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

D5.1 Prototypical Guidelines and Curriculum Design Principles for Teacher Training

www.creative-little-scientists.eu

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

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D5.1 Prototypical Guidelines and Curriculum Design Principles for Teacher Training

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

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Document Revision History

Revision	Date	Organisation	Description
0	7.10.11	AUC	GPS-brainstorm with post-its
1	23.3.12	AUC	First draft in the development of prototypical design principles: issues of review and post-its linked with components of the spiderweb (curriculum design)
2	23.03.12 - 19.04.12	AUC, BG, EA, GUF IoE, NILRP, OU, UMinho, UoM, UEF, UPJV	Comments on the issues linked with the components of the spiderweb
3	7.05.12	AUC	First draft of the prototypical curriculum design principles on Moodle/preparation expert panel on Moodle
4	7.05.12 – 21.05.12	All partners	Comments / questions / examples posted during the expert panel
5	22.05.12	AUC	ToC Deliverable D5.1
6	4.06.12	EA, UEF, IoE	Comments ToC Deliverable D5.1
7	11.07.12	AUC	Draft Deliverable D5.1
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14	22.10.12	EA	Deliverable submitted to EC.

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EXECUTIVE SUMMARY

One of the key objectives of the *Creative Little Scientists* project is to **propose a set of curriculum design principles as concrete guidelines for European initial teacher education (ITE) and continuous professional development (CPD) programmes, which will foster creative approaches to science and mathematics learning in preschool and the first years of primary education, in the frame of inquiry-based educational environments.** The proposed principles will be accompanied by illustrative teacher training materials aiming to clarify their applicability in complex and varied European educational contexts, thus facilitating implementation, evaluation and further development across Europe.

In the first phase (Task 5.1) a set of prototypical curriculum design principles for teacher education in science and mathematics teaching and learning was produced, to be used as a framework supporting the development of curriculum formats at the level of teacher training institutions and continuous professional development providers.

To construct the prototypical design principles the 'spider web' model described by Jan van den Akker (2007) was used. This model consists of 10 components: *the Rationale or Vision of the curriculum, Aims and Objectives, Content, Learning Activities, Teacher Role, Materials and Resources, Grouping, Location, Time and Assessment*. In the *Creative Little Scientists* project the model was also chosen as a basis in developing the *List of Mapping and Comparison Factors* (D3.1) as well as in analyzing the results of policy reviews (D3.2) and the survey of school practice (D3.3).

Secondly, the methodology of 'curriculum design research' was applied to develop these directions. The aim of curriculum design research is to come to (successive) prototypes that increasingly meet the innovative aspirations and requirements of the project team. The process is often cyclic or spiral and characterized by the involvement of different stakeholders (also the intended target group) in the design. The design of the (successive) prototypes is theoretically embedded.

For the *Creative Little Scientist* project the AUC team developed a new model based on the phases - analytical, prototyping and assessment phase - described by Plomp (2009) and on the characteristics of curriculum design research. In the project these phases are not only linked with Work Package 5 (WP5) but also with other WPs and WP tasks, as shown in the model on p. 19 of this Deliverable.

During the analytical phase a conceptual framework (WP2, Deliverable D2.2) was developed based on four literature reviews (Addenda of D2.2) – science and mathematics education in preschool and early years of primary school; creativity in education; teacher training for early years educators and primary teachers; and comparative education. Then, literature research was carried out concerning curriculum design and curriculum design research (WP5, Task 5.1). Information about curriculum design and curriculum design research can be

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found in the first sections of the current document. At the end of the analytical phase, a draft version of the prototypical design principles was prepared by the AUC team through discussion.

During the prototypical phase this draft version was further adjusted and evaluated in the frame of developing the curriculum guidelines for teacher education through iterative cycles. In the first cycle the draft version (prototype 1) of the prototypical design curriculum principles was adjusted to the purposes of teacher education (prototype 2) using a web-based expert appraisal panel, consisting of the *Creative Little Scientists* consortium partners.

This deliverable (D5.1) describes this prototyping phase of the process of designing the teacher education curriculum guidelines. The design principles organised according to the components of the spider web can be found in section E. However, a gap was noticed using the curricular spider web model. The starting situation – competences, expectations, beliefs, attitudes towards science and mathematics, prior experiences and prior knowledge - of the student or in-service teacher is not mentioned as a separate component of the spider web. Yet, the teacher starting situation and inflow features are important factors to be taken into account when designing a curriculum in favour of a specific audience or target group to be engaged in teacher education.

Deliverables D3.2 and D3.3 provide us with some information about differences in starting situation of teachers in different countries. The findings of D3.2 are mentioned in section B3. The findings of D3.3 will be considered in future iterations of the teacher education guidelines, in subsequent tasks of WP5.

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A. INTRODUCTION

One of the key objectives of the *Creative Little Scientists* project is to propose a set of curriculum design principles as concrete guidelines for European initial teacher education (ITE) and continuous professional development (CPD) programmes, which will foster creative approaches to science and mathematics learning in preschool and the first years of primary education, in the frame of inquiry-based educational environments. Subsequently, the proposed principles will be accompanied by illustrative teacher training materials aiming to clarify their applicability in complex and varied European educational contexts, thus facilitating implementation, evaluation, and further development across Europe. The work in Work Package 5 will be based on the findings of the theoretical, comparative and in-depth field research, as well as on a process of involvement of communities of stakeholders in asynchronous discussion groups, and in the testing and validation of design principles, implementing the methodology of curriculum design research.

In the first phase, a set of prototypical curriculum design principles for teacher education in science and mathematics education was produced, to be used as a framework for the development of curriculum formats at the level of teacher training institutions and continuous professional development providers.

This document (D5.1) seeks to offer a definition of the terms ‘curriculum’ and ‘curriculum design research’. It also presents the set of formulated prototypical curriculum design principles for teacher education and the methodology used to design them, based on the conceptual framework, research findings from Work Package 3 and the expertise of the consortium. Finally, implications for further development in WP5 are discussed.

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B. CURRICULUM DESIGN RESEARCH

B1. Curriculum and curriculum design

‘Curriculum’, originating from the Latin word *currere*, appears to be a term which is not easy to define. It is subject to a good deal of debate and even misunderstandings. Curriculum means different things to different people. This was also seen in the responses of the consortium partners to an activity carried out during the 2nd project meeting in Paris. To elaborate on their own understandings of curriculum, the partners were asked to note on a post-it what curriculum meant for them. The results of this small brainstorm can be found in Appendix A.

Some equate curriculum with the syllabus while others regard the curriculum as all of the teaching-learning experiences a student encounters while in school (Tanner, 1975; Philips, 2008).

According to Philips (2008), the definitions of curriculum are influenced by the way of approaching a curriculum. It can be approached as:

- content: a body of knowledge to be transmitted;
- product: the learning outcomes desired of learners;
- process: what actually happens in the classroom when the curriculum is practiced.

Taba (1962) on the other hand has a very short definition of the word ‘curriculum’, namely ‘plan for learning’. According to van den Akker (2010), in the context of education, this is the most obvious interpretation of the word ‘curriculum’. It limits itself to the core of all other definitions and links very well with the etymological origin of the word. The Latin word ‘curriculum’ refers to a ‘course’ or ‘track’ to be followed. The *Creative Little Scientists* consortium has adopted this definition of curriculum, formulated by Taba (1962) and recommended by van den Akker (2010). Moreover, in the project the word ‘curriculum’ is used at two different ISCED-levels; the curriculum of preschool and primary schools (WP3 and WP4) and the curriculum of teacher education (WP5).

Curricula can be represented in various forms, which can be linked with specific levels (*supra -international, macro- system/nation/state, meso – school/institution, micro - classroom, and nano - individual*) of the curriculum. To present these forms we use the typology of van den Akker (2007, p.38) (Table 1).

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Intended	Ideal	Vision (rationale or basic philosophy underlying a curriculum)
	Formal/written	Intentions as specified in curriculum documents and/or materials
Implemented	Perceived	Curriculum as interpreted by its users (especially teachers)
	Operational	Actual process of teaching and learning (also curriculum-in-action)
Attained	Experiential	Learning experiences as perceived by learners
	Learned	Resulting learning outcomes of learners

Table 1: Different forms of curriculum by van den Akker (2007, p. 38)

The intended domain refers predominantly to the influence of curriculum policy makers and curriculum developers ('supra' and 'macro' level). The implemented level relates to the domain of the schools, institutions, and educators (such as teachers). The attained curriculum relates to students as learners.

In the *Creative Little Scientists* project the curricular guidelines for teacher education will be judged and adjusted by different stakeholders, amongst them teacher educators. In this way we will receive some feedback of how these curricular guidelines are perceived by their intended users.

In designing a curriculum van den Akker (2007) argues that it is wise to pay explicit attention to several elements of it. He defines 10 components: rationale or vision of the curriculum; aims and objectives; content; learning activities; teacher role; materials and resources; grouping; location; time; and assessment. Not all curriculum designers use these 10 components. Walker (1990) defines 3 elements which are important for the development of curricula: content, purpose and organization of learning.

van den Akker's (2007) preferred visualization of the 10 components is to arrange them as a spider web (Figure 1).

The rationale in the middle of the spider web is referring to the central mission of the plan (curriculum). The rationale is the major orientation point and the nine other components are ideally linked to the rationale and preferably consistent with each other. The spider web illustrates the many interactions but also the vulnerability. If you pull or pay too much attention to one of the components, the spider web breaks up (van den Akker, 2007).

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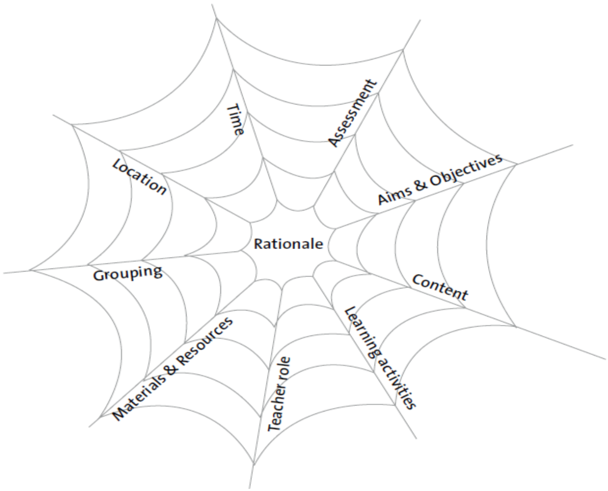

Figure 1: Curricular Spider Web (van den Akker, 2007, p. 41)

In the *Creative Little Scientists* project the AUC team proposed to use these 10 components (and spider web model) to design prototypical curriculum design principles for teacher education. In addition, the spider web model was also chosen as a basis for developing the *List of Mapping and Comparison Factors* (D3.1) as well as in analyzing the results of policy reviews (D3.2) and the survey of school practice (D3.3).

Nonetheless, it will be a challenge to achieve balance and consistency between these various components of the curriculum, which is also mentioned by van den Akker (2010). According to him it is also a challenge to involve all relevant stakeholders in curriculum design, in order to bridge the existing gap between the intended and the implemented curriculum. In the *Creative Little Scientists* project the design principles and successive guidelines will be developed and successively assessed and discussed by relevant stakeholders and the consortium, through respectively online focus groups and critical reflection on self-developed texts.

