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

D5.3 Exemplary Teacher Training Materials

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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D5.3 Exemplary Teacher Training Materials

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Executive Summary

This report focuses on the Exemplary Teacher Training Materials. The aim of these materials is to illustrate the teacher education Curriculum Design Principles and related Teacher Outcomes, which were developed during Work Package 5 as part of D5.2 *Guidelines and Curricula for Teacher Training* and can also be found in this report. They are designed for teacher educators to use in Initial Teacher Education (ITE) and teacher Continuing Professional Development (CPD). They aim to extend professional understanding and enhance professional development in order to foster creativity in science and mathematics education in the early years.

This report explains the methodology used to develop the materials, the nature and structure of the materials and includes suggestions for their use in all phases of teacher education.

Methodology used to develop the exemplary teacher training materials

In the *Creative Little Scientists* project, the comparative research and the in-depth fieldwork in particular identified significant issues that need to be tackled in teacher education in order to foster creativity in science and mathematics education in the early years. Based on these issues the teacher education Content Design Principles, created during the curriculum design research, were refined, and a set of Teacher Outcomes developed. To produce the Exemplary Teacher Training Materials, classroom examples of creative learning and teaching were selected using these Content Design Principles and related Teacher Outcomes.

All partners re-visited their data from the in-depth fieldwork (Work Package 4) to select pertinent images, interviews or classroom extracts that evidenced one or more of the Teacher Outcomes. To support and record the selection process a grid was provided where partners could record links between the fieldwork data selected, Teacher Outcomes and factors associated with creativity in learning and teaching in science and mathematics. Templates were then used to structure the classroom materials and provide consistent information about the contexts from which they were drawn.

Teacher training materials: an overview and how to use them

In total 169 templates are available containing exemplary materials from fieldwork for use in teacher education. These are structured in an Excel-file and can be found on the website http://www.creative-little-scientists.eu.

In order to support the full use of this diverse range of resources for teacher training, suggestions are provided in this report of selection and use of these exemplary materials in relation to particular themes and associated Content Design Principles as follows:

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- Suggestion 1: Use of questions and ideas of children by teachers (Principles 10 and 11)
- Suggestion 2: Resources and learning environment as essential context factors for Creativity and Inquiry (Principles 10, 14, 17)
- Suggestion 3: Focus on the nature of science – a link with creativity (Principle 3)
- Suggestion 4: Focus on Inquiry Based Science Education – link with creativity (Principle 6)
- Suggestion 5: Focus on Practical Investigations which foster creativity (Principles 2, 17)
- Suggestion 6: Collaboration/group work in inquiry and creativity based approaches (Principle 15)
- Suggestion 7: The role of play in inquiry and creativity based approaches (Principles 7, 8, 17)
- Suggestion 8: The use of the various modes of expression and representation of science and mathematics learning to support inquiry and the development of creativity – link with assessment (Principles 7, 9)
- Suggestion 9: The role of the teacher in Inquiry and Creativity approaches (Principles 1, 7, 11)
- Suggestion 10: Cross curricular project work to foster inquiry and creativity (Principle 6)

The suggestions above are carefully chosen since they encourage inquiry and creativity in science and mathematics education for early years, by focusing on the synergies between Inquiry-Based Science Education (IBSE) and Creative Approaches (CA): play and exploration; motivation and affect; dialogue and collaboration; problem solving and agency; questioning and curiosity; reflection and reasoning; teacher scaffolding and involvement; and assessment for learning.

As noted in the *Conceptual Framework* (D2.2) and experienced during the in-depth fieldwork, developing contexts for inquiry and exploration which foster creative learning, and achieving a balance between teacher intervention and children collaboration, as well as teacher standing back and learner agency, represent considerable professional challenges. The provided exemplary teacher training materials and associated suggestions for their use help address these challenges.

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1. Aims of teacher training materials

The aim of the Exemplary Teacher Training Materials is to illustrate the teacher education Curriculum Design Principles and related Teacher Outcomes that were developed during Work Package 5. The set of Curriculum Design Principles and related Teacher Outcomes are offered as guidelines for European Initial Teacher Education (ITE) and teacher Continuing Professional Development (CPD) programmes, which will foster creativity-oriented approaches to science and mathematics learning in preschool and the first years of primary education.

More specifically, the Exemplary Teacher Training Materials clarify the applicability of the Design Principles and Teacher Outcomes related to the *Content* component of the curriculum, in complex and varied European educational contexts. Consequently, the Exemplary Teacher Training Materials are designed to facilitate implementation, evaluation and further development of the proposed Content Design Principles and related Teacher Outcomes across Europe.

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2. Content Design Principles and Teacher Outcomes as the structure for teacher training materials

2.1 Content Design Principles and Teacher Outcomes

In the *Creative Little Scientists* project, the comparative research and the in-depth fieldwork in particular identified significant issues to be tackled in teacher education in order to foster creativity in science and mathematics education in the early years. Based on these issues the Content Design Principles, created during the curriculum design research, were refined and a set of associated Teacher Outcomes developed.

This set of Teacher Outcomes aim to help teacher educators frame the content of and approach to their workshops, sessions and/or courses. Based on these outcomes exemplary teacher training materials originating from the data of in-depth fieldwork were developed.

2.1.1 Content Design Principles

In summary, the Content Design Principles are part of the set of Curriculum Design Principles, presented in D5.2 *Guidelines and Curricula for Teacher Training* and designed on the basis of the ten components of the curriculum web (van den Akker, 2007). More specifically, the Content Design Principles are linked to the component 'Content', which is one component of the curriculum web. Although the teacher training materials are focused on content, it is necessary to keep in mind that all components should be taken in consideration by teacher educators, not only the content, but also for example the time needed, the materials used, the role of the teacher educator and the learning activity used.

2.1.2 Teacher Outcomes

As indicated above, related to these Content Design Principles and based upon the findings in the *Creative Little Scientists* project, a set of Teacher Outcomes was formulated. The Content Design Principles and related Teacher Outcomes were used to develop Exemplary Teacher Training materials originated from data collected during fieldwork conducted in Work Package 4. The methodology used by the *Creative Little Scientists* partners to create these principles and outcomes is described in D5.2 *Guidelines and Curricula for Teacher Training*.

An overview of the Content Design Principles and Teacher Outcomes is provided in the following section.

2.2 Methodology used to develop the teacher training materials

To develop the Exemplary Teacher Training Materials the partners were asked to consider carefully their data from the in-depth fieldwork. In particular partners were invited to identify pertinent images, interviews or classroom extracts which evidenced one or more of the Teacher Outcomes and could stand alone as an example. To support the selection process a table was provided as shown below (Table 1). The instructions to partners can be

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found in Appendix A. To each Content Design Principle a code was assigned (shown in green in the left column) for use in identifying and linking with the related classroom examples from the fieldwork data. In addition, each Teacher Outcome was linked to the codes (shown in red in the right column) used originally in the analysis of the fieldwork data. Section 3.2.1.1 gives an explanation of the origin and previous use of these latter codes. These latter codes helped further in the identification by the partners of the most appropriate classroom data for use as exemplary teacher training materials in relation to a particular Teacher Outcome or a combination of Teacher Outcomes under a given Content Design Principle.

After the partners had made their selection, they structured the teacher training materials in a template (further details and three examples are provided in 3.1.2 below). In total about 200 teacher training materials were developed, these were then screened by the Work Package leaders for appropriate match to Teacher Outcomes and corresponding Content Design Principles. Some of the teacher training materials were adjusted, others were accepted and some rejected. In total 169 were found appropriate, these can be found on the website www.creative-little-scientists.eu and in the Addendum to this report.

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	Content Design Principles and linked Teacher Outcomes	Indicative Factors
TE: SocialAffectAims	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.	
	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	AO: Affect AO: Social
	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.	P: Affect
TE: PractInvest	2. Teacher education should provide teachers with skills and competences to carry out practical investigations of science and mathematics in the classroom.	
	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.	LA: Plan
	2.2 Teachers should have a more 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.	T: Sci; T: Prec
TE: NoS	3. Teacher education should advance teachers' understandings about the nature of science and how scientists work, confronting stereotypical images of science and scientists.	
	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.	AO: Und. SI; P: R and R, LA: Expl; LA: Comm
	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	LA: Connect; LA: Expl;

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	also important for the development of learner creativity.	P: R and R
	3.3 Teachers should be able to use 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.	AO: Kn.Sc; AO: Sc ProcSkills; AO: Und. SI; P: R and R; P: Affect
TE: Creat	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.	
	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.	T: Prec
TE: IBSE/CA_ Synergies	5. Teacher education should provide knowledge about how children's creativity development could be enhanced and assessed within science and mathematics education.	
	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	T: Ped
TE: IBSE	6. Teacher education should provide pedagogical content knowledge to stimulate inquiry and problem solving in science and mathematics education.	
	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.	T: Ped; T:Sci
	6.2 Teachers should be able to open up everyday learning activities to allow greater opportunities for inquiry, problem solving and scope for creativity.	AO: IBSE/PBL;

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		AO: Creative
	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.	LA: Ques; LA: Connect; P:Ques; P: Express
	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).	P: Ques; P: Express; LA: Plan; LA: Obs; LA: Equip; LA: Connect
	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.	P: Agency; P: Ques; P: R and R; LA: Ques; LA: Plan; LA: Obs; LA: Equip; LA: Connect
TE: CreatInqPed	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.	
	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.	T: Ped
	7.2 Teacher should be able to use a range of strategies both formal and informal for supporting children's	P: Scaff;

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		extended engagement with an area of study and progression in learning in science and mathematics.	L: Formal/Informal; M: Inf.
	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.*	P: Play; P: Quest; P: Scaff; M: Expl
	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.*	P: Play; P: Agency; P: Scaff; A: Form
	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, games.*	P: Affect; M: Cr.
	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.*	P: Affect
	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.*	P: Scaff
	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.*	P: Scaff; P: Quest
	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*	A: Strat; A: Peer/Self;

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	progress, in the early years science and mathematics classroom.	P: Dialog
	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.	A: Evid.; A: Form
TE: CreatInqLA	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.	
	8.1 Teachers should be able to design and assess open-ended learning activities.	T: Ped; LA: Plan; P: Agency; A: Evid; M: Explor.; M:Cr.; M: Variet
TE: Multimodal	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.	
	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.	P: Express; A: Form
	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.	P: Express; AO: IBSE/PBL; AO: Creative
	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.	P: Express; P: R and R
	9.4 Teachers should be able to use the various modes of children's expression and representation of science	P: Express;

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	and mathematics ideas (e.g. pictures, graphs, gestures, physical activities) for assessment purposes.	A: Evid.
TE: ChildIdeas	10. Teacher education should enable teachers to recognize and build on children's ideas, theories and interests for the teaching of science and mathematics.	
	10.1 Teachers should be able to use a range of strategies for picking up on children's ideas, theories and interests.	T: Ped; AO: Affect; A: Strat
	10.2 Teachers should be able to build flexibility into planning to take advantage of unexpected events, children's interests and questions.	T: Ped; LA: Quest; A: Form.
TE: Question	11. Teacher education should enable teachers to use questioning effectively and encourage children's questions in order to foster creativity and inquiry	
	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.	AO: Creative; P:Ques; P: Scaff; P: Agency; P: R and R
	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.	LA: Ques; P: Scaff
TE: EYSciMaths	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.	
	12.1 Teachers should have knowledge of the various purposes and aims of science and mathematics education in compulsory schooling.	T: Ped
	12.2 Teachers should have knowledge of the prevailing academic rationale for the place of science and mathematics in the early years curriculum.	T: Ped

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	12.3 Teachers should have knowledge of the role of creativity in child development and in the fields of science and mathematics.	T: Ped; T: Prec.; AO: Creative
	12.4 Teachers should be able to contribute towards the goal of preparing creative citizens, who have scientific and mathematic literacy.	T: Sci; T: Ped; T: Prec.; T: Confid.; AO: Und. SI; AO: Creative
	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.	T: Sci; T: Ped; T: Confid.
	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.	T: Sci; T: Ped; T: Confid.
TE: KnowlPolicy	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.	
	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.	N/A
TE: LEnvironm	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.	

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	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.	L. Out/Indoors; M:Explor.; M: Cr; M: Space; M: Outd.; M: Inf.
	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.	P: Affect; L: Informal; L. Out/Indoors; M: Inf.
	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.	L: Outdoors; L: Informal/Non-formal
	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.	L: Outdoors; L: Informal
TE: GWork	15. Teacher education should promote teachers' use of group work to support children's inquiry processes and creative learning.	
	15.1 Teachers should have knowledge of the value of collaboration for inquiry and creative thinking and learning.	T: Ped
	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.	P: Collab; G: SmallG; G: Abil

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	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.	G: SmallG; G: Abil; P: Collab; P: Dialog; A: Strat
	15.4 Teachers should be able to use resources and teacher intervention appropriately to foster collaboration in science and mathematics.	M: Var; M: Expl; M: Cr; P: Collab; P: Scaff
	15.5 Teachers should be able to assess group work.	A: Strat
	15.6 Teachers should be able to use effective strategies for sharing ideas and discussions from different groups.	P: Dialog
TE: CrossCurr	16. Teacher education should provide teachers with knowledge of approaches to timetabling and organizing cross-curricular project work.	
	16.1 Teacher should be able to use approaches to cross- thematic, cross-curricular and project work to promote creativity in science and mathematics.	C: Sci/M Integ
	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.	Ti: Suffic; C: Sci/M Integ; P: Agency
	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.	LA: Connect; C: Sci/M Integ; AO: Creative; AO IBSE/PBL

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TE: Resources	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.	
	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.	M: Expl; M: Cr; M: Outd; M: ICT; M: Inf; M: Variet; L: Out/Indoors
	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.	M: Expl; M: Cr.; P: Agency
	17.3 Teachers should be able to evaluate and select creativity enabling ICT resources for children to use in their inquiry.	M: Cr.; M: ICT
	17.4 Teachers should be able to evaluate provision for free flow play in their school settings.	M: Expl; P: Play
	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.	M: Cr.; AO: Creative
	17.6 Teachers should be able to gain insights into children's developing explorations and creativity based on their use of resources.	A: Evid; P: Express
	17.7 Teachers should be able to develop the school grounds and the outdoor classroom for use in science and mathematics education.	M: Outd.

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TE: SubjectKnowl	18. Teacher education should encourage and assess the development of teachers' literacy, numeracy and digital literacy skills through science and mathematics.	
	18.1 Teachers should develop their literacy, numeracy and digital literacy skills through science and mathematics.	N/A

Table 1: Content Design Principles and linked Teacher Outcomes for teacher education – with codes

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3. Teacher training materials: an overview and how to use them

As noted earlier, the Teacher Training Materials originate from data - images, classroom extracts and interviews – sampled and coded during the in-depth fieldwork. Consequently they contain examples of practices in both preschool and primary settings.

The materials are offered as starting points for open debate and discussion. They aim to extend professional understanding and enhance professional development in order to foster creativity in science and mathematics education in the early years.

In the following sections:

- An overview is given of all exemplary Teacher Training Materials by Content Design Principle. The templates containing the materials can be found in the Addendum to this report. In order to facilitate the selection and use of materials, an Excel document is provided as indicated below.
- Suggestions are provided on ways to use the materials as a teacher educator.
- Some suggestions of usage in teacher education are provided.

3.1 Teacher training materials

3.1.1 An overview of the available materials

In total 169 templates containing exemplary teacher training materials are available as part of the *Creative Little Scientists* project outcomes. These are all structured in an Excel-file and are available on the website at http://www.creative-little-scientists.eu. The structure of the Excel-file with some examples is shown below. The full list of teacher training materials can be found in Appendix B of this report. Their diverse foci make it possible for teacher educators to select materials (or templates) according to need and interest in terms of Content Design Principles and in response to working with different groups of teachers, for example according to country or age range of children. In addition, information is included about which fieldwork case the piece of data in the template belongs to and whether it is part of an episode selected to be included in the deliverable D4.4 *Report on Practices and their Implications* (also available on the above mentioned project website). This information facilitates teacher educators to look up more details about the origin and context of these images, classroom extracts and interviews.

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Teacher Training Materials	Content Design Principle	Type of material	Country	Case	Selected Episodes	Age group
BE_Class_TheHail_SocialAffectAims	TE: SocialAffectAims	classroom	Belgium	BE case 6	no	7-8
FI_Class_Volcano_SocialAffectAims	TE: SocialAffectAims	classroom	Finland	FI case 3	no	3- 6
GE_Int_Materials_SocialAffectAims	TE: SocialAffectAims	interview	Germany	GE case 3	no	6
UKEN_Class_Ice_SocialAffectAims	TE: SocialAffectAims	classroom	UK	UKEN case 1	no	4 -6
UKSC_Class_Baking_SocialAffectAims	TE: SocialAffectAims	classroom	UK	UKSC case 2	no	3-5
BE_class_TheWind_PractInvest	TE: PractInvest	classroom	Belgium	BE case 4	no	5-6
GE_Img_WaterInquiry_PractInvest	TE: PractInvest	image	Germany	GE case 5	yes	6
UKEN_class_Bubbles_PractInvest	TE: PractInvest	classroom	UK	UKEN case 2	no	3-4
UKNI_Image_FlowerDye_PractInvest	TE: PractInvest	image	UK	UKNI case 3.17	no	6-7
UKWA_Class_Jelly_PractInvest	TE: PractInvest	classroom	UK	UKWA case 1	no	3-4
BE_Class_TheWaterfall_NoS	TE: NoS	classroom	Belgium	BE case 1&2	no	4 -6
.....	.....	.....	.....	.....	.....	.....

Table 2: Extract of the Excel file containing all exemplary teacher training materials

3.1.2 The structure of each template

Each template containing teacher training material has a similar structure. Three examples are shown below in Figures 1, 2 and 3.

Each template includes an introductory grid containing key information about the material and its origins. Key features with illustrations from Figure 1 are outlined below.

Title of the template - The materials are named according to the country, type of material, name of the episode and Content Design Principle. For example in relation to the title of the template in Figure 1, **GE_Class_Fremi1_CreatinqLA**:

- **GE** – indicates that the template is from Germany.
- **Class** – indicates that the template contains an extract of teaching and learning from the classroom.
- **Fermi1** - is the name of the classroom episode from which the extract is taken.
- **CreatinqLA** – is the code for the Teacher Education Design Principle that relates to the teacher training material included below.

The grid below the title provides important background information about the teacher training material:

- **Teacher Education Design Principle and code** – this provides full details of the Design Principle the material has been selected to illustrate. In Figure 1 this is **Design Principle 8** that focuses on the design and assessment of **creat**ivity enabling and **inq**uiry based **l**earning **a**ctivities. TE:**CreatInqLA**.
- **Specific Teacher Outcomes** – this refers to the specific teacher outcomes evidenced in the material. In the template shown in Figure 1 this concerns **Specific Teacher Outcome 8.1** related to the design and assessment of open-ended learning activities

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- **Type of material** – in this example the material in the template is a **classroom extract**. (Other templates may contain **images** and extracts from **interviews**. For example the template shown in Figure 3 contains classroom images and an extract from an interview with the teacher.)
- **Country Report** – This indicates the Country Report from which the training material is drawn. **D4.3** is the code for all the Country Reports of fieldwork; each CLS project report has a code starting with D (Deliverable). This is helpful in finding the relevant reports on the project's website. The teacher training material in Figure 1 is drawn from the Country Report for **Germany**.
- **Case** – Each Country Report contains a number of case studies of classroom practice. The details here indicate the specific **case study** from which the material has been drawn. **GE case 4** indicates that you will find further details related to the classroom material in **Case study 4**. In this way it is possible to go back to the relevant *Country Report* (D4.3) of fieldwork for further details.
- **Episode –** Each case study contains a number of episodes. Here you are given the name of the episode from which the material has been taken. The material in Figure 1 is taken from an episode called **Fermi 1.**
- **Teacher –** This indicates the name of the teacher who is featured in the material (and the case study from which this is drawn) – in this instance Andrea.
- **Age group** – The grid also provides information about the age group of the children – in this instance the children are 7 years old.
- **Selected episode** - The template also indicates if the material relates to a **Selected Episode** – one of the episodes selected and analysed for inclusion in the overall *Report of Practices and their Implications* (D4.4). The Selected Episodes are included in an Appendix to the report. In addition to extracts from the data collected, each *Selected Episode* contains background information and commentary on opportunities for inquiry and creativity. This may be of use in working with the material from the template.
- As with all materials produced by the *Creative Little Scientists* project, all the *Country Reports* (D4.3) and the *Report of Practices and their Implications* (D4.4) are available on the website at http://www.creative-little-scientists.eu.

