection of exemplary episodes of learning and teaching from each partner country illustrating the variety of approaches observed and the possibilities identified for creativity in early science and mathematics.

The workshop allowed participants to engage with three of these exemplary episodes from both the teachers' as well as the researchers' perspective. Three Greek preschool teachers who took part in the fieldwork acted out these episodes while researchers presented the project's viewpoint of them. The aim of the workshop was to bring out the potential for

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creativity in day-to-day early years classroom practice of science and mathematics education, as well as display some of the benefits of teachers' participation in educational research.

Plenary 3
Summary Reports from Saturday Workshops

The rapporteurs from the three Parallel Thematic Workshops on Saturday reported on the discussions during the workshops and presented the main points brought up by the invited stakeholders. A summary of the main points presented follows.

THEME A: Policies for enabling Creativity through Science and Mathematics in Early Years Education

Issues in Teaching, learning and assessment

- Inquiry-based learning and the promotion of creativity ideally require changes to assessment
- Awareness of other EU projects such as ASSIST-ME, SAILS
- Value to role of pupil opinion
- Assessment vs development of learner profiles
    - Multimodal evidence for learning
    - What would this cost?
    - Self-collection of evidence
    - Importance of class size
- PISA as a pan-Euro assessment system, driving policy – how does it relate to need for individual assessment of learners?

Challenges

- Role of textbooks – a significant constraint to promoting creativity
- Coupling creativity to learning outcomes
- Primary Teachers' ownership of subjects – Initial Teacher Education role in promoting this
- Student engagement, interest, achievement or career choice?
- Teachers have potential for - both interest in and lack of it - applying new curricula to real contexts
- Policy discontinuity, varies from year to year – curriculum over-stuffed
- Could we disconnect school system from policy cycles?
- What level of policy do we need to focus on?
- TE in Greece as more autonomous but uncoordinated, pre-school more open to teacher skills and (quality)
- Rate of change in TE, faster than elsewhere, not so scientific

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Priorities

- Team teaching, collaboration
- Terminology – a more coherent discourse?
- Pay, de-professionalisation, and performance related pay?

Recommendations

- Explicit focus on Creativity needed, but danger of reification as separate topic
- Need to encourage:
  - Understanding of science
  - NOS
  - Reflection
  - Social/affective dimensions
- Question of authentic contexts
- Space & time for problem solving
- Varied contexts
- Recognition of abilities of children
- Encourage dialogue with parents

THEME B: Teacher Education for Enabling Creativity through Science & Mathematics in Early Years Education

Observations

- Initial teacher education-CPD continuum
- Teachers (should) learn in the classroom – practitioner inquiries?
- Level of specification – need to be realistic
- Level of impact – individual, school, regional, national
- What do they look like in practice?

Common teacher perceptions

- How do teachers see themselves?
  - self-esteem/image/confidence
  - Professional identity
- Motivation and attitude – need to change mentality

Barriers

- Concerns over lack of subject knowledge – why do teachers need subject knowledge?
- TIME: a reason or an excuse

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- Priorities
- Whole school approaches

Recommendations

- Need to involve teachers in curriculum development – "there is no curriculum development without teacher development" (Stenhouse)
- Training teachers like 'engineers':
    - Design practices
    - Construction / implementation
    - Testing /evaluation
- Teacher autonomy – trust & responsibility

THEME C: Reflections on Research into enabling Creativity through Science and Mathematics in Early Years Education

Applicability of the definitions of creativity in mathematics and science, and the synergies between IBE and CA

- Synergies between Inquiry-Based Education and Creative Approaches describe a pedagogical framework broadly applicable to different age groups (e.g. elder students, adults) and different subject areas, e.g. technology, that require problem-solving
- Synergies of creative practices seem to describe generally "good" practices, basic principles of learning
- With respect to the nature of science, creative reasoning and science teaching, the conceptualization of creativity in early science and mathematics should include the aspect of negotiation of ideas and putting forward arguments according to existing evidence (nature as the final judge in inquiries, not the teacher)
- Recommendation of the workshop group to refine the wording of the definition of creativity in early science and mathematics to *"Generate alternative ideas and strategies as an individual or community and reasoning critically amongst these, and between them and plausible explanations and strategies that are consistent with the available evidence"*

Challenges and implications of *Creative Little Scientists* research methodology for future research in creativity

- Multi-layered approach of policy analysis, stakeholder perspectives and fieldwork
- Field work included many methodological , conceptual and practical challenges: short time frame, size of sample, different languages, getting consent of parents, developing instruments for measuring 5-year-olds