Literature offers many models and strategies for curriculum development. According to Jan van den Akker (2010) new ‘blended’ approaches, integrating characteristics of recent design and development approaches, are promising. He defines some key characteristics of these approaches:

- Pragmatism
- Prototyping
- Communication
- Professional development

‘Curriculum design research’ is such a ‘blended’ approach which incorporates some of these characteristics and also can strengthen the knowledge base in the form of design principles that offer heuristic advice to curriculum development teams (van den Akker, 2010).

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Already in the project's Description of Work the consortium decided to identify the methodology of 'curriculum design research' as the one to be used to develop the directions and curriculum design principles for teacher education (ITE and CPD). We will elaborate on the methodology of 'curriculum design research' in the next section.

B2. Features of curriculum design research

As already mentioned design research is a promising approach for curriculum designers. There are several reasons for conducting design research (van den Akker, 2010). Many traditional approaches (such as experiments, surveys and correlational analysis) hardly provide prescriptions with useful solutions for a variety of design problems in education. Many curriculum reform policies in education worldwide are highly ambitious and complex. They usually affect many system components, are often multi-layered including both large-scale policies and small-scale realizations, and are very comprehensive in terms of factors included and people involved.

So, curriculum reform would profit from interactive cyclical approaches such as design research, with integrated research activities and intensive involvement of different stakeholders.

According to van den Akker (2010, p. 187), *"the aim of curriculum design research is not to implement complete interventions, but to come to (successive) prototypes that increasingly meet the innovative aspirations and requirements. The process to do so is often iterative, cyclic or spiral: analysis, design, evaluation and revision activities."* Formative evaluation methods, such as comments of critical friends, systematic expert appraisal, micro-evaluations, etc. are used during this process.

We will elaborate on this formative evaluation in section C.

To have a more concrete view on the characteristics or typical elements of curriculum design research, we cite the description of van den Akker (2007: p. 45-46).

(1) Preliminary investigation

An intensive and systematic preliminary investigation of curriculum tasks, problems, and context is made, including searching for more accurate and explicit connections of this analysis with state-of-the-art knowledge from literature. Some typical activities include: literature review; consultation of experts; analysis of available promising examples for related purposes; case studies of current practices to specify and better understand needs and problems in intended user contexts.

(2) Theoretical embedding

Systematic efforts are made to apply state-of-the-art knowledge in articulating the theoretical rationale for curriculum design choices. Moreover, explicit feedback to assertions in the design rationale about essential characteristics of the intervention (substantive design principles) is collected after empirical testing of its quality. This

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theoretical articulation can increase the 'transparency' and 'plausibility' of the rationale. Because of their specific focus, these theoretical notions are usually referred to as 'mini'- or 'local' theories, although sometimes connections can also be made to 'middle-range' theories with a somewhat broader scope.

(3) Empirical testing

Clear empirical evidence is collected about the practicality and effectiveness of the curriculum for the intended target group in real user settings. In view of the wide variation of possible interventions and contexts, a broad range of (direct/indirect; intermediate/ultimate) indicators for 'success' should be considered.

(4) Documentation, analysis and reflection on process and outcomes

Much attention is paid to systematic documentation, analysis of and reflection on the entire design, development, evaluation and implementation process and on its outcomes, in order to contribute to the advance and better exemplification of the methodology of curriculum design and development.

(5) Involvement of different stakeholders (including the intended target group(s)) in the design

Intensive interaction with stakeholders (in various professional roles such as teachers, policy makers, developers) is needed to gradually clarify both the problem at stake and the characteristics of its potential solution. Researchers and stakeholders cooperatively work together.

Several design researchers have developed their own models to visualize the process (or methodology) of design research. However they all agree about the different phases in the design research. These are described by Plomp (2009: p. 15) as:

- **preliminary research***:* needs and context analysis, review of literature, development of a conceptual or theoretical framework for the study;
- **prototyping phase***:* iterative design phase consisting of iterations, each being a micro cycle of research with formative evaluation as the most important research activity aimed at improving and refining the intervention;
- **assessment phase***:* (semi-) summative evaluation to conclude whether the solution or intervention meets the pre-determined specifications. As this phase often also results in recommendations for improvement of the intervention, we call this phase semi-summative.

For the *Creative Little Scientists* project the AUC team developed a new model based on the phases described by Plomp (2009) and on the characteristics of curriculum design research. This model will be explained in section C.

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B3. Policy issues concerning the curriculum in teacher education

B3.1 Policy issues concerning initial teacher education

Based on the literature review on teacher education (D2.2 Addendum 3 of 4) and the results of Task 3.2 (D3.2), it is clear that in several of the participating countries the autonomy of the institutions providing ITE, is only restricted by competencies required of teachers at the end of initial training. For example in Belgium, France, Germany, Portugal, Romania, UK (England, Wales, Scotland) national requirements or guidelines are provided for the competencies to be achieved.

On the other hand in Finland, Greece, and Malta (preschool) there are no national regulations.

These findings are similar with the results presented in a study of the University of Jyväskylä on Teacher Education Curricula in the EU (2009). According to this study there are three kinds of models to define teachers' skills and competences in teacher education.

- In the first model, teachers' skills and competences in teacher education are defined in a fairly centralised way at national level. Germany and the UK belong to the countries that do so. The Government or the Ministry or a governmental body, such as a Teaching Council or similar, quite strictly regulates the competences which must be included in teacher education curricula or other teacher education documents.
- In the second model, the Government or the Ministry sets a broad framework for defining competences for teachers, but does not define the skills and competences the teachers should acquire during teacher education courses. In several of the partner countries of the *Creative Little Scientists* consortium, the second model is applied: Belgium, France, Portugal, Romania.
- In the third model, which is applied in Finland, Greece and Malta, the definition of skills and competences for teacher education has not been documented at all at national level.

Since in several of the partner countries national requirements or guidelines exist, we intend to link the project proposed guidelines for ITE - developed in WP5 - with these guidelines and propose suggestions and/or additions to them with the view to ensure they promote those teacher skills and competences that are required for the fostering of creativity in science and mathematics education in pre-school and the first years of primary school.

As highlighted in D3.2 the themes most commonly represented in standards and competencies for initial teacher education in partner countries are (D3.2, p. 90 -91):

- Subject and curriculum knowledge
- Pedagogical knowledge and skills - approaches to planning, teaching and assessment of learning
- Building partnerships and relationships with children, parents, school staff, team working, collaboration

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- Commitment to on-going professional development, reflection, research, innovation
- Knowledge of child development and learning
- Identifying and meeting individual needs – recognising diversity, special educational needs
- Creating a positive learning environment
- Ethics and professional values

As indicated in D3.2 as well as in the literature review of teacher education (D2.2 Addendum 3 of 4), in all partner countries the detailed curriculum content for initial teacher education is determined by individual institutions. So, in future stages of the WP5 research the guidelines designed will be distributed to the individual institutions in the partner countries. Moreover, in order to ensure the validation of the guidelines, teacher educators and heads of teacher education departments will be invited to join as stakeholders in online focus groups (cfr. asynchronous discussion groups).

B3.2 Policy issues concerning continuous professional development

Continuous professional development (CPD) is amongst the professional duties of teachers in over half of all European countries, including non-Member States (Eurydice, 2009). However, CPD in most European countries is regulated and organized in a very heterogeneous way, which is also indicated and illustrated in D3.2. For example, in some partner countries CPD is accredited, in other it is not; in some countries teachers are entitled to certain number of days CPD per year, and are expected to attend whilst in other countries teacher participation in CPD is entirely voluntary.

According to D3.2 common areas of focus include ICT, Literacy and Numeracy. Science is the topic for large scale national initiatives in only a few countries. National initiatives fostering creative approaches in science and mathematics teaching are even less common.

The designed guidelines in the *Creative Little Scientist*s project can guide the construction of CPD programmes for preschool and primary school teachers concerning creative approaches to science and mathematics education. They can also serve as criteria or standards for internal or external evaluations of these CPD programmes. They may provide an answer to the concern that effective CPD needs to be co-constructed by participants, rather than just imposed, emphasising the value of opportunities for networking and action research (D3.2).

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C. CURRICULUM DESIGN RESEARCH in *CREATIVE LITTLE SCIENTISTS*

In the *Creative Little Scientist*s project (WP5), curricular guidelines for European initial teacher training and CPD programmes, which will foster creative approaches to science and mathematics learning in pre-school and the first years of primary education, will be developed by using the approach of curriculum design research. In Figure 2 the different phases – analytical phase or preliminary research, prototyping phase and assessment phase – of the design research process can be visualised. The design principles and successive guidelines will be developed in collaboration with all relevant stakeholders in iterative cycles, represented by the gradually optimized and elaborated prototypes in Figure 2. Having said this, the implementation and evaluation of these guidelines and related teaching materials in real teacher education settings with actual (student) teachers do not form part of this research project. In other words, the assessment phase, as described by Plomp (2009) will not be carried out as part of the *Creative Little Scientist*s project. Future research aiming at this is needed. By the end of the project we will have a set of concrete guidelines for teacher education (ITE as well as CPD) which will have been intensively and successively assessed and discussed by relevant stakeholders and the consortium, through respective online focus groups and critical reflection on self-developed texts. This is in fact, as mentioned before, the aim of curriculum design research - not to implement complete interventions, but to come to (successive) prototypes that increasingly meet the innovative aspirations and requirements (van den Akker, 2010).

In our opinion, collaborative design research and prototyping of curricular alternatives can be very productive in order to discuss tensions in education and teacher concerns. Collaboration and vision-building with many different stakeholders allow us to design and validate relevant curriculum frameworks.

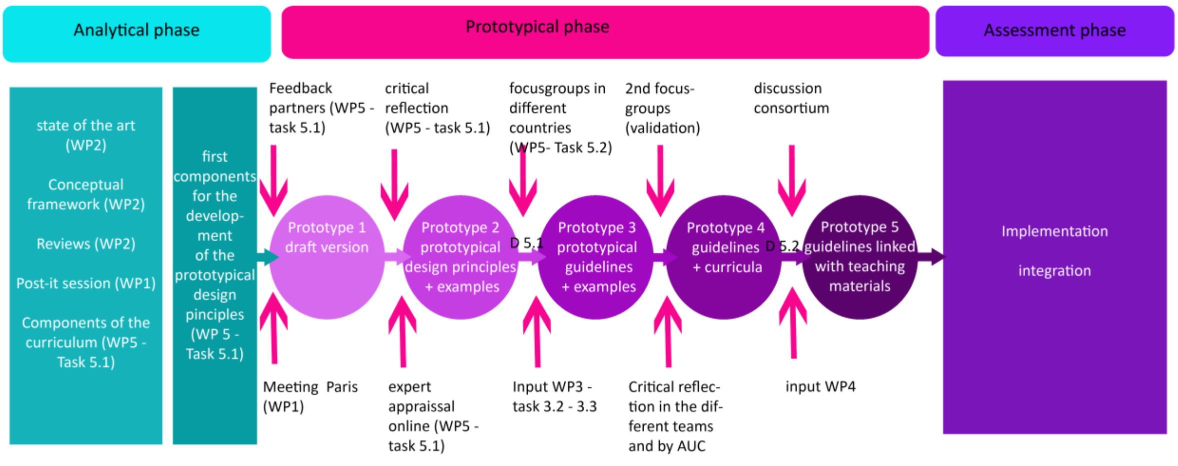

Figure 2: Curriculum design research model of *Creative Little Scientists*

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As depicted in Figure 2 the analytical and prototypical phases are not only linked with WP5 but also with other Work Packages and relevant tasks. In section C1, below, a short overview is given of the whole process of the development of the tentative curricular guidelines and related teaching materials for teacher education. In section D the focus is on the analytical phase and the development of the prototypical design principles (prototype 2, D 5.1).