Teacher training material - The grid providing background information is followed by the teacher training material itself, comprising extracts from the data collected during fieldwork (such as photographs, classroom interactions, interviews) that are illustrative of the for potential for creativity. Figures 1, 2 and 3 below give a flavour of the kinds of material that can be found in the templates – with brief suggestions of ways in which they might evidence opportunities for inquiry and creativity in early science and mathematics.

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GE_Class_Fermi1_ CreatInqLA

Teacher Education Design Principle + code:	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. **TE: CreatInqLA**
Specific Teacher Outcome(s):	8.1 Teachers should be able to design and assess open-ended learning activities.
Factors linked with:	**T: Ped; LA: Plan; P: Agency; A: Evid;**
Type of material (image – interview (int) – classroom extract (class):	Classroom extract (class)
Originating from:	
Country report :	D4.3 Germany
Case:	GE case 4
Episode:	Fermi1
Teacher:	Andrea
Age Group:	7
Selected episode from D 4.4 Appendix	Yes

Use of "Fermi questions" to promote non-traditional problem solving strategies.

Fermi questions encourage multiple approaches and emphasize process rather than the answer/result. They seek a rough estimate of quantity which is either difficult or impossible to measure directly. Example here: "Use a piece of chalk and draw a 1m-line, a 10-cm-line, and a 1-cm-line on the board. Three lines. Without ruler."

Classroom extract (class)

Children working in small groups. They estimate: How long is one meter?
As a team, the children make a guess and then discuss their estimations: they ask for the other's opinion and - based on their everyday experiences - find innovative methods in order to check their estimates.

***C5** "I jumped down from a 1-m-board in the swimming bath on Saturday" [shows the distance between board and water surface with his hands]*
***C6** "I'd say a meter is more or less as long as a leg"*
***C7** "Till here, right? Or till here?" [using C5's body to demonstrate it]*
C5 tries to maintain the distance between his hands while moving them to the board. Holds them close to the board, C7 draws a line between C5's hands.
***C7** "T-h-a-t long?"*
***C6** "No. This long"[...]*
***C7** "I don't think that this is one meter" [laughing]*
***C6** "I don't think that either"*
***C5** "Right. Much too short"*
***C6** draws a longer line.*
[...]

The teacher walked around in class, observed the children during group work, using formative ways of assessment (e.g. *"How does a child behave in the group?, What does it contribute to the group work?, How does it interact with others?, How does it approach such a task?"*, teacher interview). She occasionally gives advice or answers questions. However, her advice exclusively referred to the working approach, methods, and relevant question, but never to the solution itself.

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At the end, children write down how they had proceeded. Then they present the working process as well as the result to their class members.

Teacher: *... children get into interaction and they have to think on their own about questions like: "How can I approach this?", "What am I doing here right now?", "How can we solve such a task?" And they just have to talk to each other a lot and to think about "How does this actually work?" and not only to solve a ready-made maths problem.*

Figure 1: Template GE_Class_Fremi1_CreatinqLA

In this example the teacher introduced children explicitly to the thinking behind Fermi questions and problems that "encourage multiple approaches, emphasise processes rather than specific answers or results and promote non-traditional problem solving strategies". The aims for children's learning in this example focused on children generating and evaluating alternative strategies and novel ideas, both individually and/or communally, as identified in D2.2 *Conceptual Framework* as key features of creativity in early science and mathematics.

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GR Class IceBalloons Resources

Teacher Education Design Principle + code:	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.
Specific Teacher Outcome(s):	*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. (D3.2 and D4.4)*
Factors linked with:	**M: Expl; P: Play**
Type of material (image – interview (int) – classroom extract (class):	**class**
Originating from:	
Country report :	D4.3 Greece
Case:	Case 4 - Sonia
Episode:	1 – Ice Balloons
Selected episode?	Yes
Teacher:	Sonia
Age Group:	5

Fostering children's free exploration and thoughtful use of physical

The activity observed was part of a series of lessons entitled "Winter". A part of the Winter lessons was dedicated to ice and snow. The teacher used brainstorming to allow the children to control their learning path but also to assess previous knowledge and any major misconceptions before any activities were planned. The following day children participated in a second brainstorming activity aimed at bringing out specific activities and material which would allow them to study ice properties. In the first activity picked by the children pieces of fruit were placed in a bowl of water which was then placed in the freezer. Pieces of fruit were also left in the classroom to facilitate comparisons (children wanted to see which ones would go bad first). The second activity which children chose was to fill balloons with water and place them in the freezer to see what happens. The teacher then added one balloon that had red dye in the water before being placed in the freezer without children knowing.

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A variety of materials were placed on the floor of the classroom in the centre of the spot where all the children gather. The materials included syringes, paintbrushes, watercolours, dyes, bottle of vinegar and magnifying lenses. Children were free to add to the material chosen by the teacher.
The activity began with the teacher asking the children to think about the materials on the floor and what their purpose is. K replied that they are going to be doing experiments with colours. The teacher, after seeing that the children were more interested in the materials themselves (used for the first time in the classroom based on the pre-interview with teacher) than the topic of ice, asked children if they wanted to just play with the materials instead of looking at the ice cubes they made yesterday. Children brought up the two activities they had done during the previous day (fruit and balloons) and they decided to vote the most popular to carry out during the lesson. After counting the votes, it was decided that the children were going to play with the ice balloons. The teacher then asked if they remembered what they had done the day before and if they remembered how they made ice.

When the ice started to melt and more water started to gather in the bowl the teacher asked the children if a different material could help them in seeing the ice better. E said that colours could do that and proceeded to pick colours to paint the ice. The teacher allowed children to use whatever they wished (vinegar, newspaper, tin foil), constantly encouraging them to try out their ideas (*"Just get what you want and play with the ice", "Of course you can do what you like").*

Teacher: *Are you thinking of what else can we put in the tub to study better what happens with ice? […] Take a look at the newspaper. What can you do with the newspaper?*
Team 1 uses the coloured water to paint over the newspaper.
Team 2 same as team 1.
Team 3 cuts paper into little pieces and puts them in the tub.
Teacher: *What are you doing with the newspaper?*
Team 1: *I am painting it.*
Team 3: *We are cutting it in little pieces and throwing them inside.*
Teacher: *We have forgotten to use one material (tin foil). Does anybody want to use it?*
Team 2: *We need it.*
Teacher: *Take a big piece of tin foil and think about what you can do with it.*
Children: *We also need the syringe.*
[Children start to dip the tin foil in the tub, scratch the ice using the tin foil, etc.]

Children add tin foil and newspapers to study the ice balloons

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Children add tin foil and newspapers to study the ice balloons

Figure 2: Template GR_Class_IceBalloons_Resources

The teacher in this example provides a *rich physical environment*, with a diversity of attractive and interactive resources to foster motivation and to gain children's interest. The children's questioning and curiosity are promoted intensely. The physical context, provided by the teacher, provokes ideas and questions of children and promotes their creativity.

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UKNI_Img/Int_Gloop_SocialAffectAims

Teacher Education Design Principle + code:	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. TE: SocialAffectAims
Specific Teacher Outcome(s):	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.
Factors linked with:	AO: Affect, AO:Social
Type of material (image – interview (int) – classroom extract (class):	Image, Interview
Originating from:	
Country report :	D 4.3 - UK Northern Ireland
Case:	Case 9
Episode:	Gloop
Teacher:	Alice
Age Group:	3-4
Selected episode present in D 4.4 Appendix	Yes

'Gloop' activity developing both cognitive and affective objectives.

'Ryan' showing focus and enjoyment working with the cornflour and water starch

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This activity allows the children to develop motor skills, their ability to use tools as well as sensory development, such as observation through sight and touch. The affective aspect was most clearly shown through Ryan's enjoyment of the activity and his focus throughout.

Extract from interview with practitioner following activity, using pictures (including the two above) as a prompt:

Alice: and it is probably he is seeing it there, it is falling off the spatular and if he uses a different utensil what is going to happen and it is very hard to make patterns actually in gloop which fascinates them too, that is another stage you know, we would have a sand, we have a sand tray with combs and things, you can't really make patterns in the gloop because it all slides back into each other...

...

A: and language-wise and that is a fabulous opportunity for them to develop their language, and even just to listen, you don't necessarily need to put an adult in there, you can listen and grasp what they have achieved from that activity

Figure 3: Template UKNI_Img/Int_Gloop_SocialAffectAims

In this example children were given time and space to explore, to observe how materials behaved, try out equipment and pursue their own ideas and interests, on their own or alongside other children. Adults observed. This example illustrates the value of children having time to explore and to make their own decisions – and the importancy of children's own agency in manifesting cognitive and affective learning objectives.

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3.2 How to use these teacher training materials in teacher education

3.2.1 Suggestions for using the teacher training materials in teacher education

3.2.1.1 Background knowledge which is necessary in order to use and discuss the teacher training materials

In order to make full use of the teacher training materials, i.e. the examples offered in the templates, it is helpful to introduce teachers[1] to the curriculum dimensions used across the project and associated factors identified as important in nurturing creativity and inquiry in early science and mathematics. These teachers also need to have knowledge about the nature of science, inquiry and creativity. It would be be helpful to explore these concepts before group discussions about the examples of learning and teaching takes place (as presented in the suggestions that follow). The following frameworks may help teacher educators introduce the curriculum dimensions and factors and explore conceptions of the nature of science, inquiry and creativity.

a) Framework of curriculum dimensions, questions and factors used in the analysis of classroom episodes in the Creative Little Scientists *project*

The *Creative Little Scientists* project was dedicated to revealing current practice at the intersection between science, mathematics and creativity in both preschool and first years of primary education in the partner countries. The *Conceptual Framework* (D2.2) highlighted the need to probe:

- **Aims/purpose/priorities**, including teachers' explicit and implicit perspectives, in relation, for example, to: aims and purposes of creativity in science and mathematics education; how science and mathematics are taught and learned in relation to other domains of knowledge; how these shift from preschool to primary across the consortium; how these relate to inquiry-based science education (IBSE); views of creativity in relation to perceived purpose.
- **Teaching, learning and assessment**, including learning activities, pedagogy and resourcing, and in relation, for example, to: multimodal expression and experience; learning activity types; resources used; dynamics between adults and children; exploration; questioning and argument; also how teachers assess creativity in early science and mathematics education.

[1] In describing the training materials, the term 'teacher' is used to include both pre-service and in-service teachers, also early years practitioners who are not qualified teachers but who work closely with young children. Where a distinction is required this will be made clear.

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- **Contextual factors**, including ethos, teacher characteristics and teacher general education, knowledge, skills and confidence, curriculum, institutional factors, location, grouping, and time.

Furthermore, these three broad strands were broken down into more narrowly-defined dimensions drawing on the framework of curriculum components 'the vulnerable spider web' (van den Akker, 2007, p.39), which focuses on key questions about aspects of learning in schools. Within these dimensions and sub-questions a number of factors were identified by drawing on the *Conceptual Framework* (D2.2) as having a strong potential to foster the development of creative skills in children as outlined in the *List of Mapping and Comparison Factors* (D3.1). These factors have been employed across the project in mapping and comparing existing approaches as reported in the *Report on Mapping and Comparing Recorded Practices* (D3.2), the *Report on First Survey of School Practice* (D3.3) and the *Comparative Report* (D3.4) and are explicitly addressed in this report.

Table 3 shows these dimensions, sub-questions and factors, and their codes. The coding list is grouped to reflect the two main foci of the fieldwork, informed by the pedagogical model developed by Siraj-Blatchford et al (2002) shown in Figure 4, namely

- **Pedagogical interventions** (or interaction) documented by observing face to face classroom practice and listening to children's reflections on this, and
- **Pedagogical framing** (or framing) documented through teacher's reflections on classroom practice and wider information concerning the teacher, school, curriculum and assessment.

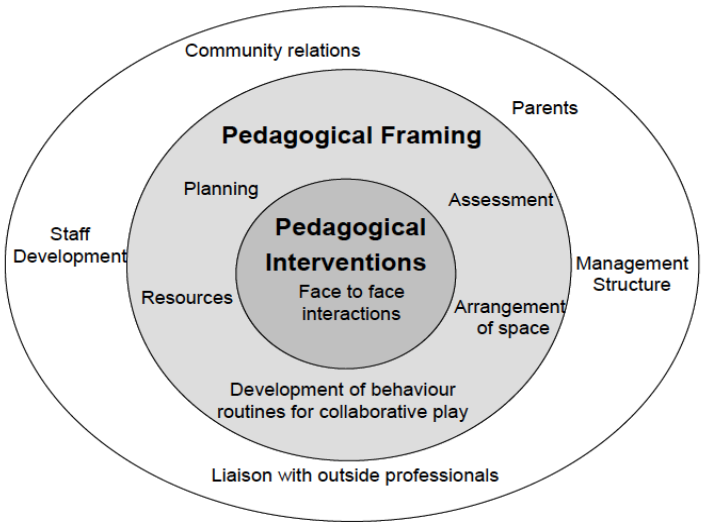

Figure 4: Pedagogical interventions in context (Siraj-Blatchford et al, 2002)

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Dimensions	Sub questions	Factors important to nurturing creativity in science and mathematics in the early years	Coding
Learning Activities ***Interaction***	How are children learning?	*Focus on cognitive dimension incl. nature of science* • Questioning • Designing or planning investigations • Gathering evidence (observing) • Gathering evidence (using equipment) • Making connections *Focus on social dimension* • Explaining evidence • Communicating explanations	• LA: Ques • LA: Plan • LA: Obs • LA: Equip • LA: Connect • LA: Expl • LA: Comm
Pedagogy ***Interaction***	How is teacher facilitating learning?	• Role of play and exploration; role of play valued • Role of motivation and affect ; Efforts made to enhance children's attitudes in science and mathematics • Role of dialogue and collaboration; *collaboration. between children valued* • Role of problem solving and agency ; use of IBE/PBL, Children's agency encouraged • Fostering questioning and curiosity - Children's questions encouraged • Diverse forms of expression valued • Fostering reflection and reasoning; children's metacognition encouraged • Teacher scaffolding, involvement, Sensitivity to when to guide/stand back	• P: Play • P:Affect • P:Collab • P:Dialog • P:Agency • P:Ques • P: Express • P: R and R • P: Scaff
Assessment ***Framing and Interaction***	How is the teacher assessing how far children's learning has progressed, and how does this information inform planning and develop practice?	*Assessment function/purpose* • Formative • Summative • Recipient of assessment results NO CODE *Assessment way/process* • Strategy • Forms of evidence ; excellent assessment of process and product, Diverse forms of assessment valued • Locus of assessment judgment – involvement of children in peer/self assessment	• A:Form. • A:Summ. • A:Strat. • A:Evid. • A:Peer /self

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Dimensions	Sub questions	Factors important to nurturing creativity in science and mathematics in the early years	Coding
Materials and Resources ***Framing and Interaction***	With what are children learning?	• Rich physical environment for exploration; Use of physical resources thoughtful; Valuing potential of physical materials; • Environment fosters creativity in sci/math • Sufficient space • Outdoor resources; recognition of out of school learning • Informal learning resources • ICT and digital technologies; confident use of digital technology • Variety of resources • Sufficient human resources • NO reliance on textbooks or published schemes	• M:Explor. • M: Cr • M:Space • M:Outd. • M:Inf. • M:ICT • M:Variet. • M:Human • M: Pol.
Aims and Objectives ***Framing and Interaction***	Toward which goals are the children learning?	• Knowledge/understanding of science content • Understanding about scientific inquiry • Science process skills; IBSE specifically planned • Capabilities to carry out scientific inquiry or problem-based activities; use of IBE/PBL • Social factors of science learning; collaboration between children valued • Affective factors of science learning;efforts to enhance children's attitudes in science and maths • Creative dispositions; creativity specifically planned	• AO: Kn.Sc • AO: Und. SI • AO: Sc Proc Skills • AO: IBSE /PBL • AO: Social • AO: Affect • AO: Creative
Location ***Framing and Interaction***	Where are they learning?	• Outdoors/indoors/both - recognition of out of school learning • Formal/non-formal/informal learning settings/ • Small group settings	• L.Out/In/ Both • L.Formal/ Non-formal/ Informal • L.grp
Grouping ***Framing and Interaction***	With whom are they learning?	• Multigrade teaching • Ability grouping • Small group settings • Number of children in class	• G:MG • G:Abil. • G:SmallG • G:No.
Time ***Framing***	When are children learning?	• Sufficient time for learning science and mathematics	• Ti: Suffic.

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Dimensions	Sub questions	Factors important to nurturing creativity in science and mathematics in the early years	Coding
Content *Framing*	What are children learning?	• Sci/ma as separate areas of knowledge or in broader grouping • Level of detail of curriculum content • Links with other subject areas / cross-curriculum approach; evidence of science and maths integration (planned or incidental) • Subject-specific requirements vs. broad core curriculum NO CODE • Content across key areas of knowledge	• C:Sci/M Sep • C:Detail • C:Sci/M Integ • C:CoreK
Teacher Personal Characteristics *Framing*	Who is the teacher?	• Gender • Age	
Teacher General Education and Training *Framing*		Qualifications: • Level • Focus / content • Professional	
Teacher Science and Mathematics Knowledge, Skills and Confidence *Framing*		• Pedagogical competence • Scientific competence • Teachers preconceptions of science and mathematics in terms of creativity • Confidence in teaching science and mathematics – do they feel well prepared • ICT skills • Views on own ITE/CPD (what/how)	
School factors *Framing*	What is the school?	• Rich CPD approach (whole school) • Whole school planning + teacher agency	

Table 3: Dimensions, Sub Questions and Factors used across the **Creative Little Scientists** *project*

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b) *Exemplary framework for discussion of the Nature of Science (from Akerson et al (2011)* (used during the teacher Summer School organized by the project team, in July 2013).

In the *Conceptual Framework* (D2.2) Gago (2004) is cited to hightlight the importance of developing pupils' understanding of the 'nature of science':

> *"The recent emphasis on understanding the nature of science is related to the attempt to give more attention to its social, cultural and human aspects. Science is now to be presented as knowledge that is built on evidence as well as upon arguments deployed in a creative search for meaning and explanation".*
>
> Gago (2004, p.138)

Akerson et al. (2011) provide an interesting research-based model and teaching strategies for teaching the Nature Of Science (NOS) to young children. The Nature of Science poster (Figure 5), which is included in their article is visual and very interesting to use when discussing the different aspects of the Nature of Science with teachers and children. For this reason the framework of Akerson can be used to initiate discussion about Nature of Science in teacher education with pre- and primary school teachers. It can come before or after a science investigation. The trainees can use the poster either to think about these aspects as they conduct their investigations, or to reflect on them after they have completed it.