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perception and creative reasoning, finding consensus in observation criteria, training observers, developing ways of categorizing and analysing the data

- Time in the research project was very short to solve all these questions in the project while starting the empirical observations and interviews – futures studies can build on this experience and should take time to tackle these challenges
- The qualitative approach yielded rich documentations that showed examples and key moments of good science teaching; children used documentations (photos, videos) for remembering and telling what they did and learn, teachers appreciated getting their videos to reflect on their own teaching and compare their preconceptions and actual performance
- Research yielded results very useful for practice

Recommendations for future research

- Focus on actual classroom practice instead of curriculum (research on what teachers do, and not on what they should do)
- Specify conceptualization on what to observe and develop instruments to investigate questions such as the role of informal learning in fostering creativity over time
- Need of precise definitions and assessment tools
- Clarify peer and self assessment, link it to a framework of personal development and development of creative dispositions in early science and mathematics

Plenary 4
Keynote Address: Inquiry-oriented science teaching: the role of design-based research

What is going to happen next? Science in society programme

The Science Group in Cyprus University's vision is to contribute to science educational community and research community internationally. It aims at involving members of different countries to collaborate together involving teachers, researchers, policy development and graduates to design online learning environment that can be used in science education. The concern of this collaboration centres on the question of how we can use innovation as a tool and as a context in local and international schools.

Further aims of the Science in Society project includes creating Internet environments, working at EU level, becoming involved in curriculum design, disseminating inquiry based science education materials and practices through CPD.

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A personal perspective on the evolution of Science in society programme

Dr. Constantinou described how a new emphasis in school education should be on broad science literacy for all students. This should be accompanied by a change in priorities to give importance to the equal footing of science education for all.

When looking back at the achievements of Science in Society programme, in 2004 the focus on pedagogy and IBSE was visible and acknowledged with an emphasis on maintaining children's natural curiosity, motivation and interest in the learning of science. This emphasis led to broadening of this pedagogy to mathematics and to the initiative to support teachers in using IBSE.

Dr. Constantinou commented that achieving change or having an impact on the educational system is not an easy accomplishment. In order for research to obtain this outcome, researchers, policy makers, teachers and education stakeholders need to rely on credible and reliable knowledge from research. Dr. Constantinou also identified two important roles of researchers:

1. Creating credible knowledge
2. And illustrating what we mean so as the knowledge we create can be enacted through educational innovation.

The *Creative Little Scientists* Final Report was described by Dr. Constantinou as taking the responsibility and care to find a definition for creativity in a way that makes sense to practitioners as it illustrates what creativity will look like. Additionally it provides illustrative materials that make sense in the school context to practitioners.

Problems identified in Science Education

There is an inherent tendency in educational research to discredit theoretical ideas through a process of recycled concepts and terms as well as a pervasive non-rigorous use of these concepts.

A problem identified in the Rocard Report involved the definition for 'science', as in this 'science' involves an attempt to model 'objective reality' and acquire knowledge based on the 'scientific method'. This definition is described as not good as there is no **one** 'scientific method' and no **one** objective reality. And yet this definition became important at policy level guiding research funding over 7 years. This definition was interpreted as a need to promote hands-on science.

What is inquiry-based science?

1. Argumentation: new framework in science education
2. Inquiry vs Investigation: There seems to be confusion around these two concepts, as we do not distinguish between them. If we are not careful to protect our theoretical ideas and use them coherently we can come to a point that an idea that means everything to anyone, pretty soon will mean nothing to everyone which will lead to waste of resources. Unless we take the responsibility to become theoretically

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coherent, we are limiting educational research and its impact on educational systems.

An important solution to the discrediting of theoretical knowledge in educational research has been discovered at the Cyprus University where design based research has been identified as a solution. This research paves the way for the community around researchers to facilitate the mission to decrease the gap between theory and practice. This is done through working with ministries, have pilot sites in the community in order to test innovation, involve teacher networks to do collaborate design that makes sense to their practice and increase ownership of practitioners of this shared conceptual space.

Hopes for the future

1. Find way at EU level to promote systemic change and reforms.
2. Involve local education systems to increase ownership of research projects and their results.
3. Try to take advantage of existing knowledge such as *Creative Little Scientists* to connect creativity to science and IBSE, and use the exemplary teacher training materials to bring about systemic change.
4. Take a step back and fund projects to help teachers shift toward IBSE since we have now established that it is evidence validated practice. Identify the process to facilitate this shift at EU policy level.
5. Produce evidence that effective change is taking place.
6. Need to be more scientific in documenting and designing science education.