C1. Process of the development of a set of tentative guidelines for teacher education – An overview

During the analytical phase of our design research process, a conceptual framework (WP2, D2.2) was developed based on four literature reviews (addenda of D2.2) – science and mathematics education in preschool and early years of primary school; creativity in education; teacher training for early years educators and primary teachers; comparative education. Moreover, additional literature research was done concerning curriculum design and curriculum design research (WP5, task 5.1).

At the end of this phase, important issues from the conceptual framework and the reviews of the state-of-the-art were combined with 10 components of the spider web (van den Akker, 2007) and the views of the consortium partners (post-it exercise at the Kick-off Project Meeting, WP1). Based on these elements and further feedback of the consortium partners during and after the Second Project Meeting (WP1), a draft version of design principles (prototype 1) was made by the AUC team.

During the next phase, the prototypical phase, this draft version was further adjusted and evaluated in the frame of developing the curriculum guidelines for teacher education through different iterative cycles. The different cycles are visualised in Figure 2 mentioning prototypes which were gradually optimized and elaborated on. In a first cycle the draft version (prototype 1 – Table 2 in section D1) of the prototypical design curriculum principles was adjusted for the purposes of teacher education, using a web-based expert appraisal panel, consisting of the *Creative Little Scientists* consortium partners. The results of this expert panel were analysed by the AUC team using negotiation and synthesis (see section D2) and guided the development of prototype 2 of the curriculum principles (see Table 3 in section E). In future cycles (see Figure 2), these prototypical design principles will be further adjusted and evaluated using online focus groups in different countries (task 5.2 and task 5.4) and critical reflection (task 5.3 and task 5.5), finally resulting in a set of curricular guidelines for ITE and CPD (D5.2). In a last phase (Task 5.6), materials of WP4 will be linked with these guidelines in order to provide exemplary teaching materials to policy makers and institutions (D5.3).

In section D the work towards a set of prototypical design curriculum principles (prototype 2) for teacher education, which will foster creative approaches to science and mathematics learning in preschool and the first years of primary education, is described in more detail.

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D. WORKING TOWARDS PROTOTYPICAL CURRICULUM DESIGN PRINCIPLES FOR TEACHER EDUCATION

D1. From partners' ideas and conceptual framework to a draft version of prototypical design principles (prototype 1)

Partners' ideas - post-it session in Athens

At the 'Kick-off' Project Meeting in Athens (6-7 October 2011) a written discussion (brainstorm) was held to generate ideas, views of the consortium partners about current teacher education practices and CPD initiatives, building on their own experiences and their prior knowledge on aims and objectives of teacher education.

The partners were divided into small groups and were asked to discuss three focus questions in three respective rounds using GPS brainstorming (see Flanders DC, World Creativity Forum, 2011).

- How should instruction be structured to facilitate IBSE (e.g. Inquiry-Based Science Education) in teacher education or professional development?
- How should the curriculum be structured to facilitate IBSE in teacher education?
- How should (school) policy be structured to facilitate IBSE in teacher education?

The groups had respectively about 10, 5, and 5 minutes time to add their ideas and views related to curriculum design on post-its - one idea or view per post-it. In each round a different colour of post-it was used (blue, green and yellow). After each round the post-its of every group were placed together on the wall. After the third round each participant received three small stickers which were added to the best ideas. In Appendix B the ideas of the partners are structured per focus or question. The ideas which received stickers are written in bold.

The spider web exercise

At the Second Project Meeting in Paris (22-23 March 2012) an (inter)active exercise with the consortium partners was held to:

- discuss the use of the 'spider web' and its 9 components for the purposes of curriculum design research;
- comment on the elements extracted from the *Conceptual Framework* (D2.2), the *Literature Review on Teacher Education* (D2.2 Addendum 3 of 4), and the Kick-off Project Meeting post-it session;
- add additional elements to the components in the spider web.

The AUC team used the spider web model of van den Akker (2007) to classify important elements from the *Conceptual Framework* and the *Literature Review on Teacher Education* (see Figure 3) as follows:

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- The *Rationale* of the curriculum principles, that is that teachers (incl. student teachers) foster creative based approaches to science and mathematics learning in preschool and the first years of primary school, was placed in the middle of the spider web.
- The elements extracted from the *Conceptual Framework* and the *Literature Review on Teacher Education* were inserted in green.
- The ideas from the partners collected during the post-it session in Athens were inserted in red.

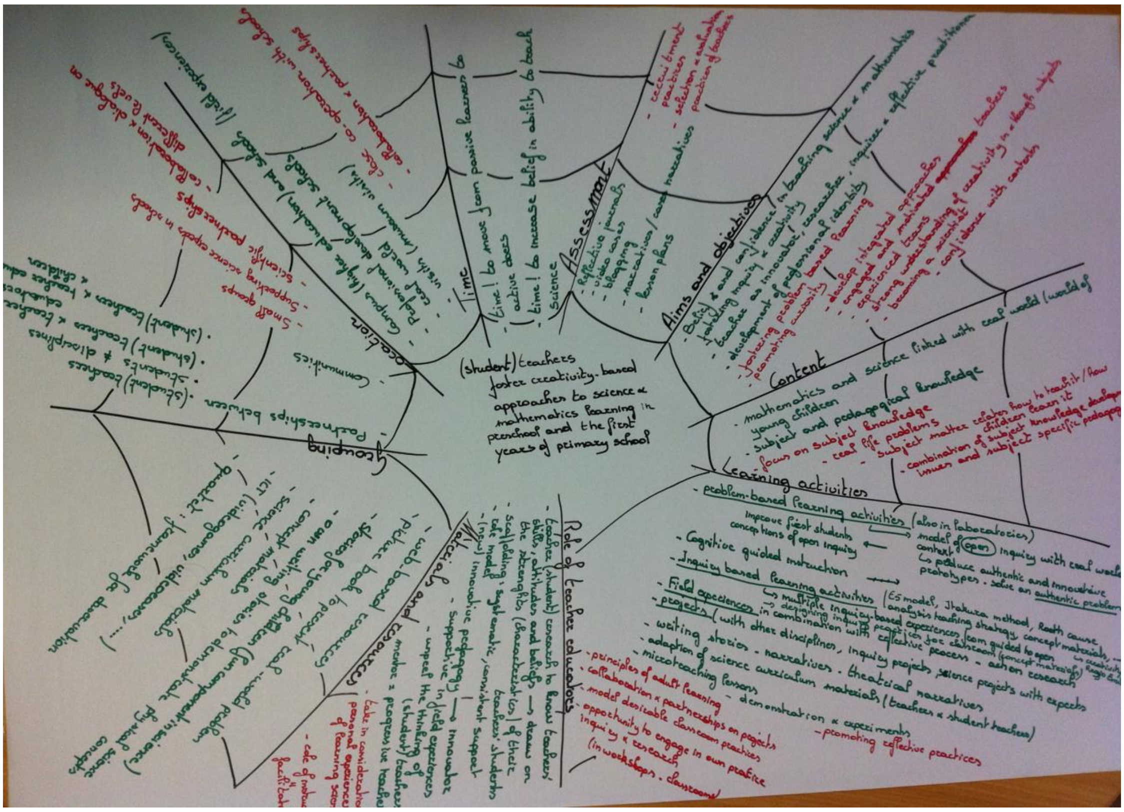

Figure 3: The spider web used in the spider web exercise

Some important green elements are: the importance of partnership approaches and teamwork for sustainable creativity. Collaboration and reflective practice are important aspects in these, as well as planning for diversity and the freedom to embed cognitive and affective aspects of learning in curricular choices. In addition, attention has to be drawn to the development of self-belief and confidence in teaching science and mathematics fostering inquiry and creativity approaches. Teacher education should take into consideration earlier experiences, beliefs and attitudes to these subjects.

The 9 components of the spider web and corresponding elements (green and red comments) were then placed on working sheets – one component per working sheet.

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At the meeting in Paris the partners were asked to work in groups of 3 to 4. Each group received 3 working sheets (3 components of the spider web + elements). The groups were asked to add comments and additional items in blue on the working sheets. The overall assignment was to write down instant ideas and requirements for making creative approaches to science and mathematics learning possible in preschool and the first years of primary education. To give an example of a comment written on the working sheet of 'Location': "Teacher education should provide and encourage partnerships within and between schools and enterprises (and countries)."

Partners were given the opportunity to add additional comments and items on the digital versions of the working sheets after the project meeting in Paris (until April 19th).

Based on these working sheets, the AUC team developed a draft version of the prototypical design principles (prototype 1). These proposed design principles were used in the expert appraisal panel (next chapter) and can be found in Table 2 below.

Rationale: (Student) teachers foster creativity based approaches to science and mathematics learning in preschool and the first years of primary school.	
Aims and objectives -- *Towards which goals are (student) teachers learning?*	Teacher education should try to reach the following aims and objectives: 1. (Student) teachers have positive attitudes towards science and mathematics. 2. (Student) teachers have confidence in teaching science and mathematics fostering inquiry and creativity. 3. (Student) teachers act as innovators, researchers and reflective practitioners in their teaching, learning and approaches. 4. (Student) teachers act with respect for all young children's views, capabilities and potentials. 5. (Student) teachers are inquirers - have an inquisitive or 'scientific' investigative attitude - they want to know, to understand, to criticize, to share, to achieve and to innovate. 6. (Student) teachers are committed to engage in partnerships with others (other teachers, experts, …). 7. (Student) teachers are committed to engage in lifelong learning (domains of science, mathematics and creativity). 8. (Student) teachers have good understandings of nature of science, children and meaning of creativity. 9. Teacher education should lead to improved pupil outcomes.
Content -- *What are (student) teachers learning?*	1. Teacher education should integrate real-life problems, connecting content with the world of young children. 2. Teacher education should provide insights into the relationships between content, how to teach, and the learning processes of children. These should be taught linked to each other. 3. Teacher education should provide subject knowledge, pedagogical knowledge and pedagogical content knowledge in a balanced way. There should be focus on:

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	• the nature of the subject • deep understanding and application of theory • positive attitudes: self-confidence, enthusiasm and practical relevance. 4. Teacher education should integrate assessment into learning and teaching. 5. Teacher education should provide insights into the national curriculum standards.
Learning activities -- *How are (student) teachers learning?*	1. Teacher education should organise learning activities from a participative model. So far, teacher education should provide collaborative learning opportunities including characteristics such as belonging, sharing, communicating, inspiring and peer learning. Inquiry-based learning activities should be learnt in teacher education by practicing them under supervision. Example is the best lesson model. 2. Teacher education should install time-consuming project work related to science for kids. 3. Teacher education should provide learning activities that promote reflective practices. (Student) teachers need to be trained in critical thinking skills. 4. Teacher education should educate (student) teachers for problem-based learning, which means that they can deal with complexity, incomplete information and authentic problems within the area of science and mathematics. 5. When challenging (student) teachers for inquiry- and creativity in science and mathematics education for young children, teacher education cannot go beyond building upon real-world activities and field experiences. 6. Teacher education should design multiple inquiry-based activities that are child-friendly and do evolve from guided to open inquiry. 7. Teacher education should refer to and elaborate on specific research processes and research outcomes during learning activities. 8. Teacher education should offer a dynamic platform for exploration and exercise. As an example, together with its (student) teachers teacher education could trial and verify varied approaches for children's expression and representation of (scientific) ideas. 9. Teacher education should strengthen its pedagogical content knowledge construction for all (student) teachers and this especially in the field of science, technology and mathematics. 10. Teacher education should (when designing and implementing adult learning activities) pay attention to prior knowledge, multiple intelligences and different learning styles. 11. Teacher education should install learning activities that encourage and evaluate scientific literacy. 12. Teacher education should facilitate interactive time and space for microteaching, lesson plan discussions, demonstration of good practice and experimental learning. 13. Teacher education should confront students with ICT-integration. 14. In teacher education teachers should experience what children experience when confronted with scientific issues so that they can better assess (1) the learning processes of children and (2) the time these children need to learn in a natural way. Teachers have to feel and experience the scientific phenomena themselves, even have to play with the materials the children

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	will be using. 15. In teacher education content knowledge should be applied as concrete and activating as possible. 16. In teacher education teachers should learn questions and answers of children as a springboard for further investigation in the field of science and mathematics. 17. Teacher education should provide learning activities that interact with the degree of self-directed learning opportunities of one or more students at a certain moment.
Role of the teacher educator -- *How is the teacher educator facilitating learning?*	1. Teacher education should provide teacher educators who take into consideration (student) teachers' skills, knowledge, attitudes, beliefs, earlier experiences in science and mathematics learning and teaching. 2. Teacher education should provide teacher educators who can take different positions in the interaction with the (student) teacher; e.g. facilitator, supporter, coordinator, leader, motivator, role model. 3. Teacher education should provide teacher educators who are innovators, that is who bring in (new) innovative pedagogy and approaches in the field of science and mathematics learning, science and mathematics teaching, etc. 4. Teacher education should provide teacher educators who build partnerships with different stakeholders such as school staff (for example communities), outside agencies, scientific laboratories, etc. 5. Teacher education should provide teacher educators who are inquirers/researchers; e.g. they provide access to research based teaching. 6. Teacher education should provide teacher educators who are reflective practitioners.
Materials and resources -- *With what are (student) teachers learning?*	1. Teacher education should provide multimedia materials and resources such as web-based resources, video with model experiments, social media, videogames, videocases, iPads and other devices (digital technologies). 2. Teacher education should provide immediate/everyday environment opportunities for learning science and mathematics. 3. Teacher education should provide picture books and story books. 4. Teacher education should provide frameworks for observation, for evaluating learning and teaching materials. 5. Teacher education should provide science and mathematics curriculum materials such as textbooks, national policy documents concerning the curriculum (aims and purpose, assessments, integration of inquiry-based science education (IBSE) and creative approaches, etc.). 6. Teacher education should provide materials and resources about inquiry, concept, research, exploratory, etc. 7. Teacher education should provide access to scientific educational journals, educational books, databases, etc.
Time -- *When are (student) teachers learning? How much time is available for various subject matter domains?*	1. Teacher education should provide time to evolve from passive learners, over active doers, to learners with ownership over their learning. 2. Teacher education should provide time to gain self-confidence with the learner, so he or she believes in his/her ability to teach science/mathematics.

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How much time can be spent on specific learning tasks?	3. Teacher education should provide time to learn through: • classroom practice with all its aspects; • interaction and collaboration with other student and in-service teachers and fellow students; • assessment; • reflection. 4. Teacher education should provide time to learn at a deep level by foreseeing: • time to concentrate and time to think; • time to make the transfer from didactical teaching skills to didactical and pedagogical teaching skills from the children's point of view.
Location -- *Where are they learning? Are (student) teachers learning in class, in the library, at home or elsewhere? What are the social / physical characteristics of the learning environment?*	1. Teacher education should make (student) teachers feel that at school there is tolerance of diversity. 2. Teacher education should provide and encourage partnerships within and between schools and enterprises (and countries). They are both useful for collaboration, sharing, visiting and networking. 3. Viewing education as a dynamic social barometer, teacher education should recognize both formal and informal learning processes. 4. Teacher education should provide learning and teaching opportunities from the viewpoint where science is located on a daily evidence-base.
Grouping -- *With whom are (student) teachers learning? How are (student) teachers allocated to various learning trajectories? Are (student) teachers learning individually, in small groups, or whole-class?*	1. Teacher education should provide 'intervision' or 'supervision'. 2. Teacher education should provide interaction and collaboration opportunities with science experts, student teachers, students from different disciplines, (student) teachers and teacher educators, (student) teachers and teacher educators and children, educational establishments and organisations. 3. Teacher education should provide the possibility to cooperate from a distance through digital or other tools that make this possible.
Assessment -- *How to measure how far learning has progressed?*	1. Teacher education (depending on its aims and objectives) should use different assessment strategies and there has to be a balance between summative and formative assessment. 2. Teacher education should integrate peer and teacher educator observations of good practices, real life practices and/or video cases. 3. Teacher education should integrate peer assessment, self assessment and tutor assessment in assignments. Assignments should include field practices, presentations, preparations of lesson plans, writing narratives/narrative cases, classroom based research projects, etc. 4. Teacher education should use new and/or evidence based assessment strategies, such as portfolio, reflective journals, teacher/children notebooks, narratives, etc.

Table 2: Draft prototypical curriculum design principles (prototype 1) based on the 'spider web' categories (van den Akker, J., 2007)

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D2. From a draft version to prototypical design principles (prototype 2)

As mentioned above, for this deliverable (D5.1) an initial set of prototypical design principles was developed in collaboration with all consortium partners who participated in a web-based expert appraisal panel that lasted two weeks (May 11 – 25, 2012). In particular, nine online forums set up in Moodle served as asynchronous discussion groups (related to all components of the spider web model, except for the *Rationale*). Participants had the assignment to elaborate on miscellaneous information related to curriculum design and curriculum development. They had to highlight possible comments, examples, and questions on 59 proposed design principles for teacher education (prototype 1) which were each related to one of the aspects in the so-called curricular spider web: *Aims and Objectives*, *Content*, *Learning Activities*, *Teacher Role*, *Materials and Resources*, *Grouping*, *Location*, *Time*, and *Assessment*.

At an early stage of development, the main focus was on the relevance and consistency of the prototype. When the prototype is elaborated on further, the focus shifted towards its actual practicability and effectiveness (Plomp & Nieveen, 2007). For instance, the recordings of cases in the field of science and mathematics learning activities were interesting as they provided examples of practice from each country. While viewing teacher education as a site for evidence, it is equally important to look at how this evidence is used in specific contexts. Referring to the feedback and interactions between the expert panel members, it is obvious that alongside examples they also located shortcomings of the suggested principles.

The AUC design team explicitly focused on the formulation of curriculum design principles for teacher education. Shortly after closing the asynchronous discussion these principles needed to be rephrased according to the expert group's written proposals. Further details were provided, some principles were split up and/or new issues were presented (see Table 3 in section E). As mentioned in the scientific literature, curriculum design concerns a cyclic process in which an exchange of experiences, feedback, discussion, and reflection is of great importance. During the entire curriculum design process, a prominent role is reserved for formative evaluation performed within an iterative or prototyping approach. According to van den Akker (2003), formative evaluation of preliminary designs provides concrete insights in how to improve the practicability of the curriculum-to-be.

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E. PROTOTYPICAL CURRICULUM DESIGN PRINCIPLES FOR TEACHER EDUCATION

In Table 3 and Appendix C, adjusted prototypical design principles (prototype 2) and corresponding examples of practice suggested by partners are outlined. During different meetings, three AUC team members extensively discussed how and why (or not) to include examples coming from the expert panel in relation to specific prototypical design principles. Sometimes, the example of practice (Appendix C) merely highlights one content aspect or specific word mentioned in the prototypical design principle. In other cases, the given example overpowers the design principle because it describes in more detail a wide-ranging principle. Examples of practice cannot therefore be considered as exhaustive; they are meant to help the reader clarify and consider the tentative guidelines within a specific teacher education context and/or school culture.

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	**Prototypical curriculum design principles for teacher education based on the components of the spider web** **Rationale: Teachers (incl. student teachers) foster creativity based approaches to science and mathematics learning in preschool and the first years of primary school.**
Aims and objectives -- *Towards which goals are teachers learning?*	1. Teacher education should provide teachers with opportunities and skills to recognise the importance of science education for society and technology development- e.g. to show them that science skills are needed and used in everyday problem solving. 2. In teacher education teachers should acquire a good understanding of basic science/mathematics ideas and processes, as well as the skills and competences to carry out simple inquiries. 3. In teacher education teachers should acquire a good understanding of the nature of science (and how science and scientists work), of child development and of the various meanings of creativity. 4. In teacher education teachers should acquire positive attitudes towards learning and teaching science, mathematics and creativity. 5. In teacher education teachers become confident to teach science and mathematics fostering inquiry and creativity. 6. In teacher education teachers should learn how to have a positive impact on the ongoing science/mathematics learning processes and science/mathematics learning outcomes of children. 7. In teacher education teachers should participate in inquiry-based science learning. 8. In teacher education teachers need to learn how to respect differences in children but also how to respond, facilitate, and support them in different ways within the fields of science, mathematics and creativity. 9. In teacher education teachers should act as innovators, researchers and reflective practitioners during both learning and teaching. 10. In teacher education teachers should be encouraged to become self-regulated learners. 11. Through teacher education teachers should commit themselves to promoting equity and inclusion in their teaching and to recognise and capitalise on diversity. 12. Through teacher education teachers should commit themselves to engage in partnerships with others (other teachers, parents, professional associations, experts, etc). 13. Through teacher education teachers should commit themselves to engage in lifelong learning. 14. In teacher education teachers should acquire skills in perspective-taking. 15. Curriculum developers of teacher education should organise vision-building sessions on dealing in a profound way with ethics and teacher safety, for example with regard to teacher practice in schools and external school visits.
Content -- *What are teachers learning?*	1. Teacher education should provide basic knowledge about science and mathematics to be used in activities linked with everyday life. 2. Teacher education should provide teachers with basic skills and competences to conduct basic practical investigations in science and mathematics.