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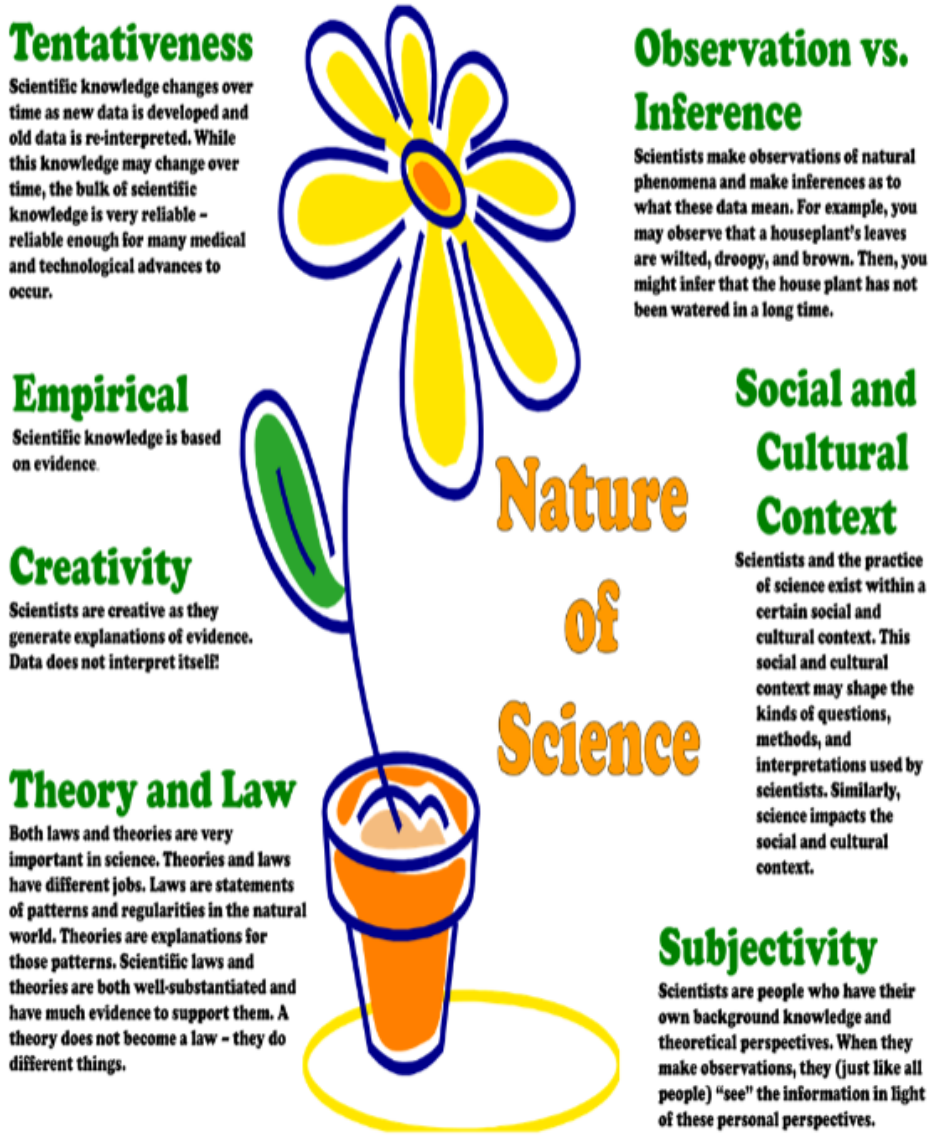

Figure 5: Poster that can be used to introduce or reinforce NOS aspects (Akerson et al., 2011, p69)

c) *Exemplary framework for discussion of inquiry-based approaches*

In the Conceptual Framework, a model developed by Barrow is used to identify approaches in inquiry teaching and learning that can foster creativity. Barrow (2010) maps the five learner attributes of inquiry identified by the US National Research Council, to dimensions of student directedness or agency (Figure 6). He considers how this scale reflects teacher approaches that range from student-directed *open* inquiry approaches, to *guided* inquiry approaches, and ultimately teacher directed *structured* approaches.

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Essential Feature	Variations			
	More……..Amount of Learner Self-Direction……..Less			
	Less……..Amount of Direction from Teacher Material……..More			
Learner engages in scientifically orientated questions	Learner poses a question	Learner selects among questions, poses new questions	Learner sharpens or clarifies question provided by teacher, materials or source	Learner engages in question provided by teacher, materials and source
Learner gives priority to evidence in responding to questions	Learner determines what constitutes evidence and collects it	Learner directed to collect certain data	Learner given data and asked to analyse	Learner given data and told how to analyse
Learner formulates explanations from evidence	Learner formulates explanations after summarising evidence	Learner guided in process of formulating explanations from evidence	Learner given possible ways to use evidence to formulate explanation	Learner provided with evidence
Learner connects explanations to scientific knowledge	Learner independently examines other resources and forms links to explanations	Learner directed toward areas and sources of scientific knowledge	Learner given possible connections	
Learner communicates and justifies explanations	Learner forms reasonable and logical argument to communicate explanations	Learner coached in development of communication	Learner provided broad guidelines to sharpen communication	Learner gives steps and procedures to communication

Figure 6: Essential features of classroom inquiry and their variations (Barrow, 2010: p3)

d) *Exemplary frameworks for discussion of the Nature of Creativity* within early science and mathematics

The framework below (Figure 7) draws upon a body of work developed around Possibility Thinking as the core of creativity (e.g Craft, 2001; Burnard et al, 2006; Cremin et al, 2006; Craft et al. 2012). It indicates that creativity is fostered by teachers offering time and space for children to immerse themselves in playful exploration (of individual, communal or collaborative nature). Also that creative teachers offer learner agency and sensitively both stand back in order to observe children's problem solving as well as step forwards to 'meddle in the middle' (McWilliam, 2008) and support their creativity.

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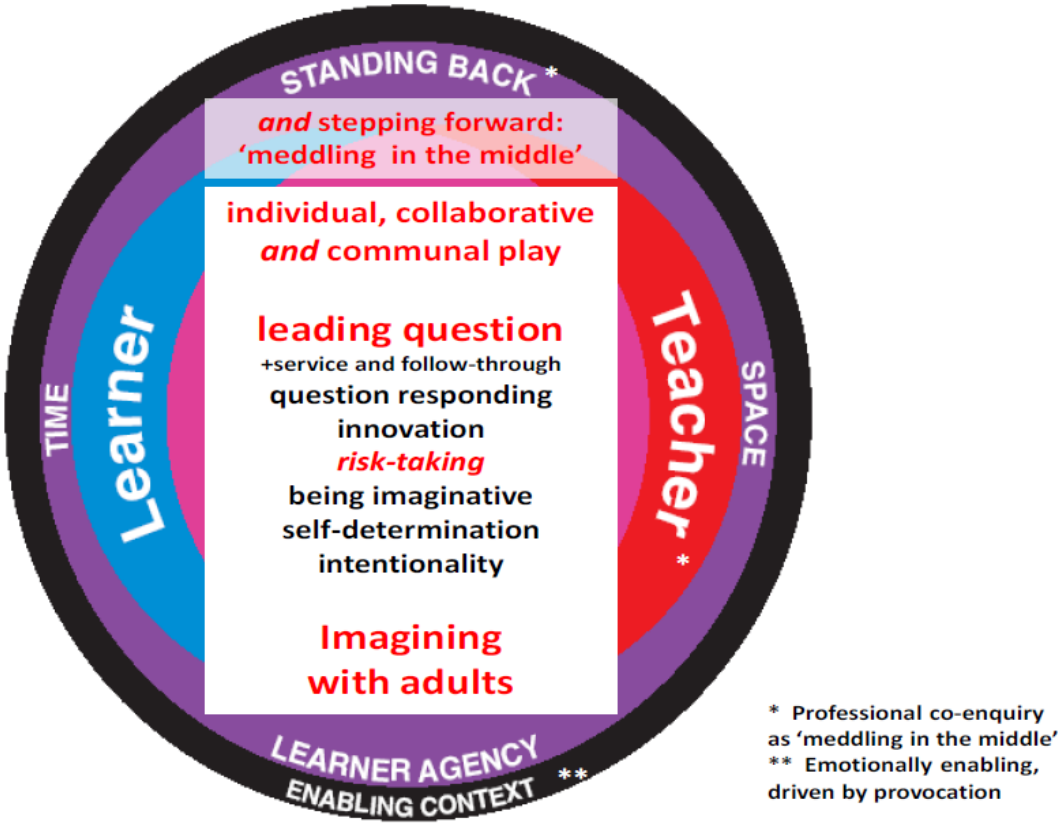

Figure 7: Pedagogy nurturing possibility thinking (Craft, MConnon and Matthews, 2012)

Teachers need to have knowledge about the differences and synergies between IBSE and CA in order to discuss the different examples offered in the materials. As such teacher educators will also need to be well acquainted with these and the argument that:

> "*Creativity and science/mathematics education have different foci; creativity emerging novelty and science/mathematics emerging children's engagement with the content and process of bodies of knowledge. What is shared is recognition of children's hands-on and minds on exploratory engagement, and a focus on inquiry and investigation, often driven by young learners' curiosity and questions."*
>
> D2.2 *Conceptual Framework* (p37)

The following definition of creativity in mathematics and science was adopted for use across the project, driven by little c creativity (which generates purposive, original and valuable outcomes):

> "*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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The following synergies were identified as common to both Inquiry-Based and Creative approaches (IBSE and CA) in the Conceptual Framework. These exist to different degrees in both approaches and are discussed in detail in the *Conceptual Framework* (D2.2) (available at http://www.creative-little-scientists.eu):

- **Play and exploration**, recognising that playful experimentation/exploration is inherent in all young children's activity, such exploration is at the core of IBSE and CA in the Early Years.
- **Motivation and affect**, highlighting the role of aesthetic engagement in promoting children's affective and emotional responses to science and mathematics activities.
- **Dialogue and collaboration**, accepting that dialogic engagement is inherent in everyday creativity in the classroom, plays a crucial role in learning in science and mathematics and is a critical feature of IBSE and CA, enabling children to externalise, share and develop their thinking.
- **Problem solving and agency**, recognising that through scaffolding the learning environment children can be provided with shared, meaningful, physical experiences and opportunities to develop their creativity as well as their own questions and ideas about scientifically relevant concepts.
- **Questioning and curiosity**, which is central to IBSE and CA, recognising that across science and mathematics teaching and learning creative teachers often employ open ended questions, and promote speculation by modelling their own curiosity.
- **Reflection and reasoning**, emphasising the importance of metacognitive processes, reflective awareness and deliberate control of cognitive activities, which may be still developing in young children but which are incorporated into Early Years practice, scientific and mathematical learning and IBSE.
- **Teacher scaffolding and involvement**, which emphasises the importance of teachers mediating the learning to meet the children's needs, rather than feel pressured to meet a given curriculum.
- **Assessment for learning,** emphasising the importance of formative assessment in identifying and building on the skills attitudes, knowledge and understandings children bring to school; supporting and encouraging children's active engagement in learning and fostering their awareness of their own thinking and progress.

As noted in the *Conceptual Framework* and experienced during the in-depth fieldwork, developing contexts for inquiry and exploration which foster creative learning and achieve a balance between intervention and collaboration, as well as standing back and learner agency, represents a considerable professional challenge.

Whilst these synergies are integrated within classroom approaches, some are discussed separately in the teacher training examples.

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3.2.1.2 Advice[2] of how to start to work with the teacher training materials

1. Identify the focus of the session/course - the themes, principles or outcomes you want to address as a teacher educator. These are likely to be related to the aims and objectives of the course or your teachers' needs.
2. Use this focus to search for appropriate templates. An Excel file, explained in the overview in section 3.1.1 and included in Appendix B is provided to support your selection. If you use the selected Content Design Principles as a filter, several templates can be found from which a selection can be made.
3. Decide how you wish to use the selected templates with the teachers. This might include general discussion and / or a structured approach requiring teachers to respond to a series of questions.
4. Some of the templates are linked with *Selected Episodes* present in the Appendix of D4.4. *Report of Practices and their Implications*. These episodes have been selected from the full range of episodes available in the *Country Reports of fieldwork* (D4.3) and have been structured to support their use in teacher education.
5. Should you require any further information about the materials included in a particular template, related, for example, to the setting for the extract, the link to the relevant Country Report and case in D4.3 is indicated.
6. However, you will see that some Content Design Principles and Teacher Outcomes are not linked with specific templates (Table 4). These are overarching principles and outcomes and include CDP 4, 5, 13 and 18. The first two need to be addressed through discussion of a range of examples from across the templates; CPD 13 and 18 go beyond the scope of the project and its exemplary training materials.

TE: Creat	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.
	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.
TE: IBSE/CA_ Synergies	5. Teacher education should provide knowledge about how children's creativity development could be enhanced and assessed within science and mathematics education.
	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

[2] This advice as well as the suggested use of the teacher training materials described below are addressed explicitly to teacher educators to facilitate their direct use by them.

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	scaffolding and involvement, to support children's creative learning and advance their creativity within science and mathematics education
TE: KnowlPolicy	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.
	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.
TE: SubjectKnowl	18. Teacher education should encourage and assess the development of teachers' literacy, numeracy and digital literacy skills through science and mathematics.
	18.1 Teachers should develop their literacy, numeracy and digital literacy skills through science and mathematics.

Table 4: Content Design Principles and Teacher Outcomes that are not linked with specific templates

A curriculum or course is based on several components. As a teacher educator you will want to consider content and your aims and objectives, the learning activities and so on. More information about framing a curriculum or course can be found in D5.2 *Guidelines and Curricula for Teacher Training*.

3.2.2 Suggestions of use in teacher education

In the following section, ten suggestions of ways of using the teacher training materials are discussed related to a range of key themes and Content Design Principles (CDP). They represent exemplary approaches for teacher educators and offer practical ideas for supporting the development of creativity in science and mathematics education in the early years.

- **Suggestion 1**: Use of Questions and Ideas of children by teachers (CDP 10, 11)
- **Suggestion 2**: Resources and Learning Environment as essential context factors for Creativity and Inquiry (CDP 10, 14, 17)
- **Suggestion 3**: Focus on the Nature of science – links with Creativity (CDP 3)
- **Suggestion 4**: Encouraging Creativity within scientific Inquiry (CDP 6)
- **Suggestion 5**: Focus on Practical Investigations which foster Creativity (CDP 2, 17)
- **Suggestion 6**: Collaboration/group work in Inquiry and Creativity approaches (CDP 15)
- **Suggestion 7**: The role of play in Inquiry and Creativity approaches in early years (CDP 7, 8, 17)

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- **Suggestion 8**: The use of the various modes of expression and representation of science and mathematics learning to support Inquiry and the development of Creativity – link with assessment (CDP 7,9)
- **Suggestion 9**: The role of the teacher in Inquiry based and Creativity approaches (CDP 1, 7, 11)
- **Suggestion 10**: Cross curricular project work to foster Inquiry and Creativity (CDP 16)

For each suggestion you will find:

- A rationale for the theme identified drawing on the *Conceptual Framework* (D2.2) for the project.
- Content Design Principles and Teacher Outcomes linked to the theme.
- Teacher Training materials (templates or episodes) selected for discussion and debate, followed by one template shown as an illustration.
- Suggestions for use of these selected materials in teacher education. It may be helpful to refer to the included template in considering how the suggested activities might be used. However it will be important to select a range of materials appropriate for your particular circumstances.

*3.2.2.1 **Suggestion 1**: Use of Questions and Ideas of children by teachers*

Focus on the use of questions and ideas of children by teachers: Rationale

The role of questions, both those which generated by children and those initiated by teachers is recognised as central within both IBSE and CA. However, children's questions or ideas are not always verbally expressed, children often convey these through action, expression and focused engagement and exploration. As teachers it is important to attend to both their explicit and implicit questions, and the young people's theories and ideas in order to build on them. As such, teachers have to value the implicit and explicit questions/ideas of children and not dismiss them either explicitly or implicitly by either ignoring them or rejecting them without any consideration.

As noted in the *Conceptual Framework* (D2.2):

"Whilst it is widely accepted that young children are innately curious and seek to explore the world around them, Nickerson (1999) suggests that the educational process can both inhibit and stifle their curiosity, their impulse to question and their engagement in mental play. Some studies indicate that teachers who use a lot of questions achieve high levels of pupil involvement and promote learning (Rojas-Drummond and Zapata, 2004),and others, that creative teachers often employ open ended questions, and promote speculation by modelling their own curiosity (Craft, 2002; Cremin et al., 2009; Robertson, 2002). Arguably, they make use of open questions to promote deeper, transferable thinking and to invite learners to engage with problems of relevance. With upper primary learners in science and

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mathematics, this can, it is claimed, improve standards of understanding and knowledge through increasing metacognition (Shayer and Adey, 2002).” (p55)

“The role of the context in questioning is also important in considering children’s own questions. As discussed in the previous section, younger children in particular may need time, and space to explore materials in order to formulate ideas and questions (Glauert, 1996). Moreover, it is important to consider that children’s curiosity may not be expressed verbally, but through other modes. Children’s drawing, gestures, or even actions with materials may illustrate the focus of their investigation; attending to these other modes can provide teachers with means to build upon the different ideas children are exploring, …” (p55)

“In science Harlen and Qualter (2004) draw attention to the different kinds and purposes of questioning for example whether they are person or subject centred, open or closed or designed to foster inquiry or to explore ideas. They indicate that questions can be framed for different purposes and emphasise the importance of giving time for thinking and response.” (p56)

Links to Content Design Principles and Teacher Outcomes

6. Teacher education should provide pedagogical content knowledge to stimulate inquiry and problem solving in science and mathematics education.

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.

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).

10. Teacher education should enable teachers to recognize and build on children’s ideas, theories and interests for the teaching of science and mathematics.

10.1 Teachers should be able to use a range of strategies for picking up on children’s ideas, interests and questions.

10.2 Teachers should be able to build flexibility into planning to take advantage of unexpected events, children’s interests and questions.

11. Teacher education should enable teachers to use questioning effectively and encourage children’s questions in order to foster creativity and inquiry.

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.

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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.

Selection of teacher training materials for discussion and debate based on the selected Teacher Outcomes

The selection of teacher training materials below focuses on children aged 3-5 years old related to the theme of use of questions and ideas by children and teachers. The template with the asterix is selected for illustrative purposes (Figure 8).

Teacher Outcome	**Teacher Training Materials** (or Templates)	**Age of children**
6.3	FRA_Class_MagnetDiscovery_IBSE	3–5
6.4	GR_Class_IceBalloons_IBSE	5
10.1	GR_Int_IceBalloons_ChildIdeas	5
6.3/6.4	PT_Class_SwinggameRope_IBSE	5
6.3	PT_Class_SunDistance_IBSE*	5
6.3	UKEN_Class_Cars_and_Ramps_BSE	3–4
6.3	UKEN_Img_Syrup_IBSE	3–4
10.1/10.2	UKSC_Class_Forest_School_ChildIdeas	3–5
11.1/11.2	GR_Class_Game_of_swallows_Question	5
11.1	BE_Class_SandBox_Question	3
11.1	UKEN_Class_Beebot_Question	3–4

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PT_Class_SunDistance_IBSE

Teacher Education Design Principle + code:	6. Teacher education should provide pedagogical content knowledge to stimulate inquiry and problem solving in science and mathematics education. **TE: IBSE**
Specific Teacher Outcome(s):	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.
Factors linked with:	**LA: Ques;** **P:Ques;**
Type of material (image – interview (int) – classroom extract (class):	Class
Originating from:	
Country report :	D 4.3 – report Portugal
Case:	Case 2
Episode:	Sun distance
Teacher:	Carol
Age Group:	5 years
Selected episode present in D 4.4 Appendix	Yes

Teacher's scaffolding questions / representation using varied materials

The aim of this activity is to understand the relative sizes of the Sun and the Earth and the distances between them, using proportions.

This activity is integrated into a bigger project, the scholar year project of this class, The Solar System. The idea of the project came up in a conversation with the children.

After some sessions talking about the Solar System, the teacher prepared an activity where the children may compare the Sun and Earth sizes as well as the distance between them: If the Sun is represented by a ball what would be the Earth size? And what is the distance between them?

The teacher makes questions to begin the exploitation of a theme where the children show and represent their ideas about it.

First, in their classroom, they had a conversation with questions and hypotheses about the Sun size, the Earth size and the distance between them. Through a dialog between the teacher and the children, they gathered many facts about the Sun and its importance for life.

The children became interested in the notion of proportion and relative sizes and wanted to compare sizes further.