To conclude Dr. Constantinou summarized that we need to take responsibility to create theoretical coherence. He also identified the discrediting of theory as a symptom of our failure to facilitate rigours action and change. He also states his belief in IBSE and in DBR where researchers work within the context of practice and community.

(Dr. Constantinou's full presentation exists on the website: http://conference.creative-little-scientists.eu/)

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APPENDIX A: CONFERENCE PROGRAMME

Saturday 22 March 2014			
Room for Plenaries: Central Meeting Hall (Basement)			
09.00-09.30	**Registration**		
09.30-10.30	**Official Opening** Chair: *Sofoklis Sotiriou, Ellinogermaniki Agogi, Greece* *Representative of the Greek Ministry of Education and Religious Affairs, Sport and Culture*		
10.30-11.30	**Plenary 1 - Keynote Address** Journeys in creativity *Patricia Cochrane, CapeUK* Comments and Questions		
11.30-12.00	**Coffee Break**		
12.00-12.45	**Plenary 2 - What have we learned?** The Final Report from the EU 'Creative Little Scientists' Project *Fani Stylianidou and Dimitris Rossis, Ellinogermaniki Agogi, Greece*		
12.45-14.00	**Plenary 3 – Round Table** Responses to the Final Report from Stakeholder Organizations Chair: *Suzanne Gatt, University of Malta, Malta* *Katerina Plakitsi, Associate Professor at University of Ioannina, Greece* *Jukka Rahkonen, Teacher and Advisor to the Finnish National Board of Education, Finland* *Peter Gray, Research manager, European Projects, NTNU, Norway* *Liz Lawrence, past Chair of Association for Science Education, UK* *Wim Peeters, Pedagogic Advisor at vzw PBDKO and Vice President of GIREP, Belgium* Comments and Questions		
14.00-15.00	**Lunch** (offered by *Ellinogermaniki Agogi)*		
15.00-17.00	**Parallel Thematic Workshops (only by invitation)**		
	Theme A	**Theme B**	**Theme C**
	Policies for enabling Creativity through Science and Mathematics in Early Years Education	**Teacher Education for enabling Creativity through Science and Mathematics in Early Years Education**	**Reflections on Research into enabling Creativity through Science and Mathematics in Early Years Education**
Room:	**B 123**	**B 121**	**B 119**
Chair:	Sari Havu-Nuutinen *University of Eastern Finland, Finland*	Ashley Compton, *Bishop Grosseteste University College Lincoln, United Kingdom*	Teresa Cremin, *Open University, United Kingdom*
Presenter:	Fani Stylianidou, *Ellinogermaniki Agogi, Greece*	Hilde van Houte, *Arteveldehogeschool Gent, Belgium*	Esme Glauert, *Institute of Education, University of London, United Kingdom*
Rapporteur:	Peter Gray, *Research Manager, European Projects, Norway*	Derek Bell, *Education Consultant, UK*	Janna Pahnke, *Haus der kleinen Forscher, Germany*
17.00-17.30	**Coffee Break**		
17.30-18.00	**Closing of Day 1**		

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Sunday 23 March 2014

Room for Plenaries: Central Meeting Hall (Basement)

09.00-09.30	**Registration**
09.30-10.00	**Plenary 1 – What have we learned about creativity in the Greek early years science and mathematics education?** Findings about Greek education from the EU 'Creative Little Scientists' Project *Dimitris Rossis and Fani Stylianidou, Ellinogermaniki Agogi, Greece*
10.00-11.30	**Plenary 2 – Other relevant EU-Projects** Chair: *Adelina Sporea, NILPRP, Romania* Pri-Sci-Net - *Suzanne Gatt, University of Malta, Malta* SECURE - *Wim Peeters, Coordinator, Belgium* SiS-Catalyst - *Peter Gray, Nat. Coordinator, Norway* CREANET - *Nicola Catellani, Coordinator, Italy* EARLY CHANGE PROJECT – *Vasilis Grammatikopoulos, Coordinator, Greece*
11.30-12.00	**Coffee Break**
12.00-13.30	**Parallel Teacher Workshops**