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	**Prototypical curriculum design principles for teacher education based on the components of the spider web** **Rationale: Teachers (incl. student teachers) foster creativity based approaches to science and mathematics learning in preschool and the first years of primary school.**
	3. Teacher education should provide knowledge about educating children creatively. 4. Teacher education should provide pedagogical content knowledge to stimulate inquiry and problem solving in science and mathematics education. 5. Teacher education should provide knowledge of how to work with primary and secondary science and mathematics sources such as national guidelines, research articles, data, etc.
Learning activities -- *How are teachers learning?*	**Focus on (inter)active learning** 1. Teacher education should involve project work related to science and/or mathematics and creativity for young children. 2. Teacher education should educate teachers in inquiry- and problem-based learning, so that they can deal with complexity, incomplete information and authentic problems within the areas of science and mathematics. 3. When engaging teachers in inquiry- and creativity-based science and mathematics education for young children, teacher education should build upon real-world activities and field experiences. 4. In teacher education teachers should experience what children experience when faced with scientific issues so that they can better assess (1) the learning processes of children and (2) the time these children need to learn in a natural way. Teachers have to feel and experience the scientific phenomena themselves and also interact with the materials children will be using. 5. Teacher education should offer a dynamic platform for exploration and activty. As an example, together with teachers, teacher education could trial and verify varied approaches for children's expression and representation of (scientific) ideas. 6. Teacher education should promote the integration of ICT in science and mathematics teaching and learning. 7. Teacher education should provide time and space for microteaching, lesson plan discussions, demonstration of good practice and experimental learning. 8. Teacher education should organise learning activities that follow a participative modelling approach. It should provide collaborative learning opportunities including characteristics such as belonging, sharing, communicating, inspiring and peer learning. **Focus on inquiry-based science education (IBSE)** 9. In teacher education, inquiry-based science activities should be experienced by teachers under various levels of guidance/self-direction. 10. Teacher education should get teachers to design multiple inquiry-based activities that are child-friendly and evolve from guided to open inquiries. 11. In teacher education teachers should learn to build on children's questions, theories, ideas, interests and answers as springboard for further investigation in the field of science and mathematics. 12. Teacher education should provide learning activities that challenge inquiry-oriented and information-seeking skills and attitudes of teachers.

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	**Prototypical curriculum design principles for teacher education based on the components of the spider web** **Rationale: Teachers (incl. student teachers) foster creativity based approaches to science and mathematics learning in preschool and the first years of primary school.**
	13. Teacher education should refer to and elaborate on specific science research processes and research outcomes during learning activities. **Focus on reflective skills** 14. In the design and implementation of learning activities, teacher education should pay attention to and confront teachers with their own prior knowledge, multiple intelligences, learning styles, misconceptions and stereotypical images of science, mathematics and creativity. 15. Teacher education should provide learning activities that promote reflective practices. Teachers need to be trained in critical thinking skills. 16. Teacher education should provide learning activities that vary the degree of self-regulated learning opportunities of one or more students at a certain moment. 17. In teacher education assessment could be perceived as a separate component, but as a learning activity too. **Focus on (pedagogical) content knowledge** 18. Teacher education should include learning activities that encourage and evaluate the development of scientific literacy. 19. In teacher education science and mathematics content knowledge should be applied as concrete and stimulating as possible. 20. Teacher education should strenghten the pedagogical content knowledge construction of all teachers in the fields of science, technology and mathematics. 21. Teacher education should provide learning activities which integrate science and mathematics content and pedagogical content knowledge in order to improve knowledge transfer.
Role of the teacher educator -- *How is the teacher educator facilitating learning?*	1. Teacher education should provide teacher educators who take into consideration teachers' prior knowledge, skills, attitudes, beliefs, earlier experiences in learning and teaching science and mathematics. 2. Teacher education should provide teacher educators who are innovators, so they can bring in (new) innovative pedagogy and approaches in the field of science and mathematics learning, science and mathematics teaching, etc. 3. Teacher education should provide teacher educators who can build partnerships (for example communities) with different stakeholders such as school staff, outside agencies, science research centres, etc. 4. Teacher education should provide teacher educators who can take different positions in the interaction with the teacher e.g. facilitator, supporter, coordinator, leader, motivator, role model. 5. In teacher education teacher educator's qualifications should be in the field of content knowledge, pedagogical content knowledge and teaching of science and mathematics. 6. In teacher education teacher educators should make explicit connections between content knowledge and pedagogical content knowledge of science and mathematics in their teaching.

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	**Prototypical curriculum design principles for teacher education based on the components of the spider web** **Rationale: Teachers (incl. student teachers) foster creativity based approaches to science and mathematics learning in preschool and the first years of primary school.**
	7. Teacher education should provide teacher educators who are inquirers/researchers; e.g. they provide access to research-based teaching. 8. Teacher education should provide teacher educators who are reflective practitioners. 9. Teacher education should encourage teacher educators to contribute to and foster dynamic relationships between research, policy and practice. 10. Teacher educators should be lifelong learners and be able to demonstrate this to teachers.
Materials and resources -- *With what are teachers learning?*	1. Teacher education should give access to science and mathematics multimedia materials and resources such as web-based resources, social media, videogames, videocases, as well as to digital technologies, such as cameas, iPads and other digital devices. 2. Teacher education should give access to the science and mathematics materials and resources in the nearby environment in which teaching and learning occurs. 3. Teacher education should give access to creative science and mathematics picture books and story books. 4. Teacher education should give access to tools for the evaluation of learning and teaching materials. 5. Teacher education should give access to science and mathematics curriculum materials such as textbooks, national policy documents, etc. 6. Teacher education should give access to materials and resources fostering inquiry-based learning and exploration of science and mathematics. 7. Teacher education should give access to scientific educational journals, books, online and other databases, etc. 8. Teacher education should model how teachers should select science and mathematics materials and resources based on criteria linked with curriculum aims and objectives. 9. Teacher education should be pro-active in finding about and investing in new learning materials and resources. 10. Teacher education should provide infrastructure and logistic support to teachers to access diverse learning materials and resources.
Grouping -- *With whom are teachers learning? How are teachers allocated to various learning trajectories? Are teachers learning individually, in small groups, or whole-class?*	1. Teacher education should provide 'intervision' and/or 'supervision' sessions. 2. Teacher education should provide interaction and interdisciplinary collaboration opportunities between student teachers, in-service teachers, science experts, research scientists, teacher educators, children, and educational establishments and organisations. 3. Teacher education should provide the possibility for collaboration at a distance through digital or other ICT tools that make this possible. 4. Teacher education should define group size and/or group composition depending on course activity aims and objectives, and teachers' needs.

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	**Prototypical curriculum design principles for teacher education based on the components of the spider web** **Rationale: Teachers (incl. student teachers) foster creativity based approaches to science and mathematics learning in preschool and the first years of primary school.**
	5. Teacher education should value peer learning. 6. Teacher education should value team teaching.
Location -- *Where are they learning? Are teachers learning in class, in the library, at home or elsewhere? What are the social/physical characteristics of the learning environment?*	1. Teacher education should provide and encourage partnerships within and between schools and enterprises (in different countries). They are useful for collaboration, sharing, visiting and networking. 2. Teacher education should take place in a variety of learning environments (formal and informal), including e.g. science museums, science research centres, natural habitats, etc., and show teachers their educational merits. 3. Teacher education should provide students the possibility to practice science and mathematics teaching in real classroom settings. 4. Viewing education as a dynamic social barometer, teacher education should recognize both formal and informal learning processes. 5. Teacher education should provide real-life learning and teaching opportunities from the viewpoints of where science is experienced on a daily evidence-base. 6. Teacher education should create an atmosphere in which there is tolerance of diversity. 7. Teacher education should provide opportunities for place-independent learning.
Time -- *When are teachers learning? How much time is available for various subject matter domains? How much time can be spent on specific learning tasks?*	1. Curriculum makers of teacher education should rethink and define time issues in relation to course credit points and teacher occupation profiles often written in policy documents. Examples of issues to be considered are: expected hours for assessment, contact hours, hours needed for teacher practical experiences of different kinds, hours for teachers to reflect on subject matter, etc. 2. Teacher education should provide time for teachers to interact with colleagues: e.g. collegial consultation, teamwork, brainstorming, vision-building. 3. Teacher education should allow time for teachers to accomplish the curriculum aims in a quality way. 4. Teacher education should provide opportunities for time-independent learning.
Assessment -- *How to measure how far learning has progressed?*	1. Teacher education (depending on its aims and objectives) should use different assessment strategies. The assessment strategies implemented in teacher education, and in particular with relation to science and mathematics, should ensure that there is: 2. - a balanced use of summative and formative assessment; 3. - a balanced use of process and product evaluation; 4. - a balanced use of self-, peer-, tutor-, group- and audience assessment; 5. - a balanced use of verbal and non-verbal tools for assessment; 6. - a balanced use of competence-based and talent-oriented assessment. 7. In teacher education, the acquisition and development of science/mathematics knowledge, skills and attitudes should equally be assessed.Teacher education

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	**Prototypical curriculum design principles for teacher education based on the components of the spider web** **Rationale: Teachers (incl. student teachers) foster creativity based approaches to science and mathematics learning in preschool and the first years of primary school.**
	should value its assessment strategies as best examples of practice that may be transferred to teaching practice. 8. Teacher education should foster teacher independence and responsibility in identifying their own progress and areas for development. 9. Teacher education should provide assessment useful for learning, as a learning activity.

Table 3: Prototypical curriculum design principles (prototype 2) for teacher education in early years science and mathematics education, based on the 'spider web' categories (van den Akker, 2007)

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F. SUMMARY

F1. Tensions

During the development and assessment of the prototypical curriculum design principles some important tensions were noticed. Amongst them are the absence of a description of the starting situation of the teachers in the components of the spider web, the differences between ITE and CPD, the considerable number of curriculum design principles and the absence of criteria to evaluate the examples suggested by the expert team. These tensions will be discussed in the sections below.

Starting situation of the teachers (inflow)

The starting situation - competences, expectations, beliefs, attitudes towards science and mathematics, prior experiences and prior knowledge - of the student teacher (ITE) and in-service teacher (CPD) is not mentioned as a separate component of the curricular spider web. Yet, the teacher starting situation and inflow features are important factors to be taken into account when designing a curriculum in favour of a specific audience or target group to be engaged in teacher education. In few design principles this starting situation is mentioned (e.g. prototype 2: learning activities, design principle 14). It is therefore inferred that in the introduction to the guidelines for teacher education it will be important to highlight the importance of (pre)determining and/or diagnosing the starting point of the teacher, in terms of knowledge, beliefs, experiences, etc, but also in terms of needs, personal and professional. Cultural and gender issues will also have to be identified, where relevant.

Both deliverables D3.2 and D3.3 provide us with some context information about differences in starting situation of student teachers and in-service teachers in different countries. The findings of D3.2 are mentioned in section B3. Findings of task 3.3 will be included in future tasks of WP5.

Differences between ITE and CPD

Initial teacher education (ITE) differs from the continuous professional learning and development of in-service teachers (CPD) in various ways. In many countries the debate centres around curriculum implementation issues, rather than on issues related to the different profiles and needs of pre-service and in-service teachers in teacher education. A critical and iterative review of prototypical curriculum design principles, as the one adopted in the *Creative Little Scientists* project, will help to address these issues.

The second prototype of the curriculum design principles has not yet addressed this distinction between pre-service teachers in ITE and in-service teachers in CPD, whereas the final guidelines will. More specifically, it will be important eventually to identify teacher education guidelines specifically linked to ITE and/or CPD respectively. Toward this end, in the next iteration of the curriculum principles, the stakeholders enrolled in the online focus

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groups of the different countries will be asked to indicate whether the design principles are relevant for ITE and/or CPD.