Children's questions and hypotheses:

(One child takes a big piece of plasticine.)
Child B: *What if this was the Earth?*

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TA: *In that case, what would be the size of the Sun?*
Child B: *Much bigger.*

(The teacher shows the ball and says it represents the Sun and the little piece of plasticine represents Earth.)
TA: *If the Earth was this size, what would be people's size?*
Child A: *I think people were the size of microbes.*
(...)
Child C: *If the ball was the Earth, what would be the Sun's size? And what would be the size of people?*
Child B: *The people would be the size of microbes.*
(Children ask questions about the sizes of the Sun, the Earth and people)
Children: *What if the Earth was this size* (ball size)*? / And if the Earth was this room size?*

TA: *If the Sun was this size* (the ball) *and the Earth this size* (the grain), *what would be the distance between them?* (Teacher put both objects on the table)
TA: *This would be a good distance?*
(A child puts the two objects apart.)
Child D: *Maybe the Sun would be here and the Earth would be in the next room.*

(The teacher uses the hands of each child to measure the diameter of the ball)

TA: *Do you see this length? What is the name of it?*
Children: *Diameter of the ball.*
TA: *Do you know how many of this we have to use to make the distance between both?*
TA: *One hundred*
Children: *Ah!*
(...)
TA: *How far is the Sun from Earth?*
Children: *150 millions of km*
TA: *What is 1km?*
Children: *Is the distance from that wall* (the opposite) *to the window / The size of this school / From Braga to Lisbon*
(...)
TA: *Let's go to the corridor and see the distance between the ball and the grain.*
(They go to the corridor. They put the ball on the floor and start to put the papers through a line.)
TA: *What are we doing?*
Children: *We are going to see where we put the Earth.*
TA: *How many papers do we have to put between them?*

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Children: *One hundred.*
(They put the papers – following a certain pattern - between the two objects and they notice they can't see the plasticine from the ball)
Children: *We can't see the piece of plasticine from the ball!*

Figure 8: Suggestion 1 – Template PT_Class_SunDistance_IBSE

Use of the selected teacher training materials in a teacher education course

Group discussions

- Divide the group of teachers into groups of 4 to 6.
- Provide about 3 templates per group (a selection).
- Focus the group discussion around questions such as :
    - What ideas, questions and children's theories are evident in the examples? Does the age of the children matter?
    - How are the ideas, questions, theories of the children triggered? Could you provide some more possibilities?
    - How are children and/or teachers building further on ideas, questions and theories? How would you react as a teacher to children's expressed ideas, questions and theories? What do you think is the role of the teacher in the examples described? Which questions might the teacher ask?
- Invite the groups to note down their key points as a structured argument.

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Making connections (to the project's Conceptual Framework)

- Invite each group to share their insights with the class.
- Record the key points, in particular the links between pedagogical interaction and pedagogical framing, as noted below.
    - Ideas, questions and theories of children can be implicit or explicit. They are products of their curiosity and imagination. They are motivated to learn more about the surrounding world. Teachers need to observe closely and listen carefully to what is happening in the classroom – Pedagogical intervention is important.
    - Children need time and space to be able to form their own ideas and questions. Time (pedagogical framing) is also influential.
    - Questions, ideas, theories can be provoked by resources and learning environment – Resources and location (pedagogical framing) are important factors
    - Children's own questions, ideas or theories are essential in promoting understandings of inquiry, science and mathematics. They are the starting point for inquiry, creativity, problem solving and practical investigations. Teachers need to be ready to respond, standing back when necessary (and assisting children's understanding and progress by intervening or asking appropriate questions. Pedagogical interventions are important in capitalising on opportunities for learning related to the nature of science and the potential for inquiry and creativity.
    - The use of questions by teachers is very important in teaching approaches associated with of IBSE and CA. Some questions promote only 'guess what I'm thinking dialogues', others are open and promote agency, inquiry and creativity. In relation to this the use of open questions and the structure of lessons plans can be discussed. – Planning (pedagogical framing) is important to make the most of opportunities.

Based on this activity the teacher educator can decide to build further on insights into the nature of science, nature of inquiry, nature of creativity, harnessingthe power of well designed questions. In order to have deeper understandings it is important that teachers themselves experience inquiry approaches (including insights into questioning), the different aspects of the nature of science and creativity approaches.

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*3.2.2.2 **Suggestion 2**: Resources and Learning Environment as essential context factors for Creativity and Inquiry*

Focus on resources and learning environment: Rationale

As noted the *Conceptual Framework* for the project:

"Providing children with shared, meaningful, physical experiences can therefore provide them with opportunities to develop their own questions as well as ideas about scientifically relevant concepts. In other words, by scaffolding the learning environment, it is possible to foster children's agency in problem finding and solving. As highlighted by Fleer (2009), teachers play a fundamental role in mediating children's thinking between everyday concepts gained through playful interaction and more formal scientific concepts." (p 54)

"In promoting opportunities for exploration in the early years, research in science, mathematics and creativity also highlights the importance of a rich physical environment, use of the outdoor environment and the importance of making links with children's everyday lives to engage interest and foster curiosity (French 2004). Furthermore provision of a wide range of materials in the classroom can be motivating and offer different ways for young children to represent ideas and express their thinking." (p 49)

"In addition, digital technologies can foster children's creativity, for example, in gaming, in connecting with others and in content generation in particular (Craft, 2011). Children may use hand held as well as fixed console digital technology to collaborate with others in generating understandings and take digital images as a record of significant learning through their eyes. Thus capabilities in science, mathematics and creativity are enabled through the rapid evolution of digital technologies but also to a degree demanded by these. However, it is important to adopt a critical eye, as there are also arguments that technology might constrain children's interaction. Manches, for example, demonstrated how interaction through devices such as the mouse could limit the range of children's problem solving strategies in comparison to interaction with physical materials (Manches et al., 2010)." (p 30)

Links to Content Design Principles and Teacher Outcomes

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.

> 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, games.

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

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environment, both the school grounds and the wider environment beyond the school, in their teaching of science and mathematics.

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.

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.

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.

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.

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.

17.3 Teachers should be able to evaluate and select creativity enabling ICT resources for children to use in their inquiry.

Selection of teacher training materials for discussion and debate based on the selected Teacher Outcomes

The selection below is an example. The selection is based on the presence of images in the teache training materials, visualising interesting materials, resources and/or physical environments and it addresses all children in the age span 3-8 years. The template with the asterix is selected for illustrative purposes (Figure 9).

Teacher Outcome	**Teacher Training Materials** (or Templates)	**Age of children**
7.5	BE_Class_TheGiant_CreatInqPed_1	4-6
7.5	BE_Img_TheCircle_CreatInqPed	7-8
7.5	BE_Class_TheTipi_CreatInq_1	5-6
7.5	MA_Class_Fruit_CreatInqPed	7-8
7.5	UKSC_Class_DayandNight_CreatInqPed	5-6
14.1/14.4	BE_Int_Case4Lies_Lenvironm	5-6
14.1	BE_Class_ModelingWax_LEnvrionment	3
14.1/14.4	FI_Image_MeasuringOutside_LEnvironm	6

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14.1	FI_Image_SmeltingSnow_LEnvironm	6
14.1	GR_Class_Baking_cheese_pies_LEnvironm	6
14.1	MA_Class_Minibeasts_Lenvironm	6-7
14.1	PT_Image_SunDistance_Lenvironm	5
14.1	UKEN_Class_Ice_LEnvironm	4-6
14.1	UKSC_Class_Scout Camp_LEnvironm	3-5
17.1/17.2	BE_Class_ThePizza_Resources	4-6
17.1/17.2	BE_Img_ColouringWater_Resources	5-6
17.1/17.2	BE_Img_TheCarpenterCorner_Resources	4-6
17.1/17.2	GR_Class_IceBalloons_Resources	5
17.1/17.2	GR_Class_Playing_with_the_microscope_Resources	6
17.2	MA_class_Senses_Resources	5-6
17.1	PT_Image_WolfSheepCabbage_Resources	8
17.1/17.2	RO_Img_Coloured lights_Resources	3-4
17.1/17.2/17.3	UKEN_class_Digiblue _Resources	3-4
17.2	UKEN_Image_CaseJennie_Resources	3-4
17.1	UKNI_Image_OutdoorSounds_Resources	5-6
17.2	UKSC_Image_CaseSarah_Resources*	3-4
17.2/17.3	UKWA_class_Makingmusicalinstrument_Resources	4-5

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UKSC_Image_CaseSarah_Resources

Teacher Education Design Principle + code:	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. TE:Resources
Specific Teacher Outcome(s):	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. 17.4 Teachers should be able to evaluate provision for free flow play in their school settings. 17.6 Teachers should be able to gain insights into children's developing explorations and creativity based on their use of resources.
Factors linked with:	M: Expl; M: Cr.; P: Agency; P:Play; P: Express; A: Evid
Type of material (image – interview (int) – classroom extract (class):	Images
Originating from:	
Country report :	UK
Case:	UKSC 2
Episode:	No episode – general photographs of construction
Teacher:	Sarah
Age Group:	3-4 year olds
Selected episode present in D 4.4 Appendix	No

Photographs of construction activities in the nursery

There is a strong emphasis throughout the nursery on the importance of the processes of learning and learning through play. This is illustrated in the range of booklets for staff and parents that spell out the rationale and learning potential of various aspects of play provision including for example block play, malleable play, baking, small world play or modelling and gluing, with links identified to the Curriculum for Excellence (www.curriculumforexcellenceScotland.gov.uk).

Activities and experiences at the Centre are based on the needs of each individual child. Children's on-going interests and ideas are recorded in individual learning folders, drawing together photographs of significant events, staff observations and children's reflections on their experiences. These are used to inform provision at the Centre. They also provide a focus for dialogue with parents about their children's learning.

As illustrated in the photographs below, a range of different construction materials are provided that offer opportunities for the development of inquiry processes and knowledge and understanding in mathematics and science.

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Figure 9: Suggestion 2 – Template UKSC_Image_CaseSarah_Resources

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Use of the selected teacher training materials in a teacher education course

Group discussions

- Divide the group of teachers into groups of 4-6.
- Provide about 5 photographs for each group (groups can share the same images).
- Invite the groups to reflect on the images and discuss how children could interact with the resources and/or learning environments. Prompt the groups to consider different aged learners and how they as teachers might use these resources and learning environments to develop creativity in science and mathematics
- Invite the groups to note down their insights about each resource and learning environment.

Making connections (to the project's Conceptual Framework)

- Project the images and discuss each photograph.
- Invite each group to share their insights about the possible interactions of children and teachers.
- Record key insights on a blackboard, whiteboard or flip chart.
- Compare the group responses with what happened in reality (based on the episode the images were taken from).

Through discussing the photographs, highlight the following insights:

- Through using resources children can develop their exploration skills and creativity.
- Varied resources and a rich learning environment can /are necessary to provoke the curiosity of children and to foster their ideas, questions and theories.
- The materials in the environment offer children opportunities to think about different ideas, to inquire about properties, to have different approaches to the same subject.

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*3.2.2.3 **Suggestion 3**: Focus on Nature of Science – links with Creativity*

Focus on Nature of Science: Rationale

As noted the *Conceptual Framework* for the project:

According to Gago et al. (2004):

> "The 'nature of science' has become an important concern in the curriculum. This often means the rejection of the stereotypical and false image of science as a simple search for objective and final truths based on unproblematic observations. The recent emphasis on understanding the nature of science is related to the attempt to give more attention to its social, cultural and human aspects. Science is now to be presented as knowledge that is built on evidence as well as upon arguments deployed in a creative search for meaning and explanation"
> (Gago et al., 2004: 138).

Links to Content Design Principles and Teacher Outcomes

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

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.

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.

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.

Selection of teacher training materials for discussion and debate based on the selected Teacher Outcomes

All teacher training materials linked with Content Design Principle 3: NoS can be used. The template with the asterix is selected for illustrative purposes (Figure 10).

Teacher Outcome	**Teacher Training Materials** (or Templates)	**Age of children**
3.2/3.3	BE_Class_TheWaterfall_NoS	4-6
3.2/3.3	FI_Class_AnimalFences_NoS	6-9
3.2	FRA_Class_MagnetAttractionOrNot_NoS	3-5
3.2/3.3	GR_Class_IceBalloons_NoS	5
3.2/3.3	GR_Class_MeasuringTables_NoS/ChildIdeas	5-6

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3.1/3.2/3.3	MA_Class_Capacity_NoS	7-8
3.1/3.2	MA_Class_Drums_NoS	5-6
3.2	MA_Class_Waterproofing_NoS	7-8
3.1/3.2	PT_Class_WolfSheepCabbage_NoS_1	8
3.3	PT_Class_WolfSheepCabbage_NoS_2	8
3.1	RO_Img_Floatandsink_NoS/CreatInqPed	5-6
3.3	UKEN_Class_MothersDay_NoS*	7-8
3.2/3.3	UKEN_Int_Doubling_NoS	5-6

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UKEN_Class_MothersDay_NoS

Teacher Education Design Principle + code:	3. Teacher education should advance teachers' understandings about the nature of science and how scientists work, confronting stereotypical images of science and scientists. TE: NoS
Specific Teacher Outcome(s):	3.3 Teachers should be able to use 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.
Factors linked with:	P: RandR
Type of material (image – interview (int) – classroom extract (class):	Classroom extract, group interview, photographs
Originating from:	
Country report :	UK
Case:	EN1
Episode:	Mothers Day
Teacher:	Louise
Age Group:	7-8
Selected episode present in D 4.4 Appendix	No

The teacher wants the children to think about the problem realistically and not just as a disconnected mathematical problem.

The cake group had to plan enough cake for 20 people for a Mother's Day party. Their questions were:

- What ingredients will we need to buy from the super market?
- How much will we need to buy?
- Is there a way we can find out how much it will cost?

Researcher - Why did you decide three cakes?
Child - Because if there's going to be 20 people we might have two but if they're going to want seconds we might need three.
Researcher – Ah, so if you're having cake do you sometimes like to have seconds?
Child – Yes, I love having seconds.
Child - I always have a bit of both if I love both.

Louise - What's the latest time you could start making the cakes?
Child - We know the preparation time for 1 cake but we're doing 3.

They talked about the variables – e.g. whether it was 3 people making 1 cake each or 1 person making all 3 cakes. Then, whether the one person would make the 3 cakes in turn or in 1 big batch and whether they would all fit in the oven at the same time.

Louise - It depends on how many cakes fit in the oven. In ours we can only fit about one.

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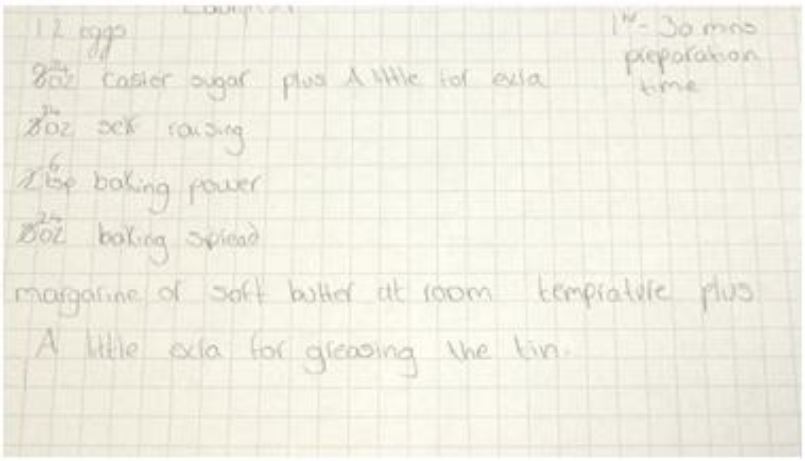
Child – I've got a giant oven. It's as big as these two tables.
Louise – That's fantastic! You must do a lot… Your mum doesn't do cooking.
Child – My dad does it. My dad always cooks.
Researcher - We'll bake the cakes at your house then.

The children working on the cakes reported back to the rest of the class.
Child - We were finding the ingredients for a cake. We had to see how many cakes we needed because there were 20 people coming.
Louise - What was the discussion we had at the end there?
Child - How long it would take to make it and bake them.
Louise – Were there any problems with that? What were the things we had to think about?
Child – Whether we would make them all at once or do them one after the other.
Louise - When you got the recipe what was the first thing you had to look for?
Child - The ingredients.
Louise - So it was a bit like a word problem.



Child's recording of what they need for three cakes.

Child - That's how much eggs and stuff we need.
Researcher - What sort of maths did you have to do when you were thinking about your cake?
Child - We had to double and then…
Child - We had to times it by three. Whatever number we had to times it by three.
Researcher - Was it easy or hard?
Child - It was a bit easy for me but I think L and H found it a bit hard.
Researcher - Did you do the tripling on the grams or the ounces or both?
Child - We did it on the ounces. Mostly.
Researcher - They're easier numbers aren't they? Because three 8s is much easier than three 225s.
Child - 225 would be 600…, 7 maybe… somewhere around seven or eight hundred.

Figure 10: Suggestion 3 – Template UKEN_Class_MothersDay_NoS

Use of the selected teacher training materials in a teacher education course

Introduce the concept of the Nature of Science and aspects of Nature of Science

If teachers are not familiar with the concept of Nature of Science, a short activity, such as Tricky Tracks (Abd- El- Khalik, F. & Lederman N.G., 1998), can be organised before the group

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discussion. During this activity teachers are triggered to think themselves about some aspects of Nature of Science. The activity prompts them to reflect and reason with others about the difference between observation and interpretation, creativity in science, the challenge of thinking 'outside the box' and reasoning.

Additional recommended activities can be found in:

- Abd- El- Khalick, F., & Lederman, N.G. (1998). Avoiding de-natured science: Activities that promote understanding of the nature of science. In W. McComas (Ed.) *The nature of science in science education: Rationales and strategies* (pp. 83-126). Dordrecht, the Netherlands: Kluwer Academic Publishers.

After the activity the different aspects of Nature of Science can be discussed using the Akerson's model, see page 38:

- Empirical – based on evidence
- Tentative – changes in light of new data/ interpretations of data
- Creative – involves imagination and creativity
- Subjective – influenced by knowledge and perspectives
- Social and cultural context – influences both practices of science and impact
- Law (pattern/regularity) and Theory (explanation)

Based on these new understandings a group discussion is organised.

Group discussions

- Divide the group of teachers into groups of 4-6.
- Provide each group with 3 templates linked to Nature of Science (groups can share the same templates).
- Provide each group with a copy of Akerson's model.
- Invite the groups to discuss which aspects of Nature of Science are evident in the examples offered in the templates and why they think this. Also to consider what aspects are discussed with the children and made explicit by the teacher and how, and what they think of the learning and teaching approaches.

Making connections

- Draw Akerson's flower on the board and add the aspects of the Nature of Science (NoS).
- Ask groups to write the names of the templates next to the aspects of NoS they reflect on.
- Ask each group to share their key insights and record these next to the name of the template.

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Consider together the class' summary. Some guiding questions:

- What is the relevance of nature of science to early years science and mathematics education?
- Are there aspects discussed with the children in the examples? Is it possible to discuss aspects of Nature of Science with young children? Or would this be a teacher's role alone?
- Which are the easier and harder aspects to focus on?
- Which learning and teaching approaches are used?
- What other approaches have been experienced by the teachers?

Give Akerson (2011)'s article to the teachers and after reading consider which ideas/approaches are noted within this and their similarity to the class's summary.

During the discussion it will be important to focus on:

- children's different interpretations or ideas. They are all interested to inquire. Ideas of children as important starting points for inquiry in science.
- creativity in science – "out of the box thinking" in order to come with different ideas or interpretations;
- the role of debate, reasoning and discussion to generate and evaluate ideas;
- the aspects of Nature of Science that can be introduced to young children;
- the importance of explicit discussion of aspects of NoS with young children.