Workshop BEE	Workshop CAT	Workshop DOLPHIN	Workshop ELEPHANT
Language: English	**Language: Greek**	**Language: Greek**	**Language: Greek**
Encouraging creativity within problem solving and inquiry in early mathematics and science *Esme Glauert, Institute of Education, University of London, UK* *Ashley Compton, Bishop Grosseteste University College Lincoln, UK* *Hilde van Houte, Arteveldehogeschool Gent, Belgium*	**Teaching about sound (to 6-8-year olds)** (Learning activities developed as part of the Pri-Sci-Net project) *Marianna Kalaitsidaki, University of Crete* *Nektarios Tsagliotis, 9th Primary School of Rethymno, Greece* **Physics and astronomy activities for preschool and first years of primary school** *Maria Kallery, University of Thessaloniki, Greece*	**Teaching about energy in preschool** *Dimitris Koliopoulos, University of Patras, Greece* **Discovering the world of probabilities** *Evdoxia Siolou and Jenny Pange, University of Ioannina Greece*	**Reflecting on creativity in teaching and learning science & mathematics in preschool** *Stella Antonakopoulou, 13th Kindergarten of Rethymno* *Maria Spatoula and Katerina Krokou, Elinogermaniki Agogi, Greece*

13.30-14.30	**Lunch** (offered by *Ellinogermaniki Agogi*)
14.30-15.30	**Plenary 3 – Summary Reports from Saturday Workshops** Chair: *Annette Scheersoi, University of Bonn, Germany* Key Messages for Policy Development and Implementation Presentations by Workshop Rapporteurs *Comments and Questions*
15.30-16.30	**Plenary 4 - Keynote Address** Inquiry-oriented science teaching: the role of design-based research *Costas Constantinou, University of Cyprus, Cyprus* *Comments and Questions*
16.30-17.00	**Closing Remarks** *Sofoklis Sotiriou and Fani Stylianidou, Ellinogermaniki Agogi, Greece*

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APPENDIX B

Enabling Creativity through
Science & Mathematics in Early Years Education

International Conference

22-23 March 2014

CONFERENCE PARALLEL THEMATIC WORKSHOPS

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THEME A
Policies for enabling Creativity through Science and Mathematics in Early Years Education

One of the main objectives of the *Creative Little Scientists* is to establish the details of the current landscape in official policy, and provide insights into whether and how children's creativity is fostered, identifying the emergence of appropriate learning outcomes in science and mathematics. Policy conceptualisations in teaching, learning and assessment of science and mathematics in Early Years across Europe are considered particularly important in the *Creative Little Scientists* project in order to develop a better understanding of challenges and strengths of science and mathematics education in Europe.

The proposed policy recommendations have been based on the findings of the theoretical review, comparative studies, and in-depth field research that took place as part of the project. In addition they have 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 fields of inquiry, creativity or science – in online and face-to-face focus groups.

The synthesis of the aforementioned research studies provided an arena to make comparisons between the countries, but also to make comparisons with existing practices recorded by teacher survey and fieldwork. The policy analysis has been formulated to answer to following questions:

- *How are the teaching, learning and assessment of science and mathematics in early years conceptualised by the policy of partner countries? What role does creativity play in these?*

Key aspects of policy analysis of teaching, learning and assessment have been derived from the framework of curriculum components the 'vulnerable spider web' (see van den Akker, 2007) and systematically used in all phases of data analysis in the project. Ten components relating to a curriculum were identified as the basis for a set of curriculum design principles for teacher education: Rationale or Vision of the curriculum; Aims and Objectives; Content; Learning activities; Role of Teacher Educator; Materials and Resources; Grouping; Location; Time; and Assessment. The Rationale refers to the central mission of the curriculum; it is the major orientation point and the nine other components are ideally linked to it and preferably consistent with each other. It should also be noted that the components are not in any hierarchical order and should not be viewed in isolation; they are both interconnected

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and interdependent. The spider web is deemed vulnerable since without strength in all nine areas the web becomes weaker.

Key findings from policy analysis of teaching, learning and assessment in early years science and mathematics education

- Policy guidance in the partner countries tends to focus in its rationale on specific drivers for science education, such as the need to develop socially and environmentally aware citizens and the importance of fostering skills and dispositions to support future learning
- The **purpose of science education** in policies across the partner countries is 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,
    - Economic benefits of developing children's basic skills and dispositions are given in France, but also in Flanders.
- The **learning aims and objectives** of the science curriculum tend to focus more often on cognitive factors than social and affective factors of science learning. The development of process skills associated with scientific inquiry and of knowledge, and understanding of science ideas, mainly in primary school, is seen as the core issue in learning science.
    - Cognitive aspects clearly outlined in Finland, France, Greece, Portugal, Romania and England.
    - Motivational skills are considered as a main learning outcome in 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.
- Policy documents across the consortium make limited reference to knowledge and understanding of the **nature of science**.
- In guidance of **learning activities** inquiry and inquiry orientated process skills were recommended in curricular policies across the countries. However, inquiry skills associated with planning and conducting investigations and using data to construct explanations did not have such a remarkable role in curriculum guidance.
- **Dialogue and collaboration** as well as **motivation and affect** are generally emphasised in the pedagogy of policy documents, but its role as creativity enabling is not explicitly described.