It is also likely that the final teacher education guidelines will be country- or education culture- bound, so context-specific. In other words, some design curriculum principles may be less relevant in some countries, depending on the starting situation and needs of student teachers (ITE) and in-service teachers (CPD) in those countries.

Number of design curriculum principles: where to start when designing a curriculum for teacher education?

For the design of the prototypical design principles each component of the spider web is viewed as equivalent and necessary, resulting in more than 60 design principles which are all interrelated to each other and sometimes even show overlap.

However, will they all need to be integrated, when these guidelines are used to create a curriculum for ITE or a CPD programme? Are all components equally relevant, in every case? These questions will be explored in the next iterations of the curriculum principles.

According to Thijs and van den Akker (2009; p. 12-13):

> "*Curriculum design or innovation can start with any component. Traditionally, the learning content receives the most attention. (…) Naturally, the relevance of the ten components varies for the five curriculum levels mentioned earlier. At macro level, for example, the 'what questions' concerning objectives and content components usually receive more attention than the 'how questions' concerning pedagogy, educational materials, and the learning environment. Also, the consistency between objectives and content on the one hand and assessment and examinations on the other is of great importance at the macro level. At school and classroom level nearly all components play a role. Here, overall consistency is of crucial importance for successful and sustainable implementation of innovations. This is a great challenge. It is an often uphill struggle with much trial and error, while making only slow progress.*"

In the *Creative Little Scientists* project guidelines will be provided for policy makers and teacher education institutions and organization. To develop a consistent curriculum, all components - and corresponding guidelines - have to be taken in account. So, information concerning the design of curricula will be essential in the final document concerning the teacher education guidelines.

How abstract or concrete should the curriculum guidelines be?

In 'Table 3' the examples of practice, suggested by consortium partners, are incorporated in the design principles. However, no specific criteria or expectations were formulated for these examples (see Appendix C).

In addition, some of the principles in Table 3 seem to be more explicitly linked to science and mathematics learning/teaching, whereas other are referring rather more generally to the

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learning environment required for fostering creative approaches to science and mathematics learning/teaching.

In future iterations of the design curriculum principles some relevant issues to be considered are:

- Are we going to ask the stakeholders of the focus groups to suggest further examples of actual practice? Which criteria are we going to use to evaluate these examples of practices? Is it interesting to add examples in the final document, clarifying and illustrating the guidelines? Do we need examples from different countries per design principle?
- WP4 findings will directly inform the development of teacher education materials. Priorities for the development of teacher education materials were identified in Deliverable D3.2. This mentions the need for strategies and tools to support self-evaluation and formative assessment, and also for case studies showing collaborative approaches, and the role of digital technologies. However these materials also have to be selected according to evaluation criteria (e.g. criteria linked with the conceptual framework, linked with the curriculum design principles).

Teacher education for the 21st century

Curriculum design for teacher education is clearly related to what the society requires from a 21st century in-service teacher in terms of competences (e.g. knowledge, skills, attitudes). It seems that vision-building on teacher education outcomes will serve as a driving force for ensuring the success of curriculum design efforts.

F2. Implications

Based on the tensions discussed in the previous section, there are several implications for the forthcoming work in the *Creative Little Scientists* project, especially in relation to WP4 and WP5.

1. In the asynchronous discussion group assignment (cfr. online focus groups) the following item will be incorporated: stakeholders have to enrich the prototypical design principles (prototype 2) with relevant good examples, based on their experiences with ITE and/or CPD, and in relation to science, mathematics and creativity in education.
   Most probably the different stakeholders will have different examples to suggest, which means that they should all be actively involved in the focus groups.
2. The descriptions of the examples and good practices offered should include clear and concrete references to their relevant context. To ensure this, appropriate guidance accompanied by a template should be prepared and distributed to the stakeholders.
3. The starting situation of teachers should be consistently and explicitly given consideration in all of the curricular guidelines. Also, differences in teacher starting

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situations should be acknowledged and illustrated with different examples based on results from research in WP3 (Deliverable D3.3) and WP4.

4. The fieldwork carried out in WP4 is expected to produce a number of case studies of ‘good practice’, as well as identify a number of exemplary teaching materials. These materials will comprise invaluable resources to use in the development of the exemplary teacher education materials in WP5 (Deliverable D5.3). Future tasks in WP5 should further elaborate answers to the following questions: How will these materials be selected? Which criteria will be used? Criteria formulated in WP4, based on the conceptual framework, and/or criteria based on the design principles?

F3. Limitations

The tentative guidelines (see Figure 2) will not be tested or tried out in a real teacher education course or programme. Examples are from earlier experiences of partners in the consortium or stakeholders in the focus groups.

Materials obtained from the in-depth study (WP4) will also not be tested in a teacher education course or programme. However they will be selected using criteria based on the conceptual framework and WP3.

F4. Conclusions

In general, the set of curriculum design principles as presented in prototype 2 are associated with a social-constructivist vision on learning and instruction. Moreover, they hold common ground with theories on inquiry-based science education.

In the final document with guidelines for teacher education (initial teacher education and professional development programmes), it will be necessary to provide:

- Information about the spider web instrument used in our curriculum design research.
- Information about the advantages of prototyping design principles in educational contexts.
- Information about the impact of the starting situation/competences of the teacher.
- Information about designing a curriculum starting from guidelines.
- Information about which prototypical design principles are more specific to the learning and teaching of science/mathematics, or more generic, so required for creating a learning environment fostering inquiry-based approaches to science and mathematics learning in preschool and the first years of primary school.
- Information about curriculum design for different purposes and target groups, for example, initial teacher education versus continuous professional development.

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- Information about the context of the described examples and practices and their possible time, local or cultural limitations. The criteria for exclusion or inclusion of examples and practices must also be mentioned. These will be related to the conceptual framework (WP2) and the factors formulated in WP3.

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APPENDIX A

During the 2nd project meeting in Paris the partners were asked to note on a post-it what curriculum meant for them.

Curriculum is …

- *a framework describing aims, objectives, methods and an environment of education. Providing guidelines and suggestions.*
- *guidance + advice: content and approaches, range of experiences, understandings, skills and attitudes, holistic, relevant.*
- *subjects and competences to be addressed.*
- *a minimum national entitlement organized around subject disciplines.*
- *a route to teaching and learning for a given educational context.*
- *Tensions:*
    - *Differences between espoused and enacted curriculum.*
    - *Permission to personal interpretation, involvement.*
    - *Just general guidelines or not.*
    - *> contents.*

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APPENDIX B:
GPS brainstorming: Results

1. How should **instruction** be structured in teacher training?

- Fostering problem-based learning
- Promoting curiosity in student teachers
- Tutors need to be capitalized on each other to develop integrated approaches
- Motivated and engaged teachers
- Recognizing the learning potential in the activities teachers with students undertake
- Instruction should follow principles of adult learning
- Experienced teams
- Visualization
- **Need strong understanding of creativity in and through subjects**
- Wide fields instruction
- **Promoting of reflective practice**
- Making the connection between principles and practice
- Becoming a scientist
- Scientific partnership
- Focus on subject knowledge (without all other things are difficult)
- To take into consideration personal experiences of learning science (being taught)
- **To take into account epistemological beliefs about science**
- Starting with student reflection on own views of science and professional teaching + attitudes
- **Collaboration and dialogue on different levels**
- **Teacher training should model desirable classroom practices**
- Animation and participation
- Role of the instructor = facilitator
- Small groups

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2. How should curriculum be structured in teacher training?

- Need for balance between structure/content and flexibility in curriculum
- **The curriculum should reflect real life problems**
- Cross-curriculum science education
- **Competence-based**
- **Combination of subject knowledge development issues and subject specific pedagogy**
- **Subject matter relates how to teach it / how children learn it**
- **Confidence with contents**
- **Opportunities to engage in own practice inquiry and research (in workshops, classrooms)**

3. How should (school) policy be structured in teacher training?

- **Recruitment practices**
- Selection + evaluation practices of teachers
- Postgraduate TT or undergraduate TT?
- **Bachelor or Master level teacher training?**
- Subject-specific teacher training or general teacher training?
- **Supporting science experts in school**
- **Collaboration and partnerships on projects in a variety of contexts + project presentations**
- **Close co-operation with schools**

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APPENDIX C:
First Findings of the Outcomes of the 'Expert Team' Focus Group Discussions

Prototypical design principles based on the components of the spiderweb - D5.1

Rationale: (Student) teachers foster creativity based approaches to science and mathematics learning in preschool and the first years of primary school.

Aims and objectives

Towards which goals are they learning?

Principles	Examples
1. In teacher education (student) teachers are meant to reach a positive attitude towards learning and teaching science, mathematics and creativity.	
2. In teacher education (student) teachers have confidence in teaching science and mathematics fostering inquiry and creativity.	
3. In teacher education (student) teachers act as innovators, researchers and reflective practitioners during both learning and teaching.	
4. In teacher education (student) teachers need to be able and so far learnt how to respect differences in children but also how to respond, facilitate, support in different ways within the fields of science, mathematics and creativity.	
5. In teacher education (student) teachers are committed to promote equity and inclusion in their teaching and to recognise and capitalise on diversity.	
6. Teacher education should provide opportunities and skills to see science education as part of society and technology - to show students that science skills are needed and used in everyday problem solving.	A web-based training platform that includes a special section to teachers projects, where some of the most relevant results are displayed. This in order to built a community/network of science teachers practicing IBSE, in order to share best practice and expertise. Example: http://education.inflpr.ro/ro/DescoperaProiecteProfesori.htm (Portugal) (NILPRP)
7. Curriculum makers enrolled in teacher education should organise vision-building sessions on dealing in a profound way with ethics and student safety, for example with regard to internship issues.	They can organise focus groups that discuss several different topics during an academic year. (AUC)
8. In teacher education (student) teachers should be self-regulated learners.	

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9. In teacher education (student) teachers are committed to engage in partnerships with others (other teachers, parents, professional associations, experts, ...).	Field visits to authentic science environments such as science research centres help demystify the work of science and scientists. (EA)
10. In teacher education (student) teachers should be educated to evoke a positive impact on the ongoing learning processes and learning outcomes of children.	
11. In teacher education (student) teachers participate in inquiry-based learning.	
12. In teacher education (student) teachers are commited to engage in lifelong learning.	There can be courses organised that are available for ITT and CPD, so they are already involved in the PD within the ITT. (EA)
13. In teacher education (student) teachers have good understanding of nature of science, child development and meanings of creativity.	
14. In teacher education (student) teachers have capacities in perspective-taking.	

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Prototypical design principles based on the components of the spiderweb - D5.1

Rationale: (Student) teachers foster creativity based approaches to science and mathematics learning in preschool and the first years of primary school.

Assessment

How to measure how far learning has progressed?