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*3.2.2.4 **Suggestion 4**: Encouraging Creativity within scientific Inquiry*

Focus on Inquiry Based Science Education: Rationale

As noted in the *Conceptual Framework* (D2.2):

"An inquiry- based approach involves a number of different classroom activities, including, "diagnosing problems, critiquing experiments, and distinguishing alternatives, planning investigations, researching conjectures, searching for information, constructing models, debating with peers, and forming coherent arguments" (Linn, Davis and Bell, 2004)." (p33)

"Young children's experiences, both informal experiences and those nurtured in the classroom, provide them with 'data' with which to generate and evaluate different ideas in collaboration with adults and peers. As argued by Drayton and Falk (2001) an inquiry-based approach to learning is not only a means of fostering understandings and skills associated with scientific procedures, but is a means of learning content. Greater procedural knowledge may be informed by, and in turn inform, conceptual understanding (Rittle-Johnson, Siegler and Alibali, 1999); knowledge of content can provide the context for developing process skills, which in turn can help learners develop further concepts (Harlen and Qualter, 2004)." (p32)

"Whilst the focus of inquiry has been predominately science education, which for many may be synonymous with 'natural sciences' Rocard et al. (2007) suggest that IBSE can also encompass problem based learning in mathematics and arguably therefore teaching and learning in other areas of the curriculum." (p45)

"Science and mathematics in the early years offer opportunities to foster and draw together processes and concepts (i.e. knowledge) and attitudes in building on children's curiosity and concern to investigate and explain the world around them from their earliest years. As outlined in a later section, through participation in play, exploration and dialogue with others, children are engaged in generating, testing out and evaluating ideas." (p34)

"Affective factors also play a significant role in the early years; science and mathematics provide a context for developing important attitudes and dispositions as a foundation for future learning. These include curiosity, motivation and confidence to engage in inquiry and debate, willingness to change ideas, flexibility and respect for evidence and more widely positive attitudes to learning and respect for the environment. There is a growing recognition that the "affective dimension is not just a simple catalyst, but a necessary condition for learning to occur" (Perrier and Nsengiyumva, 2003: 1124). "(p35)

Links to Content Design Principles and Teacher Outcomes

6. Teacher education should provide pedagogical content knowledge to stimulate inquiry and problem solving in science and mathematics education.

> 6.2 Teachers should be able to open up everyday learning activities to allow greater opportunities for inquiry, problem solving and scope for creativity.

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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.

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).

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.

Selection of teacher training materials for discussion and debate based on the selected Teacher Outcomes

All teacher training materials linked with Content Design Principle 6: IBSE can be used. The template with the asterix is selected for illustrative purposes (Figure 11).

Teacher Outcome	**Teacher Training Materials** (or Templates)	**Age of children**
6.5	FI_Class_MeasuringOutside_IBSE	6
6.1	FI_Img_SmeltingSnow_IBSE	6
6.4	FRA_Class_IceCreamSticks_IBSE*	7-8
6.3	FRA_Class_MagnetDiscovery_IBSE	3-5
6.4	GR_Class_IceBalloons_IBSE	5
6.3	MA_Class_Minibeasts_IBSE	6-7
6.4	MA_Class_ShootingBalloons_IBSE	6-7
6.3/6.4/6.5	PT_Class_SwinggameRope_IBSE	5
6.3	PT_Class_SunDistance_IBSE	5
6.4/6.5	PT_Img_WolfSheepCabbage_IBSE	8
6.2/6.3/6.4/6.5	RO_Class_FloatandSink_IBSE	5-6
6.3/6.4	RO_Class_Magic water_IBSE	5-6
6.3/6.5	UKEN_Class_CarsandRamps_IBSE	3-4
6.4	UKEN_Class_Cars_IBSE	4-6
6 .5	UKEN_Class_Sound_IBSE	7-9
6.3	UKEN_Class_StartingPoint_IBSE_	6-7
6.2/6.3/6.5	UKEN_Img_Syrup_IBSE	3-4
6.1/6.4/6.5	UKNI_Img_GingerbreadMan_IBSE	5-6
6.5	UKNI_Img_Shapes_IBSE	3-4

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FRA_Class_IceCreamSticks_IBSE

Teacher Education Design Principle + code:	6. Teacher education should provide pedagogical content knowledge to stimulate inquiry and problem solving in science and mathematics education. **TE: IBSE**
Specific Teacher Outcome(s):	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).
Factors linked with:	**T: Ped; T:Sci, P: Ques; P: Express; LA: Plan; LA: Obs; LA: Equip; LA: Connect**
Type of material (image – interview (int) – classroom extract (class):	classroom extract (class)
Originating from:	
Country report :	D 4.3 - France
Case:	4
Episode:	Ice Cream Sticks
Teacher:	Nani
Age Group:	7-8
Selected episode present in D 4.4 Appendix	Yes

Fostering children's understanding of numbers

Teacher's goal is to let children explore the material, and found a strategy to count the ice cream sticks.

- **Child**: You have eaten all of them? *[He is talking about the ice cream sticks]*
- **T**: Yes, I've eaten all of them, can you imagine it? According to you, how many are they?
- **Children**: 100, 2000… More than 100…
- **T**: That is what I want to know, how many ice cream I've eaten…

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Children try to make sense to number's composition and decomposition. Teacher's goal is to make them understand, for example that 10 units compose a dozen, or that 10 dozens compose one hundred, and so one.

At first, a child suggests to count the ice cream sticks every two. It is an interesting idea, but it is not the one that Nani is expecting (every ten is more appropriated toward her goal). Nevertheless, because in her approach the best solution is collectively decided, she doesn't make any comment on this specific solution.

- **T**: So, how will we do to know how many ice cream sticks there is?
- **A child**: We will count them.
- **T**: To count them, yes... **Sh?**
- **Sh**: We will take them every two and count them.
- **T**: To take them every two... and count them...
- **Some children**: Every ten
- **A child**: Every twenty.

The teacher fosters children reasoning and expressions of their own solution and collective decision making. It can be notice that children develop a large understanding of number through the activity. Numbers are not just representing ice cream sticks; they are useful to count faster (e.g. *'hundred is easier'*).

- **T**: Wait, wait, and listen, there is another idea which is arriving, listen, then we will choice the best idea, the easiest to count. **An** you say that we have to make?
- **An**: Hundreds.
- **T**: Packets of 100, because you have a lot of dozens...
- **T**: So do we make packets of 100? Or, the other idea is to count all the dozens on the table the other idea is that we take all the units on the tables to make dozens. So what do we do?
- **Al**: If you count all the dozens on the table you can forget some... when hundred is easier.

The teacher and the group of children will construct a new material based on ice cream sticks organization in groups of 10, 100 and 1000. This material will follow children for the entire school years. The teacher will send them to the ice cream sticks corner for any difficulty with numbers. Here children became actor of the own pedagogical material.

Figure 11: Suggestion 4 – Template FRA_Class_IceCreamSticks_IBSE

Use of the selected teacher training materials in a teacher education course

Group discussions

It would be helpful if teachers experienced an inquiry activity at their level before starting the group discussion so they can revise or gain greater understanding of key features of scientific inquiry. If this is not possible, different features of the inquiry process should discussed first. Here reference to Barrow's chart shown on section 3.2.1 *Essential features of inquiry and their variations* would be useful to support participants' reflections on their views and experiences of inquiry.

- Divide the group of teachers into groups of 4 - 6.

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- Provide each group with three templates linked to IBSE (groups can share the same templates).
- Invite the groups to discuss
    - Which features of the inquiry process are the focus of activity in each example (i.e. questioning, designing or planning investigations, gathering evidence, making connections, explaining evidence, communicating and reflecting on explanations)?
    - What are the opportunities for children's decision making and creativity? Do you think this is an example of an open, guided or structured inquiry? Explain your answer.

Making connections (to the project's Conceptual Framework)

- Draw 3 columns on the board labelled open inquiry, guided inquiry and structured inquiry.
- Ask each group to record their thoughts by writing the names of the different templates in the relevant columns.
- Discuss and compare the examples in the column labelled 'structured inquiry'. Why did teachers think these were structured inquiries? Do all groups agree with this reasoning? If not, why not?
- Compare an example from the structured inquiry column with an example in the open inquiry column. What are the differences?
- Finally take an example from the 'guided inquiry' column and compare this with the other two examples.
- Based on this comparison discuss and record key features of open, guided and structured inquiry in the corresponding columns. Do the different types of inquiry have an impact on the opportunities for developing creativity?
- Consider the role of the teacher and ways in which support was provided for children's decision making in each example (pedagogical interventions play an important role in IBSE). What are the advantages and disadvantages of open, guided and structured approaches?
- Discuss features of creative approaches within the examples selected (refer to frameworks in section 3.2.1 earlier in this document). What are the opportunities for children's creativity?
- Ask teachers to suggest examples from the templates that illustrate connections between inquiry based and creative approaches. Consider links to the synergies outlined in 3.2.1

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- Present Barrow's chart. Discuss the profile of the different examples from the templates and how these have an impact on the opportunities for developing creativity.

Further discussion of the synergies between inquiry-based and creative approaches and of opportunities for children's creativity within inquiry can be found in the *Conceptual Framework* (D2.2).

If time is not an issue, teachers can experience the difference between structured, guided and open inquiry themselves during a practical workshop. Such a workshop can be found on http://www.exploratorium.edu/ifi (workshop: Comparing Approaches to Hands-On Science).

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*3.2.2.5 **Suggestion 5**: Focus on Practical Investigations which foster creativity*

Focus on Practical Investigations which foster Creativity: Rationale

In the Content Design Principle 2: PractInvest, the focus is on the *pedagogical framing* of practical investigations, for example, their practical organisation, grouping of the provision of resources and time, although it is also necessary to reflect on *pedagogical interactions*, since both are linked. The previous suggestion related to IBSE (linked to Content Design Principle 6: IBSE) focused mainly on *pedagogical interactions*, here the emphasis is more on *pedagogical framing.*

As noted in the *Conceptual Framework* (D2.2):

"Subject knowledge and content is important, however ITE students should also receive instruction in methods and application. Yilmaz-Tuzan (2007) suggested that science methods courses should provide opportunities to learn about different methods and practice them as appropriate, ideally through field experience. Teacher educators have to provide student teachers with teacher education experiences that highlight general principles of practice, and as ITE teachers develop beliefs of science and mathematics teaching on their in-class experiences, teacher education must model new (innovative) pedagogy (Weld and Funk 2005)." (p 86)

Links to Content Design Principles and Teacher Outcomes

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

> 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.

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.

> 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.

Selection of teacher training materials for discussion and debate based on the selected teacher outcomes

The selection below is an example. In the selected teacher training materials details about the practical investigation are provided. More information about the practical investigations can be found in the corresponding national reports. The template with the asterix is selected for illustrative purposes (Figure 12).

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Teacher Outcome	**Teacher Training Materials** (or Templates)	**Age of children**
2.1	BE_class_TheWind_PractInvest*	5-6
2.1	GE_Img_WaterInquiry_PractInvest	6
2.1	UKEN_class_Bubbles_PractInvest	3-4
2.1	UKEN_Class_CountingMinibeasts_PractInvest	4-5
2.1	UKNI_Image_FlowerDye_PractInvest	6-7
2.1	UKWA_Class_Jelly_PractInvest	3-4
17.1	BE_Class_ThePizza_Resources	4-6
17.1	BE_img_ColouringWater_Resources	5-6
17.1	BE_Img_TheCarpenterCorner_Resources	4-6
17.1	FI_Class_MapSymbols_Resources	6-9
17.1	GR_Class_IceBalloons_Resources	5
17.1	GR_Class_Playing_with_the_microscope_Resources	6
17.1	MA_class_Fruit_Resources	7-8
17.1	PT_Image_WolfSheepCabbage_Resources	8
17.1	RO_Img_Coloured lights_Resources	3-4
17.1	RO_Img_PartsofaPlant_Resources	6-7
17.1	UKEN_class_Digiblue_Resources	3-4
17.1	UKNI_Image_OutdoorSounds_Resources	5-6

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BE_class_TheWind_PractInvest

Teacher Education Design Principle + code:	2. Teacher education should provide teachers with skills and competences to carry out practical investigations of science and mathematics in the classroom. TE:PractInvest
Specific Teacher Outcome(s):	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.
Factors linked with:	LA: Plan
Type of material (image – interview (int) – classroom extract (class):	Class
Originating from:	
Country report :	D 4.3 – Belgian report
Case:	4
Episode:	The Wind
Teacher:	Lies
Age Group:	5 – 6 years
Selected episode present in D 4.4 Appendix	No
Link with	DP 6: IBSE DP 17: Resources DP 11: Question

Planning investigations with wind

During the activity the children were allowed to experiment with different materials in front of a fan, to see if they move with the wind. After a while the teacher introduced boxes, the children had to arrange the objects in the boxes based on their reaction in the wind (before the fan). Later on they did a recheck and had to fill in an assignment card on which the objects were visualised. Then the children were also allowed to experiment with materials they found in the classroom.

During the activity the teacher asked questions and encouraged the thinking process of the children. At the end of the activity they discovered that the canoe made a strange movement when placed in front of the fan.

In this activity the main focus of the teacher was encouraging children to conduct an investigation and to observe and explain. She tried to make them

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check their observations by using different strategies (the boxes, the assignment card) and encouraged them to reflect on the things that were happening, such as in the fragment below.

At this point one of the children brings in a canoe from the Indians.
***Child 4**: "Teacher, the canoe doesn't move!"*
And at that moment the canoe goes sideward.
***Teacher**: "Oh, **C4** look what's happening."*
***Child 4**: "it moves sideways."*
***Teacher**: "And if we place it in the other direction, will it move too?"*
***Child 4** places the canoe in the different direction and notices it doesn't move.*
***Teacher**: "how is this possible?"*

In this activity the children's curiosity is encouraged by the research questions. The children are eager to know if an object will move. However, also in her coaching the teacher tries to foster the discovery urge and she herself is also excited. As such, she becomes an inquirer herself.

Child 4 is placing the sheet of paper in front of the fan.
***Teacher**: "Oh, should the paper always fly away?"*
Child 4 places the paper folded in two on the table in front of the fan.
***Teacher**: "Look, does the paper fly away now?"*
All the 4 children are looking at the sheet of paper.
***Teacher**: "How did it come it flew away before?"*
***Child 2** is opening the sheet of paper and sees that it is flying away then.*
***Teacher**: "What did you do with the paper?"*
***Child 2**: "I have opened it!"*
***Teacher**: "You had opened it*
***Child 4** is picking up the paper and places it open in front of the fan, but pushes it completely against the table.*
The children and the teacher are all looking what will happen. The paper stays at his places.
***Child 1** is picking up the paper and places it a little bit further on the table, and then it flies away.*
***Child 3** is picking the paper up and places it back together with C1 on the table completely flat and then it doesn't fly away, until they pick it up a bit.*

During their play, the children also discovered the possibilities of the fan, so they learned how handle this technical system in order to make it blow fast and slow, to change the direction of blowing,… So they got the opportunity to handle this technical system in a proper way.

The children discovered they could make the wind blow hard and soft, and this made them experiment with the other materials.

***Teacher**: "**C1,** you wanted to know if the styrofoam still flew, if the wind blows softer."*

Figure 12: Suggestion 5 – Template BE_class_TheWind_PractInvest

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Use of the selected teacher training materials in a teacher education course

Group discussions

- Divide the group of teachers into groups of 4 to 6.
- Provide about 2 templates per group (groups can have the same templates).
- Invite groups to discuss:
    - How are the practical investigations arranged and organised by the teachers? Consider for example:
        - setting and space, number of children, organisation of materials and resources;
        - agency of the children;
        - role of the teacher;
        - nature of the learning activity;
        - opportunities for creativity.
    - How would you prepare such activities?
- Record the results of group discussion on paper.
- Structure responses according to the assignment prompts.

Making connections (factors – Conceptual Framework)

- Ask each group to share their responses.
- Record key points (for example on a flip chart or whiteboard).
- Discuss ways of fostering creativity through practical investigations. This could include consideration of:
    - The environment where the investigations take place and arrangements such as the range of materials and resources available, the number of children involved in the investigations, the evaluation and presentation of the results (linked to pedagogical framing).
    - The role of the teacher and the opportunities for children's agency – the roles of pedagogical interventions in fostering children's independence. In this light it is interesting to discuss the framework of Barrow about structured, guided and open inquiry. This framework can be found in the *Conceptual Framework* (D2.2) (www.creative-little-scientists.eu) and in section 3.2.1.

After this discussion consider implications for planning lessons involving practical investigations. What might a lesson plan look like? What would be important elements to include? Make links with the earlier discussion about essential considerations in organising practical investigations and ways of fostering children's independence and decision making.

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Important elements in a lesson plan include:

- the arrangement of space – it is helpful/ useful to draw a map of the space where the activity will be run;
- the provision and availability of materials and resources (are there ways in which parents could help?);
- questions which could be used to initiate, support or evaluate children's investigations and foster the curiosity of the children in planning their investigations. These questions will be linked with the degree of agency afforded to the children and as such with the degree to which investigations are guided or structured by the teacher.
- possible modes to represent or communicate the results of the investigation;
- ways in which children will be encouraged to share, discuss and evaluate results and explanations;
- time required to carry out the activity.

Most of the above elements are linked with *pedagogical framing*. It is important to incorporate them in a lesson plan to support the organisation and structure of an activity. If a teacher has reflected on these issues, he/she is able to create a rich learning environment in which the agency of the children, their curiosity, their explorations, their play, ... can be promoted and supported. As such pedagogical framing is a key ingredient to promote creativity.

Findings from D4.4 *Report on Practices and their Implications* (p 11):

"Fieldwork provided many examples of teaching approaches associated with creativity. Teachers planned motivating contexts for learning linked for example to children's interests, everyday events and familiar stories. They provided a rich physical environment for inquiry making good use of everyday and household materials and natural resources. Very few relied on published resources but planned or adapted activities appropriate to their children and their contexts. Group work was another common feature of teachers' practices affording opportunities for dialogue and collaboration."

More information about the role of the teacher, the management of group work and the use of the environment and materials, can be found in other suggestions. To support deeper understanding of different forms of investigation, different ways to handle questions and the role of the teacher, it is interesting for teachers to experience themselves the differences between open, guided and structured inquiry. Interesting materials can be found on www.exploratorium.edu/ifi.

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*3.2.2.6 **Suggestion 6**: Collaboration/group work in Inquiry and Creativity approaches*

Focus on Collaboration/group work: Rationale

As noted in the *Conceptual Framework* (D2.2):

"It is widely accepted that language plays a crucial role in learning in and through science (Carlsen, 2008; Roth, 2007), and communication is seen to be one of the critical features of IBSE, although other modes of communication also enable children to externalise, share and develop their thinking (Glauert, 2009b). Listening to children's initial ideas is important not only to afford respect, but to emphasise the validity of alternative points of view (Coltman et al., 2002), their perspectives are not simply misconceptions. In school, IBSE involves problem solving activities with peers, which are often highly collaborative, and afford children access to a wider range of problem- solving strategies." (p 50)

"The communication of ideas and ways of thinking allows children to listen to others' strategies and ideas and develop increased awareness which may prompt a desire to restructure their own ideas, in the face of other more plausible or consensual ones (Varela, 2010). This links to research on the value of developing children's metacognitive awareness. Although little of this work is focused in the early years, it does suggest that if children are afforded opportunities to explore and work in small groups, this may make them more attentive to their own thoughts and the thoughts of others, encouraging monitoring and self-regulation (Larkin, 2006; Littleton et al., 2005)." (p 50-51)

"Much current creativity research recognises that creative processes are essentially social and necessarily collective and collaborative (see John Steiner, 2002; Sawyer, 2006) and there is considerable work exploring the nature of creative dialogue which indicates that dialogic engagement is inherent in everyday creativity in the classroom (Littleton et al., 2005; Mercer and Littleton, 2007; Rojas-Drummond et al., 2006; Wegerif, 2005, 2010; Vass, 2007)." (p 51)

Links to Content Design Principles and Teacher Outcomes

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

> 15.1 Teachers should have knowledge of the value of collaboration for inquiry and creative thinking and learning.
>
> 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.
>
> 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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15.4 Teachers should be able to use resources and teacher intervention appropriately to foster collaboration in science and mathematics.

15.5 Teachers should be able to assess group work.

15.6 Teachers should be able to use effective strategies for sharing ideas and discussions from different groups.

Selection of teacher training materials for discussion and debate based on the selected Teacher Outcomes

All teacher training materials linked with Content Design Principle 15: GWork can be used. The template with the asterix is selected for illustrative purposes (Figure 13).