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- **Science as a subject** is seen very similarly across the partner countries. Linking science with other curriculum areas is more strongly emphasised in the preschool phase.
    - Only a few countries include commentary that suggests curriculum content potential to enable the development of children's creativity (for example preschool policy in Finland, Germany and Greece or primary policy in Finland).
    - Role of creativity is generally identified as implicit.
- Policy guidance across the partner countries focus on the children's **physical exploration of materials** and **problem solving and agency** in both phases of education, and **questioning and curiosity** more in preschool. However, these attributes are more often seen as creative enabling in preschool than in primary education.
- The importance of **formative assessment** is increasingly recognised in policy but there is a lack of policy guidance in terms of both methods of assessment and criteria for formative assessment.

Key recommendations for policy development across Europe in early years science and mathematics education

- Give greater recognition to young children's capabilities to engage with processes associated with **evaluation as well as the generation of ideas in science** and mathematics, and with understandings related to the nature of science.
- Foster the role of **social and affective dimensions of learning** and their connection with cognitive dimensions of learning such as engagement, evaluation skills and understandings related to the nature of science.
- Need for guidelines about teaching and learning approaches which are sensitive to children's **multimodal expression**, particularly those in which children's motivation, interest and different everyday related activities such as imagination, play and field trips are explicitly linked to early years science and mathematics learning.
- Inquiry activities supporting the children's **understanding of science ideas and nature of science** should be fostered. More attention should be given to reflection, consideration of alternative ideas and using the social and collaborative factors of learning and inquiry.
- Create **cohesion in assessment** between the aims and objectives of learning and priorities in assessment. More attention should be given to social and affective and inquiry related issues in assessment guidelines.
- **Assessment methods** should be clearly linked to the multimodal approaches used in classroom practices. Policy statements should foster the use of children's

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involvement in assessment and provide increased opportunities to mirror the children's various strengths and opportunities in their learning.

- Need to give greater value and attention to **formative assessment** including dialogue between children and teachers to identify ways forward for both learning and teaching. Further guidance on formative assessment approaches should be available to support classroom practices.
- Development of **on-going assessment strategies and criteria for assessment** to better reflect the emphasis on inquiry and creativity in the aims for science and mathematics in the early years.
- More explicit and detailed focus in policy on the **role of creativity in early science and mathematics**. Implicit connections to creativity commonly found in policy for early years science and mathematics need to be drawn out and exemplified to support teachers in translating policy priorities concerning creativity into specific classroom practices. Provide explanation and illustration of the nature of creativity in learning and teaching in early years science and mathematics.
- **Digital technologies and ICT resources** are under-exploited in preschools. Preschool teachers would benefit from training on best practices of their use and potential for creativity development in science and mathematics.
- Emphasise the need for **space and time for teachers** to practice inquiry approaches, to explore opportunities for creativity in learning and teaching in early science and mathematics and to gain confidence.
- More detailed attention to **key features of problem solving and inquiry based learning and teaching** particularly with regards to providing sufficient space and time in the curriculum for problem solving and inquiry to study areas in depth.
- Encourage **dialogue with parents and the wider community** concerning the aims of science and mathematics education in the early years including the development of skills, processes and attitudes associated with inquiry and their roles in developing not just factual knowledge but long term understanding of concepts.
- Emphasise the important **roles of play-based approaches**, child–initiated activity and practical investigation in both preschool and early primary school.
- Encourage **meaningful and authentic contexts** for inquiry linked, for example, to events and experiences in everyday life, children's interests and concerns, questions emerging from cross-curricular projects or explorations and issues in the wider environment beyond school.

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QUESTIONS FOR DISCUSSION

Please reflect on the following questions and be prepared to discuss them at the workshop.

1. How well do the proposed Creative little Scientists policy recommendations respond to the challenges countries face in promoting creativity in science and mathematics learning in preschool and the first years of primary education?
2. What barriers would there be to implement these policy recommendations? What is needed for successful change? What are the characteristics of successful strategies for change in policy? How can research results be effectively put forward in policy development?
3. What do you consider to be the major priorities for policy change in preschool and primary education in the areas of science, mathematics and creativity at national and international levels?

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THEME B
Teacher Education for Enabling Creativity through Science & Mathematics in Early Years Education

One of the key deliverables of the *Creative Little Scientists* project, D5.2 *Guidelines and Curricula for Teacher Training*[1], proposes 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. 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.