Principles	Examples
1. Teacher education should use different assessment strategies depending on the aims and objectives to reach and there has to be a balance between summative and formative assessment.	**a.** Portfolio as a tool in continual teacher development and multidimensional assessment tool is good. This can be done by using an electronical platform and/or traditional folder. (UEF) **b.** Formatieve evaluation can be done by negotiating the assignment given to the students, in order to find a common point of interest. An outcome can be that the (student) teachers ask if for their assignment they could go and try out the work and examples which have been discussed in the classroom and then to reflect on their practice and the impact on the children's learning. (UoM)
2. Teacher education should use different assessment strategies depending on the aims and objectives to reach and there has to be a balance between process and product evaluation.	**a.** We had a mathematics module where the students had to undertake mathematical investigations themselves, with the possibility of working with others for one of the investigations. in the assignement they annotated the investigations with reflections on their learning at each pointy and then they finished with a summary of the key points they had learnt about their own learning process. The second assignment in the module was to plan a series of investigations for the pupils to undertake in schools with a rationale linking to wath they had learnt about the investigative process from undertaking it themselves. (BG) **b.** All teachers attending our courses are asked to prepare for their evaluation stage a collection with each student's portfolio as a testimony of the way they apply the IBSE method in class. Based on this documents teachers are able themselves to evaluate students progress. In some situations these documents are supported by video/ photo recordings. (NILPRP)
3. Teacher education should use different assessment strategies depending on the aims and objectives to reach and there has to be a balance between self-, peer-, tutor-, group- and audience assessment.	In our demo session we run by teaching children ourselves (as examples for teachers who attend the sessions) we ask children to fill, by the end of the session, two forms: a) one for indirect self-assessment; b) one to assess knowledge, competences and attitudes of their peers. (NILPRP)
4. Teacher education should use different assessment strategies depending on the aims and objectives to reach and there has to be a balance between verbal and non-verbal tools for assessment.	

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5. Teacher education should value its assessment strategies as examples of practice that may have a transfer to teaching practice.	Teacher education should integrate peer and teacher educator observations of practices - real life practices or video cases.
6. Teacher education should foster student teacher independence and responsibility in identifying their own progress and areas for development.	In order to balance formative and summative assessment, traditional teacher education designs – in which teachers are 'told' what to do – are not appropriate. A process of supported teacher development, in which the teachers in their classrooms have to work out the answers to many of the practical questions that the research evidence cannot answer is essential. The issues have to be reformulated in collaboration with them, where possible in relation to fundamental insights, and certainly in terms that could make sense to their peers in ordinary classrooms. (EA)
7. Teacher education should use different assessment strategies depending on the aims and objectives to reach and there has to be a balance between evaluating knowledge, skills and attitudes.	
8. Teacher education should use different assessment strategies depending on the aims and objectives to reach and there has to be a balance between competence-based and talent-oriented assessment.	Teacher education should use new and/or evidence based assessment strategies, such as portfolio, reflective journals, teacher/children notebooks, narratives, … (AUC)
9. Teacher education should provide assessment as useful for learning, as a learning activity.	Staring for the last year we are offering a short course for teachers' CPD during which we run a demo session working with children and in the mean time we are training teachers to do formative assessment during our session. So, it is a combination of class work on science teaching and assessment. (NILPRP)

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Prototypical design principles based on the components of the spiderweb - D5.1

Rationale: (Student) teachers foster creativity based approaches to science and mathematics learning in preschool and the first years of primary school.

Content

What are they learning?

Principles	Examples
1. Teacher education should provide basic knowledge about science and mathematics to use this knowledge in activities linked with everyday life.	
2. Teacher education should provide knowledge about educating children creatively.	**a.** Student teachers undertake case studies of children's views and learning in science/mathematics with a focus on inclusion. They explore varied ways of finding out about their ideas and consider implications for future learning and teaching. (IoE) **b.** Teachers education need to take in consideration children's cognitive and conative development and the relation between them, in order to adjust their teaching in the classroom according to the needs and interest of pupils. (UPJV)
3. Teacher education should provide pedagogical content knowledge to stimulate inquiry and problem solving in science and mathematics education.	**a.** Many of our BA undergraduate programmes have research modules also, so students are being introduced to research much earlier on and encouraged to apply this to their practice. (UEF) **b.** Through reading short articles, teacher students learn to apply new approahes to their teaching. In master level they have good opportunities to conduct their own research. Old en new, placing opposites to each other. (BG) **c.** Leech and Moon talk about overlapping circles of subject knowledge, school knowledge and pedagogic knowledge overlaid with a personal construct - Leech and Moon (2002) - The curriculum knowledge of teachers: a review of the potential of large-scale electronic conference environments for professional development. Curriculum Journal 13(1), pp. 87 - 120. This approach underlies most of the science and mathematics sessions in out first year. (BG) **d.** Examples about concrete/abstract knowledge construction. **e.** In learning science, mathematics and creativity their should be focus on the nature of the subject, understanding deep and application, skills, attitude: confidence, own enthousiasm and scale of relevance, historical change, and own experiences, comparison of existing strategies in different countries. (IoE)
4. Teacher education should provide knowledge of how to work with sources such as national guidelines, research articles, data, ...	For these courses we designed learning units embedded into an e-learning platform. At the beginning of each learning unit a statement referring to the national curriculum content related this module was included. In this way, teachers enrolled into our CPD courses are aware about the link existing between the course and the official requirements/ recommendations. (NILPRP)

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Learning activities

How are they learning?

Principles	Examples
(inter)active learning	
1. Teacher education should install project work related to science and/or mathematics and creativity for kids.	**a.** In the UK in some insititutions offer integrated weeks of learning to students such that they engage together in learning 'across the curriculum' in line with learning opportunities in primary schools and this can be excellent. In this way students focus in small collaborative groups on problem based activities which include science, maths and much more and find for themselves some of the challenges and affordances of such an approach. (OU) **b.** Our experience is that if the project work has visible and practical outcomes in daily life, it works better. For example, bachelor proof students working together over time challenged to make an interactive game or a website for primary school children visiting sea life center. Feeling of 'ownership' is of importance from start to end. (AUC) **c.** We have a 'starting point' project where the students choose a natural object and study it in detail, seeing what they can learn from first hand enquiry rather than secondary sources. The students are learning about scientific enquiry but also their own learning processes. We used to get them to do the same project with children in schools to compare their own learning processes with the childrens but changes to the curriculum structures have meant that schools are less willing to let us do this recently. This doesn't really count as innovation but was reflective practice. (BG)
2. Teacher education should educate students for problem-based learning, which means that they can deal with complexity, incomplete information and authentic problems within the area of science and maths.	We help teachers to apply problem-based learning starting from real life situations/ cases. See for example the research subjects proposed in the 2012 brochure of the "Would be scientists - CHERCHEUR EN HERBE" project (http://education.inflpr.ro/ro/CercetatorInDevenire1.htm). (NILPRP)
3. When challenging students for inquiry and creativity in science and maths education for young children, teacher education can't go beyond building upon real-world activities and field experiences.	

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4. In teacher education teachers should experience what children experience when confronted with scientific issues so that they can better assess (1) the learning processes of children and (2) the time these children need to learn in a natural way. Teachers have to feel and experience the scientific phenomena themselves, even have to play with the materials the children will be using.	
5.Teacher education should offer a dynamic platform for exploration and excercise. As an example, together with its students teacher education could trial and verify varied approaches for children's expression and representation of (scientific) ideas.	Student teachers undertake investigations in the local urban environment with a focus on access and inclusion, provide visual and oral presentation of their data for peer interpretation and consideration of alternative explanations. (IoE)
6.Teacher education should facilitate time and space for microteaching, lesson plan discussions, demonstration of good practice and experimental learning.	
7. Teacher education should organise learning activities from a participative model. So far, teacher education should provide collaborative learning opportunities including characteristics such as belonging, sharing, communicating, inspiring and peer learning.	
8. Teacher education should confront students with ICT-integration.	We are working a lot with school teachers to use ICT such as automatic data collection and robots, to complement classical science teaching (e.g. https://docs.google.com/present/view?id=0AQWu99yEFLH0ZGdmN2Q4a2NfNTUyMjd6Y3BkdGdi&hl=en_US and http://education.inflpr.ro/ro/Fibonacci1.htm > Activitati > Clubul de robotica "Robotics Club Galati" a luat fiinta la Colegiul National "Alexandru Ioan Cuza" din Galati)
inquiry-based	
9. Teacher education should refer to and elaborate on specific research processes and research outcomes during learning activities.	**a.** It is important to become aware of current research results of science and maths education. Through reading short articles, teacher students learn to apply new approahes to their teaching. In master level they have good opprtunities to conduct their own research. (GUF) **b.**Many of our BA undergraduate programmes have research modules also, so students are being introduced to research much earlier on and encouraged to apply this to their practice. (BG)
10. Inquiry-based learning activities should be learnt in teacher education by practicing them under supervision. Example is the best lesson model.	
11. Teacher education should design multiple inquiry-based activities that are child-friendly and do evolve from guided to open inquiry.	

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12. In teacher education (student) teachers should learn to build on questions, theories, ideas, interests and answers of children as springboard for further investigation in the field of science and maths.	**a.** Maybe it would be a good idea to show them authentic classroom activities that have been filmed before example. (GUF) **b.** (student) teachers have to write down questions, remarks, ideas of young children during a periode of 2 weeks to discuss in group afterwards. (UoM)
13. Teacher education should provide learning activities that challenge inquiry-oriented and information-seeking skills and attitudes of the (student) teachers.	
reflective skills	
14. Teacher education should (when designing and implementing learning activities) pay attention to and confront (student) teachers with their own prior knowledge, multiple intelligences, learning styles, misconceptions and stereotypical images of science and creativity.	Prior to the programme student teachers are asked to write about and reflect on opportunities and varied experiences of learning science at different ages both in and outside schooling and consider how this has affected their views of science and approaches to teaching. (IoE)
15. Teacher education should provide learning activities that promote reflective practices. Students need to be trained in critical thinking skills.	
16. Teacher education should provide learning activities that interact with the degree of self-regulated learning opportunities of one or more students on a certain moment.	
17. In teacher education assessment could be perceived on itself, but as a learning activity too.	
(pedagogical) content knowledge	
18. Teacher education should install learning activities that encourage and evaluate on scientific literacy.	In lessons mainly supposed to be language lessons (e.g. reading comprehension) texts and learning materials can deal with contents related to science and mathematics. (AUC)
19. In teacher education content knowledge should be applied as concrete and activating as possible.	**a.** I try to teach them the main biological facts and ideas and we do a lot of practical work that the teachers can than repeat - more or less one-to-one - with their children at school; e.g. fish dissection, small experiments with living earth worms, experiments with plants (water transport, colours in leafs...), and we go to different out-of-school learning places (museum, zoo, botanical garden, forest...) to meet "the original". (GUF) **b**. Visual and schematic support-giving during teaching content knowledge seems crucial to me. (AUC)
20. Teacher education should strenghten its pedagogical content knowledge construction for all students and this especially in the field of science, technology and mathematics.	Matters like the theories of conceptual training (transition from the naïve conceptions to the scientific knowledge), the knowledge organization in the memory, the categorization of different categories (perspective, thematic, taxonomic). (UPJV)
21. Teacher education should provide learning activities which integrate content and pedagogical content knowledge in order to make transfer.	Creative learning can motivate both children and teachers through play and in-role engagement. (AUC)

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Prototypical design principles based on the components of the spiderweb - D5.1

Rationale: (Student) teachers foster creativity based approaches to science and mathematics learning in preschool and the first years of primary school.

Role of the teacher educator

How is the teacher facilitating learning?