Teacher Outcome	**Teacher Training Materials** (or Templates)	**Age of children**
15.1/15.4	BE_Class_ColouringWater_GWork	5-6
15.3	BE_Class_MeasuringandEstimating_GWork	6-7
15.1/15.4	BE_Class_SandBox_GWork	3
15.1/15.4	BE_Class_TheCarpenterCorner_GWork	4-6
15.4	FRA_Class_Collaboration_GWork	3-4
15.1/15.2/15.4	FRA_IceCreamSticks_Gwork	7-8
15.1/15.2	FRA_Class_Share_GWork	3-4
15.1/15.3/15.4/15.5	GE_Int_Materials_GWork	6
15.1/15.3/15.4	GR_Class_BeeBot_Gwork	7-8
15.1/15.5/15.6	GR_Class_ShapeTrees_GWork	5-6
15.2/15.3/15.4	MA_Class_Minibeasts_Gwork*	6-7
15.2/15.4	MA_Class_Money_GWork	6-7
15.2/15.3/15.4	MA_Class_Senses_GWork	5-6
15.1/15.2/15.3/15.4	UKEN_Class_BalancingPens_GWork	5-6
15.6	UKEN_Class_MothersDay_GWork	7-8

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MA_Class_Minibeasts_GWork

Teacher Education Design Principle + code:	15. Teacher education should promote teachers' use of group work to support children's inquiry processes and creative learning. **TE: GWork**
Specific Teacher Outcome(s):	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. 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. 15.4 Teachers should be able to use resources and teacher intervention appropriately to foster collaboration in science and mathematics.
Factors linked with:	**P: Collab; M:Expl**
Type of material (image – interview (int) – classroom extract (class):	classroom extract (class)
Originating from:	
Country report :	D4.3 – report Malta
Case:	Case 2
Episode:	Minibeasts
Teacher:	Lydia
Age Group:	6-7
Selected episode present in D4.4 Appendix	Yes

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Providing the students space and freedom to work in groups and to direct their own groups as they explore their outdoor environment; Generating ideas and connecting evidence they collect to their own experiences whilst sharing it with the group

Reflecting and hypothesizing about the pupa stuck to the tree

Lydia: O.K. You are now in the yard and I am going to ask you to work in your groups and to try and find minibeasts... You have to record what you find in yoursheets...

The children look at their worksheets and prepare the pencil in their hands.
They wander around.

Child 1: See what this is...
Child 2: That is a pupa...is was a caterpillar once.
Child 3: Yes, we had one in our garden...it turns into a butterfly...
Child 1: Look, how it is stuck to the tree...will it fall?
Child 2: How long do they take to become a butterfly?
Researcher: They can become moths too...you know...

The children look at the pupa for some more time, make a note in their worksheet under caterpillar and move on to look for other minibeasts.

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Children asking each other questions and sharing own experiences to make sense of evidence or minibeasts found

Another group saw some ants walking on the soil.

Child 1: Look, we have lots of those, ants at home too...
Child 2: How many are there?

Children are counting the ants that they see...1...2...3 etc.

Child 1: We also have them in garden, the ants...
Child 2: We also have them inside; my mum does not like them in the kitchen...
Child 1: Look how they run about; they go fast...do they have food?

Children are busy recording the number of ants in the worksheet. They ask the researcher to help them on how to fill it in as they were not sure where they had to put in the number of ants that they had observed.

Figure 13: Suggestion 6 – Template MA_Class_Minibeasts_Gwork

Use of the selected teacher training materials in a teacher education course

Group discussions

- Divide the group of teachers into groups of 4 to 6.
- Provide about 3 templates per group (groups can have the same templates).
- Invite groups to discuss:
    - How far are the children collaborating?
    - How is the group work arranged?
    - What are children doing? Which goals are fostered?
    - What is the agency of the children? What are their roles, for example, who is in charge?
    - What is the role of the teacher?
    - Is the group work assessed and by what means?
    - Is creativity fostered and how?

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Ask groups to record their responses to each question, including any questions or issues raised.

Making connections (to the project's Conceptual Framework)

- Invite each group to share their responses with the rest of the class. Record key points in relation to the planning of the group work, role of the teacher, role of the children, resources and materials used, the assessment of the group work.
- Ask the teachers to reflect on ways in which creativity was fostered within the classroom examples discussed. Draw on the frameworks for creativity and inquiry and the similarities between creativity and inquiry outlined in section 3.2.1 of this report. Both frameworks and the connections between inquiry based and creative approaches are discussed in detail in the *Conceptual Framework* (D2.2).
- Encourage the teachers to reflect on the processes of group discussion during the session - ways in which they experienced collaboration and the impact on their learning. Questions that could be considered include:
    - Who was leading the group discussion at different points?
    - What was the role of each member in the group?
    - What was the role of the teacher educator?
    - Was the group discussion assessed? How might you assess the group discussion (as a participant or an educator?
    - In what ways were the ideas of the different groups shared?
    - To what extent was creativity fostered? In what ways?

This provides opportunities for teachers to make links between their own experiences and group work in preschools or primary schools. This can help emphasise the role of group work and collaboration in sharing ideas and in debating activities and outcomes.

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*3.2.2.7 **Suggestion 7**: The role of play and exploration in Inquiry and Creativity approaches in early years*

Focus on play and exploration: Rationale

As noted in the *Conceptual Framework* (D2.2):

"Whilst pre-school children differ with regard to their experience of play, exploration and interaction, the significance of play in early learning is widely recognised and represents the focus of considerable research within both approaches. It is argued that informal playful experiences nurture children's motivation to understand their world, (Larsson and Halldén, 2010) and Gopnik, Sobel, Schulz and Glymour (2001) claim that from as young as two or three, children are able to make causal inferences about information they gain from the environment, demonstrating an ability to reason and reach conclusions, although not necessarily verbally." (p 47)

"Most scholars appear to perceive that playful experimentation/exploration is inherent in all young children's activity, such exploration is at the core of IBSE and CA in the early years." (p 48)

"Research in science, mathematics and creativity indicates that play based exploratory contexts afford rich opportunities for supporting the development of both positive attitudes and motivation; which as noted earlier are key constructs of the affective domain in science education (Koballa and Glynn, 2008) and arguably mathematics. Based on the Experiential Education project, Laevers (2000, 2005) argues that the creation of playful learning contexts which foster deep learning is at the core of quality early education which he posits is affectively engaging and 'affects the deeper structures on which competencies and dispositions are based' (2000: 20)." p 49

Links to Content Design Principles and Teacher Outcomes

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.

> 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.
>
> 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.

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.

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8.1 Teachers should be able to design and assess open-ended learning activities.

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.

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.

17.4 Teachers should be able to evaluate provision for free flow play in their school settings.

17.6 Teachers should be able to gain insights into children's developing explorations and creativity based on their use of resources.

Selection of teacher training materials for discussion and debate based on the selected Teacher Outcomes

The selection below is an example. The selected teacher training materials are focused on examples of children's free play and exploration, with minimal guidance from a teacher. The template with the asterix is selected for illustrative purposes (Figure 14).

Teacher Outcome	**Teacher Training Materials** (or Templates)	**Age of children**
7.3/7.4	BE_Class_TheTipi_CreatInqPed	5-6
7.3	GE_Class_BuildingBlocks_CreatInqPed	5
7.3/7.4	MA_Class_MeasuringRobots_CreatIngPed	3-4
7.3	UKEN_Class_Pulleys_CreatInqPed	3-4
7.3/7.4	UKEN_Class_Ramps_CreatInqPed	3-4
7.3	UKNI_Class_OutdoorSand_CreatInqPed	3-5
7.3	UKSC_Class_MeltingandFreezing_CreatInqPed	3-4
7.4	UKSC_Class_WaterPlay_CreatInqPed*	3-4
8.1	BE_Class_TheBags_CreatinqLA	3
8.1	UKEN_Class_Ice_CreatInqLA	3-4
8.1	UKNI_Img/Int_Foam_CreatInLA	3-4
17.2	BE_img_ColouringWater_Resources	5-6
17.2/17.4	GR_Class_IceBalloons_Resources	5
17.4	UKNI_Image_OutdoorSounds_Resources	5-6
17.2	UKWA_Class_Makingmusicalinstrument_Resources	4-5

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UKSC_Class_Water Play_CreatInqPed

Teacher Education Design Principle + code:	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. **TE: CreatInqPed**
Specific Teacher Outcome(s):	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.
Factors linked with:	**P: Play; P:Agency; M: Expl; A: Form**
Type of material (image – interview (int) – classroom extract (class):	Classroom extract (class)
Originating from:	
Country report :	D 4.3 – report UK Scotland
Case:	UKSC 1 Martha
Episode:	Water Play
Teacher:	Martha
Age Group:	3-4
Selected episode present in D4.4 Appendix	No

Rich physical environment for exploration
Material organised to support independence and improvisation

In the nursery provision is made each day for the exploration of materials including water, sand and malleable materials. Adults vary the resources provided in the water tray over time based on their observations of children's interests and wider events in the life of the nursery. Children also have free access to trays of resources nearby to extend their observations. The organisation of space allows easy access for groups of children.

The setting for the water tray

On this occasion a wide variety of resources had been set out at the start of the day to support children's explorations including measuring jugs of various sizes, boats, whisks and spoons. To these

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children had added plastic pipes and syringes taken from the trays of resources behind the water tray. Staff had placed balance scales and pipettes on a table right next to the water tray intended to support the exploration of ice balloons. These resources too were incorporated by children into their water play. Children were mostly left to explore on their own or in collaboration with others throughout the morning. Adults interacted occasionally to show interest or ask questions in response to the direction of children's activities.

The episode reported here concerns the sustained and focused explorations of one child, Anna. Across the episode she engaged in a series of repeated activities, showing focused attention throughout

In the first phase of her explorations she repeatedly poured water into the bucket on one side of the balance and then the other – gradually filling each side to the top and making the two sides balance.

Anna pouring water into buckets on the balance scales

Anna noticed connections between the level of the water in the bucket and whether it was heavier or lighter, *"heavier when it's higher"*.

Noticing the children had moved the balance scales into the water tray Vera, one of the nursery officers, came over to see what was happening and suggest ideas.

***Anna**: Too much water (on one side, commenting on balance tipping)*
***Vera**: Will you put some on the other side as well?*
***Anna**: Need to put some here.*
***Vera**: Good idea.*

Filling the bucket with a syringe.

Trying to fill the pipette with the syringe

Anna then started filling the bucket with the syringe. Following this her focus of attention shifted to the pipette. She tried various ways of filling the pipette, first trying to fill it with the measuring jug

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and then by attaching the pipette to the syringe, but she could not manage to attach it securely. Eventually she asked the researcher what the pipette was and was shown how to fill it.

Next she used the whisk to create bubbles in the water – singing away as she did so *"swish, swish, swish"* and watching closely the bubbles produced. She returned to the whisk on several occasions during her time at the water tray.

A further activity that gained her close attention was using one of the balance scale buckets to fill a measuring jug. She filled the jug very slowly and carefully until no more water could be added saying *"careful, careful and pour" "put one here put one there" "all of the water in there"* feeling the rounded surface of the water in the jug. She repeated this several times.

A final focus of activity that provoked Anna's attention and commentary was watching the water flow through holes, through the bottom of a bucket with holes and through the holes in a plank that ran across the water tray. She articulated her observations for example *"Going through the holes - – shhhhh''* (pouring water through the hole in the middle of the plank). She made connections between her actions and the water flow for example *"If you pull this up it comes out the bottom"* (the bucket with holes).

Recognising and capitalising on the potential of children's explorations

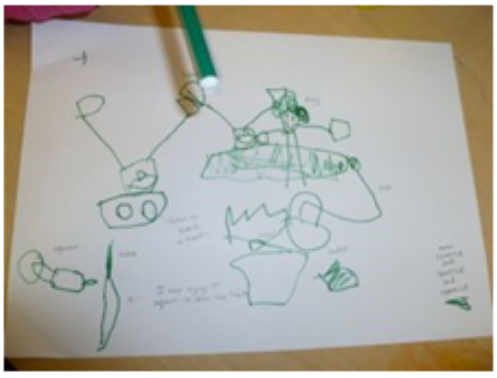
Dialogue with Anna prompted by photographs of her explorations and her drawing of her experiences provided opportunities for reflection and gave further insights into her explorations and thinking. For example in discussing photographs of her activities with the researcher Anna explained

> *"I was putting the water in to see which one was the heaviest" (balancing activity)*
> *"I was squirting – yeh something happened and it squirted in my face" (syringe).*
> *"I was it put through the little 'tuber' and it didn't work' … 'it kept slipping off, slip, slip, slip" (trying to fix the pipette on to the syringe.*

When asked what she found most interesting she quickly referred to *"the tuber"*. When asked what she thought was new or special she commented on her observations of water flow – the sound it made and its appearance:

> *"Well the special thing was the water goes woo, woo, woo"…. "the water glows a wee bit".*

Key equipment and events also featured in her reflective recording of the activity with annotations dictated to the researcher. The drawing highlights the balance scales, the holes in the board, the incident with the syringe and the pipette *"I was trying to squirt it down the tube"* and her observations of moving water *"water sparkled and sparkled and sparkled"*.



Anna's drawing of her experiences in the water tray

The photographs, drawing and dialogue were recorded in Anna's profile, providing valuable evidence to support staff and parents in recognising and building on Anna's interests and capabilities.

Figure 14: Suggestion 7 – Template UKSC_Class_WaterPlay_CreatInqPed

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Use of the selected teacher training materials in a teacher education course

Group discussions

- Divide the group of teachers into groups of 4 to 6.
- Provide a selection of about 3 templates per group (groups can have the same templates).
- Focus the group discussion around questions such as:
    - What are children doing during this activity?
    - What do you think they are they learning?
    - What factors do you think were influential in provoking play, exploration and/or creative thinking in the examples given?
    - What is the role of the teacher?
- Ask the groups have to note key points from their discussion as a structured argument.

Making connections (to the project's Conceptual Framework)

- Bring together the responses of the different groups and note key points on the board. Possible issues to be considered are indicated below.
    - First, it will be important to consider definitions of play in science and mathematics education and make links with creativity. In the examples in the templates, play is linked to exploration, creative thinking and learning about the world around children. It will be important to examine the opportunities for children's agency and discuss the role of the teacher in supporting and extending play. What is the teacher doing in each example? Does the teacher provoke play and exploration or does s/he block the creative thinking and explorations of the children? (In Suggestion 9 the role of the teacher is the focus).
- Second, discuss factors that are crucial to provoke play. Pedagogical framing is critical for example related to the factors of time, space, rich physical environment, materials and resources.

As noted in the *Conceptual Framework* (D2.2):

"Several studies which can be seen to involve examination of IBSE and CA, albeit implicitly, demonstrate the importance of providing children with sufficient time and space to foster such exploration and creative thinking (e.g. Cremin et al., 2006; Jeffrey, 2005; Martin and Schwartz, 2005). The provision of 'stretchy' time in the possibility thinking studies encouraged children's immersion in extended playful activities and, alongside the enriched and mutually-owned space, appeared to motivate and involve the young thinkers (Cremin et al., 2006)." (p 49)

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"This need for time to support exploration is also emphasised by Glauert (2009a), who proposes that over time children "may begin to raise questions for investigation, look for patterns and relationships and offer explanations"." (p 49)

"In promoting opportunities for exploration in the early years, research in science, mathematics and creativity also highlights the importance of a rich physical environment, use of the outdoor environment and the importance of making links with children's everyday lives to engage interest and foster curiosity (French 2004). Furthermore provision of a wide range of materials in the classroom can be motivating and offer different ways for young children to represent ideas and express their thinking." (p 49)

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*3.2.2.8 **Suggestion 8**: The use of the various modes of expression and representation of science and mathematics learning to support Inquiry and the development of Creativity – link with assessment*

Focus on various modes of expression and representation: Rationale

As noted in the *Conceptual Framework* (D2.2):

"Harrison and Howard (2011) highlight the key roles of feedback, sharing criteria with learners, questioning and self assessment in promoting effective learning. The role of children in assessment is particularly significant when considering that evaluating ideas is an important learning process. This may include peer assessment as well as self assessment, thereby contributing to community aspects of the class.

In the early years there are also arguments that a more holistic approach to assessment is important, that takes account of children's attitudes and interaction with others and with the environment in thinking (e.g. Glauert, 2009b). Insights from recent research highlight the need to develop assessment approaches sensitive to the capabilities of young children (Robbins, 2005) and to afford opportunities for children to express their ideas in different ways through for example speech, gestures or visualisations (Glauert 2009b)." (p 61)

More information about assessment (formative, summative and multimodal assessment) can be found in pages 64 to 69 of the *Conceptual Framework* (D2.2).

Links to Content Design Principles and Teacher Outcomes

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.

> 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.
>
> 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.

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.

> 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.

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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.

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.

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.

Selection of teacher training materials for discussion and debate based on the selected Teacher Outcomes

The selection below is an example. In fact all teacher training materials linked with Content Design Principle 9: Multimodal and linked with Content Design Principle 7 (more specific 7.9 and 7.10) can be used. The template with the asterix is selected for illustrative purposes (Figure 15).

Teacher Outcome	**Teacher Training Materials** (or Templates)	**Age of children**
7.10	BE_Img_TheCircle_CreatInqPed	7-8
7.9	MA_class_Feet2_CreatInqPed	3-4
7.9	RO_Class_Natural phenomena_CreatInqPed	7-8
7.10	RO_Img_Float and sink_NoS/CreatInqPed*	5-6
7.9	UKEN_Class_Habitat_CreatInqPed	6-7
7.9	UKEN_Class_Sound_Multimodal/CreatInqPed	7-9
7.10	UKEN_Img_CaseJennie_CreatInqPed	3-4
7.10	UKSC_Image_CaseSarah_CreatInqPed	3-4
7.9/7.10	UKSC_Int_Counting Money_CreatInqPed	5-6
9.1/9.2	BE_class_TheCircleandtheOval_MultiModal	6-7
9.2	FI_Class_Multiplication stories_Multimodal	6-9
9.3	FI_Image_Floorplan_Multimodal	6-9
9.1/9.2/9.3/9.4	GR_Class_Plants_Multimodal	7-8
9.4	MA_class_Fruit_Multimodal	7-8
9.2	MA_class_Numbers_Multimodal	5-6
9.2	MA_class_Totals_Multimodal	5-6

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9.1/9.3	UKEN_Class_Volcano_ Multimodal	3-4
9.1	UKEN_Img_CattBoots_Multimodal	6-7
9.1/9.2	UKSC_Class_Day and Night_Multimodal	5-6

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RO_Img_Float and sink_NoS

Teacher Education Design Principle + code:	3. Teacher education should advance teachers' understandings about the nature of science and how scientists work, confronting stereotypical images of science and scientists. TE: NoS
Specific Teacher Outcome(s):	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.
Factors linked with:	LA: Comm; A: Form
Type of material (image – interview (int) – classroom extract (class):	Image
Originating from:	
Country report :	D 4.3 – report Romania
Case:	1
Episode:	Float and sink
Teacher:	Maria
Age Group:	5 - 6 years
Selected episode present in D 4.4 Appendix	Yes

Children are trained to communicate their results and to provide explanations. Such a presentation is a good opportunity for the assessment of pupils in a formative manner

There are two purposes for the use of pupils' results presentations: a) to teach them to communicate their findings, as scientists do; b) for children learning formative assessment

Experiments being done, one representative of each group presents and discusses their findings in front of the class. During this final class discussion, the teacher highlights a special part of one experiment.

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Class dialogue:
T: And here, who will present what you had done?
Ch1: Me (very convinced).
T: Everyone agrees? Is it OK with your team?
Ch4: I would like to present.
T: Then I leave you to discuss and decide who will make the presentation. There are two proposals. Let's decide in a democratic manner.

Pupils debate and vote and take a decision with a majority.

The first group presents its conclusions as they are drawn on the worksheet.

Class dialogue:
T: Silence please. Those who expect to be listened, have to listen to others. Let's listen to P. Please tell me P. what did you verified?
P: We verified a cone, a piece of bark, a nut sell, a feather, and a stone.
T: According to your opinion, what can be the most useful object? All of them suit?
P: Yes. Except the stone.