Both the proposed teacher education Curriculum Design Principles and Teacher Outcomes have been based on the findings of the theoretical review, comparative studies, and in-depth field research that took place as part of the project. In addition they have 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 fields of inquiry, creativity or science – in online and face-to-face focus groups.

Teacher Education Curricula promoting Creativity in Early Years Science and Mathematics

In the *Creative Little Scientists* project, the work of van den Akker (2007)[2] 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: Rationale or Vision of the curriculum; Aims and Objectives; Content; Learning activities; Role of Teacher Educator; Materials and Resources; Grouping; Location; Time; and Assessment. The Rationale refers to the central mission of the curriculum; it is the major orientation point and the nine other components are ideally linked to it and preferably consistent with each other. It should also be noted that the components are not in any hierarchical order and should not be viewed in isolation; they are both interconnected and interdependent.

[1] http://www.creative-little-scientists.eu/sites/default/files/D5_2_Guidelines%26Curricula_for_Teacher_Training_Final.pdf

[2] van den Akker, J. (2007). Curriculum design research. In: Plomp, T. and Nieveen, N. (Eds.). *An introduction to Educational Design Research*. Enschede, The Netherlands: SLO.

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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.

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CURRICULUM DESIGN PRINCIPLES

Rationale

Why are teachers learning?

Teachers (incl. student teachers) should foster inquiry and creativity in science and mathematics learning[3] in preschool and the first years of primary school.

Aims and Objectives

Towards which goals are teachers learning?

Competences for teachers

In teacher education teachers should:

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.

Foci of teacher education

Teacher education should:

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.

[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.

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Rationale

Why are teachers learning?

Teachers (incl. student teachers) should foster inquiry and creativity in science and mathematics learning[3] 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.

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Rationale *Why are teachers learning?* **Teachers (incl. student teachers) should foster inquiry and creativity in science and mathematics learning[3] 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.

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Rationale *Why are teachers learning?* **Teachers (incl. student teachers) should foster inquiry and creativity in science and mathematics learning[3] in preschool and the first years of primary school.**	
Assessment *How to measure how far teachers' learning has progressed? How is assessment information used to inform planning and develop practice?*	**Focus of assessment** In teacher education: 4.1 Teachers' acquisition and development of science/mathematics content and pedagogical content knowledge, skills and attitudes should be assessed. 4.2 The development of teachers' inquiry and creativity-based teaching and assessment approaches should be assessed. 4.3 Teachers' acquisition and development of understanding about what it is to foster children's creativity in science and mathematics should be assessed. 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. **Process of assessment** Teacher education should: 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. 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. 4.7 Use different forms of evidence (e.g. portfolios, teacher diary, observation lists, tests, essays, project work, teaching practice) for assessment purposes.

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Rationale

Why are teachers learning?

Teachers (incl. student teachers) should foster inquiry and creativity in science and mathematics learning 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.

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Rationale *Why are teachers learning?* **Teachers (incl. student teachers) should foster inquiry and creativity in science and mathematics learning in preschool and the first years of primary school.**	
Content (cont.) *What are teachers learning?*	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. 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. 5.15 Promote teachers' use of group work to support children's inquiry processes and creative learning. 5.16 Provide teachers with knowledge of approaches to timetabling and organizing cross-curricular project work. 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. 5.18 Encourage and assess the development of teachers' literacy, numeracy and digital literacy skills through science and mathematics.
Materials and resources *With what are teachers learning?*	Teacher education should: 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. 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. 6.3 Facilitate and promote access to materials and resources (including everyday materials) fostering inquiry and creativity in early years science and mathematics.

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Rationale *Why are teachers learning?* **Teachers (incl. student teachers) should foster inquiry and creativity in science and mathematics learning in preschool and the first years of primary school.**	
Grouping *With whom are teachers learning? How are they allocated to various learning trajectories? Are they learning individually, in small groups, or whole-class?*	Teacher education should: 7.1 Provide a range of learning trajectories to teachers to choose from according to their needs and preferences. 7.2 Promote collaborative learning practices, including peer learning, in science and mathematics education in order to foster creativity and inquiry. 7.3 Promote team teaching and working in the fields of science and mathematics education. 7.4 Support teacher collaboration, including at a distance through digital media and other ICT tools that make this possible. 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.
Location *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?*	Teacher education should: 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. 8.2 Facilitate access to industries and research centres of science and mathematics to promote collaboration, sharing, visiting, and networking of teachers. 8.3 Provide opportunities for place-independent and collaborative learning, i.e. flexibility and variety of teaching locations.