Principles	Examples
1. Teacher education should provide teacher educators who take into consideration (student) teachers' prior knowledge, skills, attitudes, beliefs, earlier experiences in learning and teaching science and mathematics.	
2. Teacher education should provide teacher educators who can take different positions in the interaction with the (student) teacher e.g. facilitator, supporter, coordinator, leader, motivator, role model.	**a.** Teacher educators need to balance being a guide and a 'meddler in the middle' with 'sage on the stage'. (OU) **b.** We do some of this. We try to act as role models in our teaching, making it clear when we are using teaching styles that would not be appropriate for young children (like lectures) and why. We try to be motivators, bringing our enthusiasm to our teaching. We also supervise the students when they are teaching in schools which allows us to support and facilitate as well as assess. I'm not sure if they view us as leaders and co-ordinators. (BG)
3. Teacher education should provide teacher educators who are innovators, so they can bring in (new) innovative pedagogy and approaches in the field of science and mathematics learning, science and mathematics teaching, ...	We are encouraging teachers to support children in developing "research" type projects staring form an early age (e.g. http://education.inflpr.ro/ro/Fibonacci1.htm > Simpozionul national "Sa ne jucam de-a stiinta" la Gradinita Happy Kids din Ramnicu Valcea, 14.05.2011). (NILPRP)
4. Teacher education should provide teacher educators who build partnerships with different stakeholders such as school staff (for example communities), outside agencies, scientific laboratories, ...	This does happen to some degree in England, where through an intitiative called Creative Parternships there have been opportunities for student teachers and TE to work with partners/agents from the creative and business sectors . Equally there is an opportunity in many HEI to allow student teachers to exchange a teaching practice experience with working in a business or culural sector organisation, many work in museums for 3 weeks, some in laboratories such that new relationships are built for future collaboration. (OU)
5. Teacher education should provide teacher educators who are inquirers/researchers; e.g. they provide access to research-based teaching.	
6. Teacher education should provide teacher educators who are reflective practitioners.	

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7. In teacher education teacher educator's qualifications should be in the field of content knowledge, pedagogical content knowledge and teaching.	Many teacher trainers have a master or doctoral degree in education but have never worked in schools themselves (except for short practicals). (GUF)
8. In teacher education teacher educators should interconnect content knowledge and pedagogical content knowledge during (teaching) practice.	Workshops, teaching practice tasks interspersed with 'lectures'.
9. Teacher education should encourage teacher educators to contribute to and foster dynamic relationships between research, policy and practice.	
10. Teacher educators should be lifelong learners and be able to demonstrate this to their (student) teachers.	

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Rationale: (Student) teachers foster creativity based approaches to science and mathematics learning in preschool and the first years of primary school.

Materials and resources

With what are they learning?

Principles	Examples
1. Teacher education should give access to multimedia materials and resources such as web-based resources, social media, videogames, videocases, iPads and other devices (digital technologies).	**a.** Our schools have all been installed with interactive whiteboards which offer opportunities - but both from my observation of classes with young children as well as research on story telling - the actual things which children can feel and touch remain the best and most effective resource. So in using new technologies as resources, we should not forget that the effectiveness of the 'old traditional' ones. (UoM) **b.** IPads with apps like a plant identification key to use during a field trip. (GUF) **c.** E-learning and video conference server on which an archive of science experiment movies is located. (NILPRP)
2. Teacher education should give access to the materials and resources in the nearby environment in which teaching and learning is supposed to occur.	
3. Teacher education should give access to picture books and story books.	We do sessions with first year students on mathematics and science through story. Previously we had an assignment where they had to design a story sack that would help them teach mathematics or science through a story book and associated resources. This had variable success because many of the first year students were still too focussed on doing rather than learrning. (BG)
4. Teacher education should give access to observation tools in order to evaluate learning and teaching materials.	
5. Teacher education should give access to science and mathematics curriculum materials such as textbooks, national policy documents.	
6. Teacher education should give access to materials and resources fostering inquiry-based learning and exploration.	Data loggers and sensors. (NILPRP)
7. Teacher education should give access to scientific educational journals, books, databases, …	
8. Teacher education should model how to select materials and resources on criteria linked with curriculum aims and objectives.	
9. Teacher education should be pro-active in getting to know and invest in new learning materials and resources.	

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10. Teacher education should provide infrastructure and logistic support in order to get broad access to diverse learning materials and resources.	Borrow opportunities for both staff en students. (AUC)
11. Teacher education should model how to select materials and resources based on criteria linked with curriculum aims and objectives.	

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Prototypical design principles based on the components of the spiderweb - D5.1

Rationale: (Student) teachers foster creativity based approaches to science and mathematics learning in preschool and the first years of primary school.

Time

When are the learning? How much time is available for various subject matter domains? How much time can be spent on specific learning tasks?

Principles	Examples
1. Curriculum makers in teacher education should rethink and define time issues in relation with both predetermined credit points and occupation profiles written in policy documents, more specifically concerning expected hours to assess, contact hours, hours needed to exercise in different ways, hours aiming students to reflect on subject matter, etc.	ECTS (AUC)
2. Teacher education should provide time to interact with colleagues: e.g. collegial consult, teamwork, brainstorming, vision-building.	I can see how 'time' is very crucial for the achievement of a number of aims in teacher education, I wonder how however it is especially crucial for primary teacher education in science and mathematics. I would expect that most student teachers of primary teacher education do not have overall positive attitudes to science and mathematics teaching and learning. Teacher education needs to challenge (if not change) these (often firmly held over a long time) attitudes. Time is definitely needed for this. (EA)
3. Teacher education should receive, provide and create time to reach the curriculum aims in a qualitative way.	**a.** The accredited courses for CPD have structure encouraging practice in the classroom and offering enough time for collaboration and reflection on the subjects taught: 24 face-to-face training of teachers and 48 hours to develop project in the classroom with their students. (NILPRP) **b.** In the collaborative project with have with the French school in Bucharest "The would-be scientists") partner teachers develop in cooperation with French teachers common projects over several months, having enough time to interact each-other and to reflect on personal work. (NILPRP)
4. Teacher education should provide opportunities for time-independent learning.	

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Location

Where are they learning? Are students learning in class, in the library, at home or elsewhere? What are the social/physical characteristics of the learning environment?

Principles	Examples
1. Teacher education should provide and encourage partnerships within and between schools and enterprises (and countries). They are useful for collaboration, sharing, visiting and networking.	
2. Viewing education as a dynamic social barometer, teacher education should recognize both formal and informal learning processes.	**a.** We regulary go to wastewater treatment plants, waste management plants and farms. (GUF) **b.** We have a strong partnership with schools. Mostly this involves students observing practice in schools and practising teaching themselves. We have had some links with with enterprises but this is less well established and can be problematic e.g. we had some people from a well known company run some science workshops with our students that they then took into schools where the students led them for the children, however some staff had problems with the companies ethics and were uncomfortable collaborating with them (BG) -- adding ESSO as an exemplary enterprise: taking into account all points of view for the students/teacher... **c.** Answering question with example: Is there any reason why HEIs could not organise joint CPD and ITE sessions in unusual locations? Their core audience would be the ITE studnts perhaps but combining both might be valuable- (EA) **d.** Joint courses (CPD and ITE) seem to be very fruitful to me as CPD/teachers can talk about their experiences with children and thereby link ITE students to praxis. (GUF)
3. Teacher education should provide real-life learning and teaching opportunities from the viewpoint where science is located on a daily evidence-base.	
4. Teacher education should create an atmosphere in which there is tolerance of diversity.	

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5. Teacher education should take place in different out-of-college environments and show the (student) teacher how fruitful these experiences can be.	**a.** Field visits to authentic science environments such as science research centres help demystify the work of science and scientists. Example: In our CPD science courses, we used state-of-the-art labs and ordinary lecture rooms (of classroom-size), but also organised field trips to science centres, museums. and research centres (such as CERN, pharmaceuticals, etc.). (EA) **b.** Teacher education should build upon current projects running in elementary education, for example, in the frame of the Fibonacci project we are coordinating in Romanian there is a sub-project (the Greenwave) where children from elementary and middle schools are requested to run outdoor observations and measurements. The project is a big success in Romanian as far as over 80 teachers are enrolled this year (http://www.greenwave-europe.eu/index.php?p=statistics&q=map). (NILPRP) **c.** In some cases, biology teachers attending our courses are asked to pay visits to the Natural Science Museum and develop some project based on observations in an informal educational environment, as part of their competences evaluation. (NILPRP) **d.** In museums, courses/events are organised for CPD and ITE as well, especially to show them how to work with their exhibitions. We often visit these places with future teachers and teachers to have sessions about using these out-of-school environments for biology education. (GUF)
6. Teacher education should provide opportunities for place-independent learning.	**a.** online learning envirronment (IOE) - A key priority on our programmes is to foster student teachers own active and wider interests in science and mathematics learning by highlighting opportunities in their everyday lives, as well as through engagement with debate and issues in the media, ongoing informal discussion of current TV programmes, exhibitions - try to put postings on our equivalent of Moodle to draw attention to topical events. **b.** Makes me thinking of mobile school projects in the world: low-budget education which links to special needs for creativity. (AUC) **c.** E-portfolio when it is used systematically. (UEF)
7. Teacher education should provide students the possibility to practice science and maths teaching in a real occupied classroom settings.	360° feedback becomes possible. (AUC)

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Prototypical design principles based on the components of the spiderweb - D5.1

Rationale: (Student) teachers foster creativity based approaches to science and mathematics learning in preschool and the first years of primary school.

Grouping

With whom are they learning? How are students allocated to various learning trajectories? Are students learning individually, in small groups, or whole-class?

Principles	Examples
1. Teacher education should organise 'intervision' and/or 'supervision' sessions.	Intervision is our opinion a discussion, reflection, debate group of students who are active around the same problem, context, course, internship. They talk to each other to reflect, to find a possible solution for a problem of one student or more students without a person who is in charge and has the authority by his position to lead the conversation. In supervision they can do the same, but with a supervisor who is in charge of the structure of the conversation. (AUC)
2. Teacher education should provide interaction and interdisciplinary collaboration opportunities between (student) teachers, science experts, teacher educators, children, and educational establishments and organisations.	
3. Teacher education should provide the possibility to coöperate from a distance through digital or other ICT tools that make this possible.	**a.** In future or nowadays already, it seems, that distance learning and different ICT tools become even more significant. This is important and could be expanded like, that different modes of social media could be applied. We have tried, with quite relevant results. (UEF) **b.** In a number of CPD courses I coordinated, a web-based forum was used to facilitate interaction and collaboration among participant teachers and between participants their tutor(s). (EA) **c.** We've tried video links from students on placement to the campus, in addition to students watching an exemplar lesson from a leading science teacher which was followed by a question and answer session. However, technologies can be a problem alongside gaining the necessary permissions to video / broadcast the pupils. (BG) **d**. In the collaborative project with have with the French school inBucharest"The would-be scientists") we provide a virtual space where teachers from both sides can share their views and results. (NILPRP) **e.** For example, internship students do upload video fragments of themselves during teacher practice on a private but formal digital learning platform from school. In this way, both self-, tutor-, and peer feedback become possible time- and place-independently. (AUC)
4. Teacher education should define group size and/or group composition depending on differences, aims, objectives and/or students' needs.	

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5. Teacher education should value peer learning.	Peer tutoring. (AUC)
6. Teacher education should value team teaching.	

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