The teacher concludes on the results of the first team, in this way the entire class agrees.

Class dialogue:
T: Besides this conclusion I notice D. that you tested a material which was discharged away by the end of the investigation. We had an object which, according to my opinion, can be use to rescue the ant. What was that object?
D: The red feather?
T: No, besides the red feather. What it was? A piece of….
Several Chs: Napkin.
T: What did you notice happened to this piece of napkin?
D: It sank.
T: Yes. It went to the bottom of the water. It is very interesting what your colleagues are saying. They took a piece of napkin placed it on the water surface, and what he noticed? At the beginning, it floated…
D: It went wet and went to the bottom of the container.
T: Do you think this object can be used to save the ant?
Several Chs: No. No.

The worksheet of a pupil belonging to the second group is presented in front of the class.

Figure 15: Suggestion 8 – Template RO_Img_Float_and_Sink_NoS/CreatInqPed

Use of the selected teacher training materials in a teacher education course

Group discussions

- Divide the group of teachers into groups of 4 to 6.
- Provide 4 templates for each group. (Groups can have the same templates).
- Focus the group discussion around questions such as:
    - How are the children's ideas expressed or represented in these examples? Is there any difference based on the age of the children? In what ways is creativity fostered?
    - Which assessment methods are used in these examples? Try to make a list of various assessment approaches used in science and mathematics education,

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based on the different examples provided. In what ways might they foster creativity?
    - Could you provide any additional examples of assessment approaches, which have the same purposes as those shown in these examples?
    - If feedback is given, which type of feedback encourages creativity?
    - Consider how one might assess / recognise creativity in children. What behaviours would we be looking for? Are these behaviours present in any of the examples?

- Ask the groups to record the results of their discussion on paper.

Making connections (to the project's Conceptual Framework)

- Bring together the responses of the different groups and note key points on the board.
- First, based on their findings discuss the difference between summative and formative assessment. Points to be considered could include:
    - "assessment that is formative '*directly informs learning and teaching*' (Black and Wiliam, 2003, 2009) and emphasises the trajectory of each learner; this is generally shared in the learning and teaching process thus may involve children themselves in self-assessment, peer-assessment and reflection and evaluation within a learning community, but is not necessarily reported more widely." (D2.2 *Conceptual Framework*, p 65)
    - "summative assessment, sometimes also framed as high stakes in itself (Taylor, Jones, Broadwell and Oppwal, 2008) summarises performance at a particular point in time in order to compare children over time or to compare cohorts. This may be reported to parents or used for monitoring or accountability." (D2.2 *Conceptual Framework*, p 65)
- Second draw attention to:
    - the importance of multimodal approaches to assessment in early mathematics and science activity that attend to, for example, children's gestures, speech or visualisations;
    - the roles of peer assessment and self assessment.

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*3.2.2.9 **Suggestion 9**: The role of the teacher in Inquiry based and Creative approaches*

Focus on the role of the teacher: Rationale

As noted in the *Conceptual Framework* (D2.2):

"Notwithstanding the recognition that IBSE and CA both include attention to problem solving in exploratory contexts, in which questions, collaboration, motivation and reflection play a significant role, the efficacy of these approaches depend in large part on the teacher's role, scaffolding children's learning. Scaffolding has been considered beneficial for young children fostering their independence as inquirers and problem-solvers (Rittle-Johnson and Koedinger, 2005; Metz, 2004), their creativity as possibility thinkers (Cremin et al., 2006; Craft et al., 2012), their conceptual knowledge (Coltman, Petyaeva and Anghileri, 2002), and their strategies (Secada, Fuson and Hall, 1983), and meta-cognitive strategies (Aleven and Koedinger, 2002)." (p 58–59)

"However, studies of scaffolding in varied contexts indicate the complexity of the issues involved in relation to the context and purposes of activities. For example, in a quasi-experimental study undertaken with pre- schoolers in a science museum, Bonawitz et al. (2011) investigated the implications of explicit instruction on exploratory play. … Their work on the 'two- edged sword of pedagogy' has considerable implications for the project Creative Little Scientists, and suggests for example that delaying instruction until the learner has had a chance to investigate and inquire on their own or with others could promote innovation and discovery. "(p 59)

"This suggests that IBSE and CA to fostering creativity and problem solving requires professional restraint and well developed skills of close observation. Hyvönen (2008) too highlights the role of teacher as 'allower', implying some degree of standing back and avoiding too much intervention, though she also mentions other roles: leader, afforder, coordinator, supporter, tutor, motivator and facilitator." (p 60)

"This connects to McWilliam's (2008) conception of the 'meddler in the middle' and involves the teachers in working alongside children with intense sensitivity as to appropriate interventions." (p 60)

Links to Content Design Principles and Teacher Outcomes

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.

> 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.

7. Teacher education should familiarise teachers with a range of formal and informal inquiry- and creativity-based learning, teaching and assessment approaches and strategies

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and their use in relation to authentic problems within the areas of science and mathematics.

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.

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.

11. Teacher education should enable teachers to use questioning effectively and encourage children's questions in order to foster creativity and inquiry.

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.

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.

Selection of teacher training materials for discussion and debate based on the selected Teacher Outcomes

The selection below is an example of teacher training materials focused on the role of the teacher in inquiry based and creative approaches and based on the above Curriculum Design Principles and associated Teacher Outcomes. The template with the asterix is selected for illustrative purposes (Figure 16).

Teacher Outcome	**Teacher Training Materials** (or Template)	**Age of children**
1.2	BE_Class_TheHail_SocialAffectAims	7-8
1.2	FI_Class_Volcano_SocialAffectAims	3-6
1.2	GE_Int_Materials_SocialAffectAims	6
1.2	GR_Int_MeasuringTables_SocialAffectAims*	5-6
1.2	UKEN_Class_Ice_SocialAffectAims	4-6
1.2	UKSC_Class_Baking_SocialAffectAims	3-5
11.1	BE_Class_SandBox_Question	3
11.1	BE_Class_TheMask_Question	4-6
11.1	FI_Class_PairtoTen_Question	6
11.1	GR_Class_Game_of_swallows_Question	5

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11.1	GR_Class_MagicFlute_Question	6-7
11.1	GR_class_ShapeTrees_Question	5-6
11.1	MA_class_Drums_Question	5-6
11.1	MA_class_ShootingBalloons_Question	6-7
11.1	RO_Class_Measuringvolumes:nonstandardized units_Question	5-6
11.1	UKEN_Class_Beebot_Question	3-4
11.1	UKEN_class_Classifying_Question	5-6
11.1	UKWA_class_flapjack _Question	5-6
7.8	BE_Class_TheGiant_CreatInqPed_2	4-6
7.8/7.9	GE_Class_BuildingBlocks_CreatInqPed	5
7.8	GR_Class_Building_MrZip_CreatInqPed	5
7.9	MA_class_Feet2_CreatInqPed	3-4
7.8	PT_Img_WolfSheepCabbage_CreatInqPed	8
7.8/7.9	RO_Class_Natural phenomena_CreatInqPed	7-8
7.9	UKEN_Class_Habitat_CreatInqPed	6-7
7.8/7.9	UKEN_Class_Sound_Multimodal/CreatInqPed	7-9
7.8	UKNI_Class_Gloop_CreatInqPed	3-4
7.9	UKSC_Int_Counting Money_CreatInqPed	5-6

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GR_Int_MeasuringTables_SocialAffectAims

Teacher Education Design Principle + code:	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. TE:SocialAffectAims
Specific Teacher Outcome(s):	*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.* *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.*
Factors linked with:	AO: Affect, AO: Social
Type of material (image – interview (int) – classroom extract (class):	Interview
Originating from:	
Country report :	D4.3 - Greece
Case:	Case 1 - Mina
Episode:	Measuring Tables
Teacher:	Mina
Age Group:	5-6

The teacher embeds the task in an everyday life context.
She encourages collaboration and fosters children's agency.

T (Mina): *Since few days ago we have said that we would like to order a new table from a carpenter. The carpenter rang me and said: Mrs Mina, I will make the table you want. However, you have not given me any instructions. You have not told me how you wish the table to be: what shape you want it to be; how high you want it to be; how wide you want it to be. If you do not give me any instructions, if you do not give me any measurements, I cannot make the table you want, and they you will tell me: Mr Carpenter the table you have made is not good for our classroom.*

I want you to help me to give instructions to the carpenter. OK? So this is what we are going to do: Every team will go to their table and take its measurements. I will give you notebooks so you can write down your notes. I will provide some instructions. [...] Each team will decide how they are going to take their measurements. We need to provide three measurements to the carpenter: shape, height and width. Last time we said that we can use different tools for measurement. Each team will deliberate and decide on the measuring tool they wish to use: a ruler, a (wooden) meter, a ribbon, the palms of their hand, their fingers, their spoons? You will decide. Meet as a team now and decide on the way you wish to measure your table.

[Teams decide on the measuring tool to use. The teacher makes sure that the team's decision is unanimous.]

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Next step: To every team I will give a notebook. In the notebook you will write your notes after taking the measurements. What do we need? Shape, height and width. [...]

Just a minute. Before you start taking the measurements... I know that the materials you now have on your table have caused a pleasant excitement in you. However, one more instruction: To make it easier for you, you need to collaborate. If every one of you wants to keep the tool for himself/herself, the team will not succeed in the task.

Figure 16: Suggestion 9 – Template GR_Int_MeasuringTables_SocialAffectAims

Use of the selected teacher training materials in a teacher education course

Group discussions

- Organise the teachers into groups of 4 to 6.
- Divide the groups into A groups and B groups. Ask the A groups to focus on the agency and learning of the children and the B groups to focus on the role of the teacher. Make up pairs of A and B groups.
- Provide the same 5 templates to each pair of A and B groups so that both A and B groups within the same pair get the same templates. This means you need these templates in double.
- Set the following task for the groups
    - For the A group: To what extent is the agency of the children fostered in the examples given? Try to give a number from 0 to 5, where 5 = 'agency is highly fostered', 0 = 'agency is not fostered'. Please explain the basis for your evaluation.
    - For the B group: Try to describe in detail the role of the teacher in the different examples used. Think of interaction with the children, questions used, explanations given, bringing in different materials, encouraging the agency of the children, supporting creative thinking etc.
- Ask the groups to note their findings on paper.

Making connections (to the project's Conceptual Framework)

- Draw a table with three columns on the board: the first column for the name of the template, the second to record the degree of agency (in children's learning) and the third column for a description of the role of the teacher.
- Ask all groups to record their findings in the table.
- Invite the group to draw on their findings to reflect on connections between the role of the teacher and children's creative learning using questions such as:
    - What is the role of the teacher when the degree of agency = 5?
    - What are children learning and to what extent are they learning when the degree of agency = 5?

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- In the template in which the degree of children's agency is lowest, what is the role of the teacher in this example and what are children learning?
- Is it possible to increase opportunities for children's agency in this example? What has to be changed?
- What about the learning environment in the different examples? Is there is any link between high agency and the learning environment?

In this Suggestion the focus is on *pedagogical interactions*; however the teacher can also improve the learning outcomes of children by creating a powerful learning environment (*pedagogical framing*).

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*3.2.2.10 **Suggestion 10**: Cross curricular project work to foster Inquiry and Creativity*

Focus on cross curricular work: Rationale

As noted in the *Conceptual Framework* (D2.2):

In commenting on links between creativity and inventive problem solving, DeHaan observes that

> *"evidence suggests that instruction to support the development of creativity requires inquiry-based teaching that includes explicit strategies to promote cognitive flexibility. Students need to be repeatedly reminded and shown how to be creative, to integrate material across subject areas, to question their own assumptions, and to imagine other viewpoints and possibilities."*
>
> (DeHaan, 2009: 172).

Links to Content Design Principles and Teacher Outcomes

16. Teacher education should provide teachers with knowledge of approaches to timetabling and organizing cross-curricular project work.

16.1 Teacher should be able to use approaches to cross- thematic, cross-curricular and project work to promote creativity in science and mathematics.

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.

Selection of teacher training materials for discussion and debate based on the selected Teacher Outcomes

All teacher training materials linked with Content Design Principle 16: CrossCurr can be used. The template with the asterix is selected for illustrative purposes (Figure 17).

Teacher Outcome	**Teacher Training Materials** (or Template)	**Age of children**
16.1/16.3	BE_Class_TheCarpenterCorner_CrossCur*	4-6
16.1/16.3	BE_Class_TheMask_CrossCurr	4-6
16.1/16.3	BE_Class_ThePirates_CrossCurr	4-6
16.3	GR_Class_MagicFlute_CrossCurr	6-7
16.3	MA_class_Money_CrossCurr	6-7
16.1/16.3	UKEN_class_SoftPlay _CrossCurr	3-4
16.1/16.3	UKEN_Interview_Egg Carrier_CrossCurr	6-7

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BE_Class_ TheCarpenterCorner_CrossCurr

Teacher Education Design Principle + code:	16. Teacher education should provide teachers with knowledge of approaches to timetabling and organizing cross- circular project work. **TE: CrossCurr**
Specific Teacher Outcome(s):	16.1 Teachers should be able to use approaches to cross-thematic, cross-circular and project work to promote creativity in science and mathematics. 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.
Factors linked with:	**C: Sci/M Integ; LA: Connect**
Type of material (image – interview (int) – classroom extract (class):	Classroom extract
Originating from:	
Country report :	D 4.3 – Belgian report
Case:	Case 1 & 2
Episode:	The Carpenter Corner
Teacher:	Maaike
Age Group:	4 – 6
Selected episode present in D4.4 Appendix	Yes

Making connections – linking mathematics and science

Two children chose to work in the carpenter corner. One of the children was a four year old girl, she worked already in the carpenter corner. The other child was a five year old boy. For him everything was new as it was his first time in this atelier and this classroom.

The Carpenter Corner had a very rich physical environment with a special work bench and with real carpentry tools; several saws, nails, pincers, hammers, and wooden materials were made available. The children could also go outside the classroom to bring in other materials. Maaike stressed the importance of using real materials to design and inquire. The children could select the materials they wanted to use by themselves, so, ownership and agency was very much stimulated.

The boy wanted to measure the wooden box. He recognized the need for accurate measurements.

Child 1: *I'm going to have a look with the metre* (ruler).
Teacher: *Yes, you can measure it.*
The boy finds a fold metre (folding ruler) in one of the bins and he unfolds the metre. He kneels on the ground.
Child 1: *I'm going to look how long this measures.* (He measures the wooden box.)
Child 1: *That's not going.*
Teacher: *Is it not good?*

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Child 1: *I have to have a pen.* (He draws a line on the wooden box.)
Teacher: *Child 2 is it already OK?*
Child 2: *No*
Teacher: *Maybe Child 1 has to put there a line too, such as here.*

The teacher showed the other measurement that was done by Child 1.

Figure 17: Suggestion 10 – Template BE_Class_TheCarpenterCorner_CrossCur

Use of the selected teacher training materials in a teacher education course

Group discussions

- Divide the group of teachers into groups of 4 to 6.
- Provide about 3 templates for each group. (Groups can have the same templates).
- Focus the group discussion around questions such as:
    - What connections are made across the curriculum?
    - What approaches are used? Could you think of other possible approaches?
    - In what ways do cross – curricular links foster creativity and/or inquiry?
- Ask the groups to note down key points as a structured argument.

Making connections (to the project's Conceptual Framework)

- First ask the group to try to sort the templates. Which templates show examples in which inquiry is promoted? Which templates show examples in which creativity is promoted? Which templates show examples in which creativity and inquiry are promoted?

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- When the templates have been sorted into two overlapping sets (with examples promoting inquiry and creativity in the overlapping section) ask the groups to explain the cross-curricular connections made in each example. Which aspects of the curriculum are linked? How are they linked? Record the connections identified.
- Invite groups to analyse the results. For example, there is any commonality between the examples in which creativity is promoted?
- Second, share and record the approaches used in the examples in the relevant columns. Again compare these approaches. Ask the groups if they thought about other approaches? Which ones? What are the implications for planning and teaching?

3.3 Conclusion

As mentioned before, the teacher training materials (or templates) are provided to start debate and discussion in teacher education about approaches in preschool and primary schools which foster creativity in science and mathematics education.

In order to facilitate the use of these materials in teacher education ten suggestions of use are provided. These suggestions have to be seen as illustrations on how the templates might be used to explore important themes related to improving creativity in science and maths. In fact the suggestions focus on the synergies between IBSE and CA: play and exploration; motivation and affect; dialogue and collaboration; problem solving and agency; questioning and curiosity; reflection and reasoning; teacher scaffolding and involvement; and assessment for learning.

Throughout the suggestions opportunities for flexible thinking about these key themes are encouraged. Teachers (in-service and pre-service teachers) are encouraged to discuss and provide a diversity of ideas and to reflect on them critically. If reflection, discussion, collaboration, dialogue and questions play a key role in promoting creativity and conceptual understanding in science and mathematics education, teachers themselves have to experience the processes of reflection, collaboration, dialogue and debate in their own education. Establishing opportunities for flexible thinking and encouraging a diversity of thinking/ideas to be considered/tested are important dimensions that underlie teacher education for creativity and run through all the suggestions of use above.

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Appendix A: Instructions given to partners

Dear partners,

It is necessary to think about task 5.3, please read the text below in detail.

For task 5.3 (and D 5.3) we have to select exemplary teacher training materials based on the data we have from WP 4. In fact, we have different materials which all can be used by teacher educators to frame their courses or sessions. In summary we have:

- the selected narrative episodes

- the data of the field work : the images, the interviews, the classroom extracts

- the example teacher training materials from the summerschool + own experiences

All these data have to be structured in order to guide the teacher educators, keeping in mind that there have to be some freedom for them to frame their own lessons based on our materials. As such we think of using a file with all the materials (images, interviews, classroom extracts and selected episodes) and some general guidelines to use these data + some advice concerning training methods (linked with design principles). The examples of the summer school have to be seen as examples for teacher educators of how to use the materials in the file (however this is work for later on).

In order to structure the file, we will work with the 'Teacher outcomes' which were formulated based on the content design principles and the findings from WP 3 and 4. These Teacher Outcomes will be present in D 5.2. In **attachment 1** you will find a document with the teacher training design principles (content) and more specific Teacher Outcomes. Each principle is coded starting with the letters: TE (a code you need to work with, see beneath). Some additional information can be find in the document.

Assignment

For the moment, we need your help to link your country data to these teacher outcomes

In particular we **need your help to go through all your data (images, interviews and classroom extracts) and select these images, interviews or classroom extracts which are linked to one or more of the Teacher Outcomes and which can stand on their own (data which isself containing).**

In order to link the data with the Teacher Outcomes, Fani has linked the Teacher Outcomes with the factors used to code the data of WP 4.

In order to structure the work, we have made **a template**, see **attachment 2**. It is important to fill in all the data required, based on this data we will be able to design the file. An example with Flemish data can be find in **attachment 3**.

We count on your expertise to provide us with as much templates as possible.

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Pay attention the templates (and file) will be made public, so don't put data (such as photographs) in it, which can't be made public.

Additional information linked with the Grid.

In the left hand column you can see the Code for the Teacher Education Design Principle; in the middle column you can see the Design Principle and relevant Teacher Outcomes; and in the right hand column an indication of the Factor Codes (used in WP4), which correspond to the Teacher Outcomes. The codes have to be seen as support to select pieces of data from work done during the in-depth fieldwork (see template), the codes are indicative and not definitive and could be discussed. They are meant to provide help to identify the most appropriate pieces of evidence from your episodes. Please select only the data you think that is MOST APPROPRIATE for use to achieve a particular Teacher Outcome or a combination of Teacher Outcomes under a given Design Principle. The data will be coded under the GREEN code of the Design Principle and not per Teacher Outcome, so think flexibly about which examples you might want to use (or have already used) in your training to achieve few or all of the Outcomes under each of the 18 Design Principles. Do not worry if you do not have data for a number of the Teacher Outcomes. We cannot cover all of them.