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

Teacher Outcomes: a set of concrete guidelines

In addition to the above teacher education Curriculum Design Principles, and based on the project's literature reviews and research findings, desired Teacher Outcomes were formulated. These (as seen below) are linked to the design principles of the 'Content' component of the spider web and contribute to the project's recommendations to teacher education institutions and teacher educators.

In deliverable D5.3 *Exemplary Teacher Training Materials*[4] advice is given as to how these Teacher Outcomes and the related set of Curriculum Design Principles can be used to frame sessions or workshops for ITE and CPD. Furthermore, exemplary teacher training materials originating from the fieldwork and linked to these Teacher Outcomes are proposed, together with suggestions about how to use some of these in training sessions or workshops.

[4] http://www.creative-little-scientists.eu/content/deliverables

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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	*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.*
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	*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*
5.6	Teacher education should provide pedagogical content knowledge to stimulate inquiry and problem solving in science and mathematics education.
5.6.1	*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.*
5.6.2	*Teachers should be able to open up everyday learning activities to allow greater opportunities for inquiry, problem solving and scope for creativity.*
5.6.3	*Teachers should be able to recognise the key roles of children's questioning and existing ideas (both implicit and explicit) of science and mathematics.*
5.6.4	*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).*
5.6.5	*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.*
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	*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.*
5.7.2	*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.*

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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. allower, 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	*Teachers should be able to design and assess open-ended learning activities.*
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	*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.*
5.9.2	*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.*
5.9.3	*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.*
5.9.4	*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.*
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	*Teachers should be able to use a range of strategies for picking up on children's ideas, theories and interests.*
5.10.2	*Teachers should be able to build flexibility into planning to take advantage of unexpected events, children's interests and questions.*
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	*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.*
5.11.2	*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.*
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	*Teachers should have knowledge of the various purposes and aims of science and mathematics education in compulsory schooling.*
5.12.2	*Teachers should have knowledge of the prevailing academic rationale for the place of science and mathematics in the early years curriculum.*

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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.*

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QUESTIONS FOR DISCUSSION

Please reflect on the following questions and be prepared to discuss them at the workshop.

1. How well do the proposed teacher education Curriculum Design Principles respond to the challenges countries face in developing preschool and primary teachers' attitudes, knowledge and skills?
2. What barriers would there be to enact these Curriculum Design Principles and Teacher Outcomes? What is needed for successful change in teacher education?
3. What are the major priorities for preschool and primary teacher education in the areas of science, mathematics and creativity at national and international levels?

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THEME C

Reflections on Research into enabling Creativity through Science and Mathematics in Early Years Education

The *Creative Little Scientists* project aimed to identify and characterise what, if any, creativity is evidenced in early science and mathematics, in relation both to children's learning and teachers' pedagogy. It focused on the following main research questions:

> *RQ1: Mapping conceptualisations:* How is the teaching, learning and assessment of science and mathematics in Early Years across Europe conceptualised in policy and by teachers? What role if any does creativity play in these?
>
> RQ2: *Probing practice:* What approaches are used in the teaching, learning and assessment of science and mathematics in early years? What role if any does creativity play in these?
>
> RQ3: *Probing practice:* In what ways do these approaches seek to foster young children's learning, interest and motivation in science and mathematics? How do teachers perceive their role in doing so?
>
> RQ4: How can findings emerging from analysis in relation to questions 1-3 inform the development of practice in the classroom and in teacher education (ITE and CPD)?

Issues for consideration

Conceptually: Drawing on substantial literature reviews, which encompassed research not published in English, the study commenced with co-joining five areas of substantive research into one Conceptual Framework. This significant and encompassing document afforded a strong theoretical frame from which to proceed.

An important task of the reviews (linked to research questions) was to examine conceptualisations in the literature of inquiry and creativity in early science and mathematics education, including synergies and differences between them. It was evident that creative approaches appear to include less emphasis on rational explanation and reasoned argument than inquiry-based approaches, which tend to highlight reasoning and metacognition in relation to a focus on scientifically or mathematically oriented questions. Notwithstanding their different emphases, both are employed as tools for knowledge construction and are motivational supports for the development of positive attitudes with regard to science, mathematics and creativity.

The *Creative Little Scientists* project, having documented that definitions of creativity were almost entirely absent in policy documentation across the partner countries, adopted its own definition. Significantly also it advanced a conceptual definition of creativity in

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mathematics and science with reference to the early years – namely that it involves '*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'.* This conceptualisation, developed from the literature, has been empirically tested in diverse classroom contexts across Europe through the project and has been found to be appropriate, valid and productive.

Additionally and significantly, the project's core conceptual work highlighted that a number of pedagogical synergies exist between inquiry-based and creatively based approaches. These, determined through detailed analysis of relevant literatures, innovatively examined for synergistic features, represent a core part of the CLS theoretical contribution. These include: play and exploration, motivation and affect, dialogue and collaboration, problem solving and agency, questioning and curiosity, reflection and reasoning, teacher scaffolding and involvement.

Methodologically: The comparative dimension of *Creative Little Scientists* recognised the differently-positioned curriculum framing of science, mathematics and creativity in partners' national policy documentation and acknowledged the range of interpretations and references to creativity in the Early Years. Creditably, both a questionnaire (accompanied by supporting judgements) and reflective discussion of key themes were used in the survey of policy across partner countries. This afforded important contextual information in order to interpret ratings in the questionnaire. Looking across the national reports enabled the mapping and comparison to be undertaken alongside additional thematic analysis structured around the curriculum components (van den Akker, 2007).

This multi-layered approach was further extended through the involvement of multiple stakeholders across the 9 partner countries and afforded a unique mix of policy analysis, stakeholder perspectives and fieldwork in 71 preschool and early primary settings across Europe. This represents an unusually large, rigorously collected and analysed data set of considerable practical importance and relevance. Nonetheless in order to ensure credibility and trustworthiness it required substantial cross moderation, and methodological training with regard to the common application of the rich range of research tools to be utilised or, in the case of the field-work to be selected from as contextually appropriate.

Whilst the fieldwork was comprehensive, well planned and documented across countries, the time frame of this work was fairly tight and fairly short. A more extended period would afford more in-depth understanding about the *development* of creativity in these curriculum contexts and perhaps reveal more about the role of play and exploration over time. In addition, more video based data would have been advantageous and the use of VSR with teachers might have enabled a more coherent picture of the teachers' understanding of creativity in science and mathematics contexts to emerge. Nonetheless the interviews with practitioners served a valuable purpose and informal conversations with educators sought to capture their views in this regard.

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Data: With regard to the comparative policy insights, both the mapping and comparing of recorded practices and the fieldwork highlighted a diverse picture of the influence of policy on opportunities for inquiry and creativity. Whilst policy in many of the partner countries advocates inquiry-based approaches, there are relatively few explicit references to creativity in learning within policy documentation. Though creative dispositions (e.g. curiosity or thinking skills) are mentioned, these are not framed within overt aims to foster creativity in teaching and learning. In addition although in some instances general references to creativity and inquiry are expressed in policy, these are often not reflected in specific curriculum or assessment requirements. This provides arguably conflicting and incoherent support for teachers and schools.

In applying the identified pedagogical synergies deductively to the cross-national comparative classroom-based field work, the empirical data indicate that across the data set as a whole, with close analysis of 218 episodes, differences exist with regard to the opportunities afforded play and exploration in the pre-school and early primary age phase. In addition the provision for and fostering of children's questions and curiosity was not as strongly evidenced across the exemplar classrooms visited, as was the development of motivation and affect, reflection and reasoning and the opportunities for problem solving in agentic collaborative and dialogic contexts. In these contexts teachers scaffolded by standing back to watch and listen attentively as well as intervened to extend children's understanding in diverse ways.

Fieldwork provided rich examples of young children's capabilities in mathematics and science. Children's inquiry skills and understandings noted in episodes were interconnected with evidence of a number of creative attributes. For example children's *motivation, curiosity* and *abilities to come up with something new* were evidenced in raising questions and in their active pursuit of explorations and investigations. The episodes offered many examples of children's *sense of initiative* and *growing abilities to collaborate* in deciding what to do in carrying out investigations. Children showed *imagination, ability to make connections and thinking skills* in offering explanations and reflecting on their experiences.

QUESTIONS FOR DISCUSSION

Please reflect on the following questions and be prepared to discuss them at the workshop.

1. To what extent do colleagues consider the definitions of creativity in mathematics and science, and the synergies between inquiry-based and creative approaches, applicable in other curriculum areas or age phases ?
2. What do colleagues consider are the implications of CLS research methodology for future research in creativity, including with older age groups?
3. In the light of the pressures afforded by international comparative indicators which measure efficiency and quality, (e.g. through TIMMS and PISA), the recognised difficulties in recruiting STEM subjects across Europe in higher levels in secondary

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schools and in universities, and the EU recommendations and Horizon 2020 research call, which seeks to build a competitive and strong Europe with particular reference to the sciences, technology and innovation (2014), what suggestions do colleagues have for further research regarding the development of young people's creativity in mathematics and science across Europe?

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