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Appendix B: Excel sheet showing all Exemplary Teacher Training Materials

Teacher Training Materials	Content Design Principle	type of material	Country	Case	selected episodes	age group (in years)
BE_Class_TheHail_SocialAffectAims	TE: SocialAffectAims	classroom	Belgium	BE case 6	no	7-8
FI_Class_Volcano_SocialAffectAims	TE: SocialAffectAims	classroom	Finland	FI case 3	no	3- 6
GE_Int_Materials_SocialAffectAims	TE: SocialAffectAims	interview	Germany	GE case 3	no	6
GR_Int_MeasuringTables_SocialAffectAims	TE: SocialAffectAims	interview	Greece	GR case 1	yes	5-6
UKNI_Img_Int_Gloop_SocialAffectAims	TE: SocialAffectAims	image	UK	UKNI case 3.14	yes	3-4
UKEN_Class_Ice_SocialAffectAims	TE: SocialAffectAims	classroom	UK	UKEN case 1	no	4 -6
UKEN_Int_Ice_SocialAffectAims	TE: SocialAffectAims	interview	UK	UKEN case 1	no	4 -6
UKSC_Class_Baking_SocialAffectAims	TE: SocialAffectAims	classroom	UK	UKSC case 2	no	3-5
BE_class_TheWind_PractInvest	TE: PractInvest	classroom	Belgium	BE case 4	no	5-6
GE_Img_WaterInquiry_PractInvest	TE: PractInvest	image	Germany	GE case 5	yes	6
UKEN_class_Bubbles_PractInvest	TE: PractInvest	classroom	UK	UKEN case 2	no	3-4
UKEN_Class_Counting Minibeasts_PractInvest	TE: PractInvest	classroom	UK	UKEN case 8	yes	4-5
UKNI_Image_FlowerDye_PractInvest	TE: PractInvest	image	UK	UKNI case 3.17	no	6-7
UKWA_Class_Jelly_PractInvest	TE: PractInvest	classroom	UK	UKWA case 1	no	3-4
BE_Class_TheWaterfall_NoS	TE: NoS	classroom	Belgium	BE case 1&2	no	4 -6
FI_Class_AnimalFences_NoS	TE: NoS	classroom	Finland	FI case 6	no	6-9
FRA_Class_MagnetAttractionOrNot_NoS	TE: NoS	classroom	France	FRA case 1	yes	3-5
GR_Class_IceBalloons_ NoS	TE: NoS	classroom	Greece	GR case 4	yes	5
GR_Class_MeasuringTables_ NoS/ChildIdeas	TE: NoS	classroom	Greece	GR case 1	yes	5-6
MA_Class_Capacity_NoS	TE: NoS	classroom	Malta	MA case 5	no	7-8
MA_Class_Drums_NoS	TE: NoS	classroom	Malta	MA case 3	no	5-6
MA_Class_Waterproofing_NoS	TE: NoS	classroom	Malta	MA case 5	no	7-8
PT_Class_ WolfSheepCabbage NoS_1	TE: NoS	classroom	Portugal	PT case 3	yes	8
PT_Class_ WolfSheepCabbage _NoS_2	TE: NoS	classroom	Portugal	PT case 3	yes	8
RO_Img_Floatandsink_ NoS	TE: NoS	image	Romania	RO case 1	yes	5-6
UKEN_Class_MothersDay_NoS	TE: NoS	classroom	UK	UKEN case 1	no	7-8
UKEN_Int_Doubling_NoS	TE: NoS	interview	UK	UKEN case 7	no	5-6
FI_Class_MeasuringOutside_IBSE	TE: IBSE	classroom	Finland	FI case 2	no	6
FI_Img_SmeltingSnow_IBSE	TE: IBSE	image	Finland	FI case 1	yes	6
FRA_Class_IceCreamSticks_IBSE	TE: IBSE	classroom	France	FRA case 4	yes	7-8
FRA_Class_MagnetDiscovery_IBSE	TE: IBSE	classroom	France	FRA case 1	yes	3-5
GR_Class_IceBalloons_ IBSE	TE: IBSE	classroom	Greece	GR case 4	yes	5
MA_Class_Minibeasts_IBSE	TE: IBSE	classroom	Malta	MA case 2	yes	6-7
MA_Class_ShootingBalloons_IBSE	TE: IBSE	classroom	Malta	MA case 2	no	6-7
PT_Img_WolfSheepCabbage_IBSE	TE: IBSE	image	Portugal	PT case 3	yes	8
PT_Class_SwinggameRope_IBSE	TE: IBSE	classroom	Portugal	PT case 4	yes	5
PT_Class_SunDistance_IBSE	TE: IBSE	classroom	Portugal	PT case 2	yes	5
UKEN_Class_Cars and Ramps_ IBSE	TE: IBSE	classroom	UK	UKEN case 6	no	3-4
UKEN_Class_Cars_IBSE	TE: IBSE	classroom	UK	UKEN case 1	no	4 -6
UKEN_Class_Sound_IBSE	TE: IBSE	classroom	UK	UKEN case 1	yes	7-9
UKEN_Class_StartingPoint_IBSE_	TE: IBSE	classroom	UK	UKEN case 3	yes	6-7
UKEN_Img_Syrup_IBSE	TE: IBSE	image	UK	UKEN case 3.9	no	3-4
UKNI_Img_GingerbreadMan_IBSE	TE: IBSE	image	UK	UKNI case 3.16	no	5-6
UKNI_Img_Shapes_IBSE	TE: IBSE	image	UK	UKNI case 3.15	yes	3-4

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BE_Class_TheGiant_CreatInqPed_1	TE: CreatInqPed	classroom	Belgium	BE case 1&2	no	4 -6
BE_Class_TheGiant_CreatInqPed_2	TE: CreatInqPed	classroom	Belgium	BE case 1&2	no	4 -6
BE_Class_TheTipi_CreatInq_1	TE: CreatInqPed	classroom	Belgium	BE case 4	no	5-6
BE_Img_TheCircle_CreatInqPed	TE: CreatInqPed	image	Belgium	BE case 6	no	7-8
FI_Img_Burr_Burr_CreatInqPed	TE: CreatInqPed	image	Finland	FI case 3	no	5-6
FRA_Class_IceCreamSticks_CreatInqPed	TE: CreatInqPed	classroom	France	FRA case 4	yes	7-8
GE_Class_BuildingBlocks_CreatInqPed	TE: CreatInqPed	classroom	Germany	GE case 1	yes	5
GR_Class_Building_MrZip_ CreatInqPed	TE: CreatInqPed	classroom	Greece	GR case 4	no	5
GR_Class_LittlePrince_CreatInqPed	TE: CreatInqPed	classroom	Greece	GR case 3	no	6-7
GR_Class_Pansies_ CreatInqPed	TE: CreatInqPed	classroom	Greece	GR case 6	no	4-5
MA_Class_CountingCaterpillar_CreatInqPed	TE: CreatInqPed	classroom	Malta	MA case 6	yes	7-8
MA_class_Feet2_CreatInqPed	TE: CreatInqPed	classroom	Malta	MA case 1	yes	3-4
MA_Class_Fruit_CreatInqPed	TE: CreatInqPed	classroom	Malta	MA case 6	no	7-8
MA_class_MeasuringRobots_CreatIngPed	TE: CreatInqPed	classroom	Malta	MA case 1	no	3-4
PT_Img_WolfSheepCabbage_CreatInqPed	TE: CreatInqPed	image	Portugal	PT case 3	yes	8
RO_Class_Natural phenomena_CreatInqPed	TE: CreatInqPed	classroom	Romania	RO case 5	no	7-8
RO_Img_Float and sink_CreatInqPed	TE: CreatInqPed	image	Romania	RO case 1	yes	5-6
UKEN_Class_Habitat_CreatInqPed	TE: CreatInqPed	classroom	UK	UKEN case Ella	yes	6-7
UKEN_Class_Pulleys_CreatInqPed	TE: CreatInqPed	classroom	UK	UKEN case 2	no	3-4
UKEN_Class_Ramps_CreatInqPed	TE: CreatInqPed	classroom	UK	UKEN case 2	no	3-4
UKEN_Class_Sound_Multimodal/CreatInqPed	TE: CreatInqPed	classroom	UK	UKEN case 1	yes	7-9
UKEN_Class_Waterproof Materials_CreatInqPed	TE: CreatInqPed	classroom	UK	UKEN case 7	no	5-6
UKEN_Img_CaseJennie_CreatInqPed*	TE: CreatInqPed	image	UK	UKEN case 6	no	3-4
UKNI_Class_Gloop_CreatInqPed	TE: CreatInqPed	classroom	UK	UKNI case 3.9	yes	3-4
UKNI_Img_GingerbreadMan_CreatInqPed	TE: CreatInqPed	image	UK	UKNI case 3.16	no	5-6
UKNI_Class_OutdoorSand_CreatInqPed	TE: CreatInqPed	classroom	UK	UKNI case 3.15	no	3-5
UKSC_Class_Day and Night_CreatInqPed	TE: CreatInqPed	classroom	UK	UKSC case 1	yes	5-6
UKSC_Class_Melting and Freezing_CreatInqPed	TE: CreatInqPed	classroom	UK	UKSC case 1	no	3-4
UKSC_Class_Water Play_CreatInqPed	TE: CreatInqPed	classroom	UK	UKSC case 1	no	3-4
UKSC_Image_CaseSarah_CreatInqPed*	TE: CreatInqPed	image	UK	UKSC case 2	no	3-4
UKSC_Int_Counting Money_CreatInqPed	TE: CreatInqPed	interview	UK	UKSC case 1	no	5-6
BE_class_TheBags_CreatinqLA	TE: CreatInqLA	classroom	Belgium	BE case 4	no	3
GE_Class_Fermi1_CreatInqLA	TE: CreatInqLA	classroom	Germany	GE case 4	yes	7
GR_Class_Game_of_swallows_CreatInqLA	TE: CreatInqLA	classroom	Greece	GR case 4	no	5
MA_class_Minibeasts_CreatIngLA	TE: CreatInqLA	classroom	Malta	MA case 2	yes	6-7
PT_Class_SwinggameRope_CreatInqLA	TE: CreatInqLA	classroom	Portugal	PT case 4	yes	5
UKEN_class_Art_ CreatInqLA	TE: CreatInqLA	classroom	UK	UKEN case 1	no	7-8
UKEN_class_Ice_CreatInqLA _1	TE: CreatInqLA	classroom	UK	UKEN case 2	no	3-4
UKNI_Img/Int_Foam_CreatInLA	TE: CreatInqLA	image	UK	UKNI case 3	no	3-4
BE_class_TheCircleandtheOval_MultiModal	TE: Multimodal	classroom	Belgium	BE case 6	no	6-7
FI_Class_Multiplication stories_Multimodal	TE: Multimodal	classroom	Finland	FI case 6	yes	6-9
FI_Image_Floorplan_Multimodal	TE: Multimodal	image	Finland	FI case 6	no	6-9
GR_Class_Plants_Multimodal	TE: Multimodal	classroom	Greece	GR case 5	no	7-8

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MA_class_Fruit_Multimodal	TE: Multimodal	classroom	Malta	MA case 6	no	7-8
MA_class_Numbers_Multimodal	TE: Multimodal	classroom	Malta	MA case 4	no	5-6
MA_class_Totals_Multimodal	TE: Multimodal	classroom	Malta	MA case 3	no	5-6
UKEN_Class_Volcano_ Multimodal	TE: Multimodal	classroom	UK	UKEN case §	no	3-4
UKEN_Img_CattBoots_Multimodal	TE: Multimodal	image	UK	UKEN case 6	no	6-7
UKEN_Class_Sound_Multimodal/CreatInqPed	TE: Multimodal	classroom	UK	UKEN case 3.7	yes	7-9
UKSC_Class_Day and Night_Multimodal	TE: Multimodal	classroom	UK	UKSC case 1	yes	5-6
FI_Class_Ways to Count_ChildIdeas	TE: ChildIdeas	classroom	Finland	FI case 5	yes	6-9
GR_Class_MeasuringTables_ChildIdeas	TE: ChildIdeas	classroom	Greece	GR case 1	yes	5-6
GR_Int_IceBalloons_ChildIdeas	TE: ChildIdeas	interview	Greece	GR case 4	yes	5
UKSC_Class_Forest School_ChildIdeas	TE: ChildIdeas	classroom	UK	UKSC case 2	yes	3-5
BE_class_SandBox_Question	TE: Question	classroom	Belgium	BE case 3	yes	3
BE_Class_TheMask_Question	TE: Question	classroom	Belgium	BE case 1&2	no	4 -6
FI_Class_Pair to Ten_Question	TE: Question	classroom	Finland	FI case 1	no	6
GR_Class_Game_of_swallows_Question	TE: Question	classroom	Greece	GR case 4	no	5
GR_Class_MagicFlute_Question	TE: Question	classroom	Greece	GR case 3	no	6-7
GR_class_ShapeTrees_ Question	TE: Question	classroom	Greece	GR case 1	no	5-6
MA_class_Drums_Question _1	TE: Question	classroom	Malta	MA case 3	no	5-6
MA_class_ShootingBalloons_Question _1	TE: Question	classroom	Malta	MA case 2	no	6-7
RO_Class_Measuring volumes: non standardized units_Question	TE: Question	classroom	Romania	RO case 4	yes	5-6
UKEN_Class_Beebot_ Question	TE: Question	classroom	UK	UKEN case 6	no	3-4
UKEN_class_Classifying_Question	TE: Question	classroom	UK	UKEN case 3	no	5-6
UKWA_class_flapjack _Question	TE: Question	classroom	UK	UKWA case 1	no	5-6
BE_class_parallellines_SciMaths	TE: EYSciMaths	classroom	Belgium	BE case 5	no	6-7
RO_ Img_Coloured fingers stamps_ EYSciMaths	TE: EYSciMaths	image	Romania	RO case 3	no	3-4
UKEN_class_Buttons_EYSCiMaths	TE: EYSciMaths	classroom	UK	UKEN case 2	yes	3-4
BE_Int_Case4Lies_Lenvironm	TE: LEnvironm	interview	Belgium	BE case 3	no	5-6
BE_Class_ModelingWax_Lenvrionment	TE: LEnvironm	classroom	Belgium	BE case 4	no	3
FI_Image_MeasuringOutside_Lenvironm	TE: LEnvironm	image	Finland	FI case 2	no	6
FI_Class_MeasuringOutside_Lenvironm	TE: LEnvironm	classroom	Finland	FI case 2	no	6
FI_Image_ Smelting Snow_ LEnvironm	TE: LEnvironm	image	Finland	FI case 1	yes	6
GR_Class_ Baking_cheese_pies_ LEnvironment	TE: LEnvironm	classroom	Greece	GR case 2	no	6
MA_class_Minibeasts_Lenvironm	TE: LEnvironm	classroom	Malta	MA case 2	yes	6-7
PT_Image_SunDistance_ Lenvironm	TE: LEnvironm	image	Portugal	PT case 2	yes	5
UKEN_class_Ice_Lenvironm	TE: LEnvironm	classroom	UK	UKEN case 1	no	4 -6
UKEN_class_Cafe_Lenvironm	TE: LEnvironm	classroom	UK	UKEN case 1	yes	4 -6
UKNI_Image_Bubbles_Lenvironm	TE: LEnvironm	image	UK	UKNI case 3.14	no	3-4
UKSC_Class_Scout Camp_LEnvironm_	TE: LEnvironm	classroom	UK	UKSC case 2	no	3-5
BE_class_ColouringWater_Gwork	TE: Gwork	classroom	Belgium	BE case 4	yes	5-6
BE_Class_MeasuringandEstimating_GWork	TE: Gwork	classroom	Belgium	BE case 5	no	6-7
BE_Class_SandBox_Gwork	TE: Gwork	classroom	Belgium	BE case 3	yes	3
BE_class_ TheCarpenterCorner_Gwork	TE: Gwork	classroom	Belgium	BE case 1&2	yes	4 -6
FRA_Class_Collaboration_Gwork	TE: Gwork	classroom	France	FR case 5	no	3-4
FRA_Class_IceCreamSticks_Gwork	TE: Gwork	classroom	France	FR case 4	yes	7-8
FRA_Class_Share_Gwork	TE: Gwork	classroom	France	FR case 6	yes	3-4
GE_Int_Materials_Gwork	TE: Gwork	interview	Germany	GE case 3	no	6
GR_Class_BeeBot_Gwork	TE: Gwork	classroom	Greece	GR case 5	no	7-8
GR_Class_ShapeTrees_GWork	TE: Gwork	classroom	Greece	GR case 1	no	5-6
MA_class_Minibeasts_Gwork	TE: Gwork	classroom	Malta	MA case 2	yes	6-7

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MA_class_Money_GWork	TE: Gwork	classroom	Malta	MA case 2	no	6-7
MA_class_Senses_GWork _1	TE: Gwork	classroom	Malta	MA case 3	no	5-6
UKEN_Class_Balancing Pens_GWork	TE: Gwork	classroom	UK	UKEN case 7	yes	5-6
UKEN_class_MothersDay_Gwork	TE: Gwork	classroom	UK	UKEN case 1	no	7-8
BE_class_ TheCarpenterCorner_CrossCur	TE: CrossCurr	classroom	Belgium	BE case 1&2	yes	4 -6
BE_Class_TheMask_CrossCurr	TE: CrossCurr	classroom	Belgium	BE case 1&2	no	4 -6
BE_Class_ThePirates_CrossCurr	TE: CrossCurr	classroom	Belgium	BE case 1&2	no	4 -6
GR_Class_MagicFlute_CrossCurr	TE: CrossCurr	classroom	Greece	GR case 3	no	6-7
MA_class_Money_CrossCurr _1	TE: CrossCurr	classroom	Malta	MA case 2	no	6-7
UKEN_class_SoftPlay _CrossCurr	TE: CrossCurr	classroom	UK	UKEN case 2	no	3-4
UKEN_Interview_Egg Carrier_CrossCurr	TE: CrossCurr	interview	UK	UKEN case 8	no	6-7
BE_Class_ThePizza_Resources	TE: Resources	classroom	Belgium	BE case 1&2	no	4 -6
BE_img_ColouringWater_Resources	TE: Resources	image	Belgium	BE case 4	yes	5-6
BE_Img_TheCarpenterCorner_Resources	TE: Resources	image	Belgium	BE case 1&2	yes	4 -6
FI_Class_MapSymbols_Resources	TE: Resources	classroom	Finland	FI case 5	no	6-9
GR_Class_IceBalloons_ Resources	TE: Resources	classroom	Greece	GR case 4	yes	5
GR_Class_ Playing_with_the_microscope_ Resources	TE: Resources	classroom	Greece	GR case 2	no	6
GR_Image_BranchesLeavesPinecones_ Resources	TE: Resources	image	Greece	GR case 6	no	3-4
MA_class_Senses_Resources	TE: Resources	classroom	Malta	MA case 3	no	5-6
MA_class_Totals_Resources	TE: Resources	classroom	Malta	MA case 3	no	5-6
MA_class_Fruit_Resources_	TE: Resources	classroom	Malta	MA case 6	no	7-8
PT_Image_ WolfSheepCabbage_Resources	TE: Resources	image	Portugal	PT case 3	yes	8
RO_Img_Coloured lights_Resources	TE: Resources	image	Romania	RO case 3	no	3-4
RO_Img_Seasons_Resources	TE: Resources	image	Romania	RO case 5	no	7-8
RO_Img_PartsofaPlant_SocialAffectAims	TE: Resources	image	Romania	RO case 6	no	6-7
UKEN_Image_CaseJennie_Resources	TE: Resources	image	UK	UKEN case 6	no	3-4
UKNI_Img_OutdoorMeasuring_Resources	TE: Resources	image	UK	UKNI case 3.17	no	6-7
UKNI_Image_OutdoorSounds_Resources	TE: Resources	image	UK	UKNI case 3.8	no	5-6
UKSC_Image_CaseSarah_Resources*	TE: Resources	image	UK	UKSC case 2	no	3-4
UKWA_class_Makingmusicalinstrument_Resources	TE: Resources	classroom	UK	UKWA case 2	no	4-5
UKEN_class_Digiblue _Resources	TE: Resources	classroom	UK	UKEN case 2	no	3-4

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